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Original Article

Physiology Section

Effect of Different Phases of Menstrual Cycle on Cardio-respiratory Efficiency in Normal, Overweight and Obese Female Undergraduate Students

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ABSTRACT

Introduction: The influence of obesity on cardio-respiratory efficiency in the various phases of menstrual cycle is not well understood until now. As majority of Indian women have a favourable attitude towards participation in sports it is significant to understand the variation in exercise performance during different phases of menstrual cycle to have an optimum performance.

Aim: To evaluate the endurance capacity and cardio-respiratory responses in normal, obese and overweight female undergraduate students during different phases of menstrual cycle.

Materials and Methods: Twenty normal weight, 20 obese and 20 over weight, unmarried, undergraduate female volunteers between the age group of 18-22 years, were recruited by convenient sampling. Cardio-respiratory efficiency was assessed by cardiac efficiency test, respiratory endurance test and respiratory blast test.

Results: Overall, exercise efficiency varied significantly during the different phases of the menstrual cycle with the highest during luteal phase and lowest during menstrual phase. Similar trend was observed in all the three weight sub-categories, but it was statistically significant in the normal and overweight category only. There was no significant difference in blast test during menstrual phase, follicular phase and luteal phase of menstrual cycle among three groups of individuals. Overall the obese and overweight females had a decreased value for blast test compared to the normal individuals. Significant difference was observed in endurance test among follicular and luteal phase of normal females but there is no change in overweight and obese. Significant difference was observed in Peak Expiratory Flow Rate (PEFR) among luteal phase in normal and overweight individuals but there is no change in obese females. Overall obese individuals have a significant low PEFR compared to normal and overweight individuals.

Conclusion: Significant increase in cardiac and respiratory efficiency was observed in the luteal phase of the menstrual cycle in normal weight where as in overweight and obese females, there is an overall decrease in fitness capacity with increase in the Body Mass Index (BMI). Therefore, practice of regular exercise and intake of healthy diet which help in reducing the weight and in turn the BMI will help in enhancing the physical fitness of the individuals.

Keywords: Body size, Cyclical variation, Female college students, Thinness

INTRODUCTION

Female sex hormones play wide cyclic swings and the tissues influenced by these hormones also undergo cyclical changes, the most obvious of which is the monthly menstrual cycle [1]. As majority of Indian women express favourable attitude towards participation in sports and [2], it is essential to understand the variation in performance during different phases of cycle. Cardio-respiratory function should be normal and efficient to perform physical exercise as it demands more oxygen and blood supply [3-5]. Reports on cyclical variation of cardio-respiratory efficiency are contradictory [6]. Maximum respiratory efficiency was reported in luteal phase and maximum cardiac efficiency was reported in post-menstrual phase [7,8]. In contrast, it was reported that menstrual cycle has no influence on cardio-respiratory efficiency [9-11]. Prevalence of cardio vascular disorders is higher in younger adults with high body fat [12-14]. Excessive amounts of body fat adversely effects cardiac function and uptake of oxygen by skeletal muscles [15].

The present study was conducted to evaluate the endurance capacity and cardio-respiratory responses in normal, obese and overweight female undergraduate students during different phases of menstrual cycle.

MATERIALS AND METHODS

The present experimental study was conducted at Department of Physiology, Saveetha Medical College, Saveetha University. The study was approved by the Scientific Review Board (SRB) and Institutional Ethical committee (IEC) (Number 027/03/2016/IEC/Su) of Saveetha University. Twenty normal weight, 20 obese and 20 over weight, unmarried, undergraduate female student volunteers between the age group of 18-22years, having regular 28+5days menstrual cycle for at least last 6months prior to the study, were recruited by convenient sampling after obtaining written, informed consent. The sample size was estimated for a mean difference of 12 and a standard deviation of 10 in each group of participants, with a power of 90% and significance level of 0.05. The estimated sample size was 19 for each group and round to 20. Sigma Plot 12.0 (SYSTAT Software, USA) was used to calculate the sample size.

Individuals with cardio-respiratory diseases, dysmennorhea, irregular menstrual cycles, polycystic ovarian diseases, infective diseases were excluded. Categorization of normal weight, over weight and obese was performed according to World Health Organisation (WHO) guidelines [16,17].

All the participants were instructed to come to the clinical lab of Department of Physiology, Saveetha Medical College, Chennai, during each of three different phases. Day-2 during menstrual phase, Day-7, during follicular phase and Day-22 during luteal phase and the following parameters were recorded.

Anthropometric measurements

Measurement of height was performed by using stadiometer (to nearest 1cm) with participant in erect posture against a vertical surface, and weight by using weighing machine to the nearest 1kg with subjects standing motionless, with feet about 15cm apart and weight equally distributed on each leg. Participants were instructed to wear light clothes (culturally appropriate) and not to wear shoes while measuring the body weight. BMI in kg/m^2 was calculated by Quetelet's index [18,19].

Recording of Blood pressure and pulse rate

Recording of Blood pressure and heart rate were done in a quiet room during which participants were sitting, awake and breathing normally. Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) and pulse rate were recorded in the left arm after 10 minute of rest using digital sphygmomanometer (Model No Ch-49, Citizen Company).

CARDIAC EFFICIENCY TEST

After explaining the procedure and familiarising the participants, they were instructed to perform exercise on bicycle ergometer (Viva fitness company KH -695) for 3minutes. The tension was adjusted at 2kg resistance. Blood pressure and pulse rate was recorded after 1st, 2nd, 3rd min after exercise [20]. Exercise efficiency was calculated by the formula.

$$\text{Exercise Efficiency (\%)} = \frac{\text{Duration of exercise in seconds}}{(1^{st}\text{min} + 2^{nd}\text{min} + 3^{rd}\text{min}) \text{ pulse rate after exercise}} \times 100$$

Respiratory efficiency tests

1. Peak Expiratory Flow Rate (PEFR): After a deep inspiration subject was asked to expire forcefully into the mouth piece of the Pulmo peak- Peak flow meter (manufactured by Medicare equipments (I) Pvt Ltd. Design no: 2100423) after adjusting the knob to zero level. Three successive trails were performed and the maximum value was recorded.

2. Expiratory blast test: The rubber tube of sphygmomanometer was disconnected from the mercury reservoir to the cuff. The participants were instructed take deep inspiration and to expire to the maximum into the mercury manometer of a sphygmomanometer to raise the mercury level as high level as possible. Three successive trials were performed and the maximum value was recorded [21].

3. Respiratory endurance tests: Participants were instructed to take maximum inspiration and to expire into the mercury manometer of a sphygmomanometer and raise the level up to 40mmHg and to maintain it as long as possible. Three successive trials were performed and the maximum value was recorded. The time (in seconds) that the participant could maintain the mercury level at 40mmHg was recorded [22].

STATISTICAL ANALYSIS

Statistical analysis was done using One-way Analysis Of Variance (ANOVA). Data is presented as mean± SD. The Student Newman Keul's multiple comparison tests was used to observe the significance of difference between the groups. The $p<0.05$ was considered as statistically significant.

RESULTS

[Table/Fig-1] presents the demographic characteristics of the participants which were not significantly different between the groups. [Table/Fig-2] shows that overall, exercise efficiency varied significantly during the different phases of the menstrual cycle with the highest during luteal phase and lowest during menstrual phase. Similar trend was observed in all the three weight sub-categories, but it was statistically significant in the normal and overweight category only. There is no significant difference in blast test during menstrual phase, follicular phase and luteal phase of menstrual

Variable	Overall (n=60)	Normal (n=20)	Overweight (n=20)	Obese (n=20)	p-value
Age (years)	19.55±0.946	19.55±1.1	19.6±0.995	19.5±0.76	0.947
Age at menarche (years)	13.08±0.696	13.05±0.95	13±0.65	13.2±0.41	0.647
Duration of cycle (days)	30.48±1.38	30.35±1.5	30.5±1.24	30.6±1.47	0.852

[Table/Fig-1]: Demographic characteristics of the participants. Values are given as mean ± SD.
(*p<0.05, **p<0.01, ***p<0.001) Statistical analysis was done using One-way Analysis Of Variance (ANOVA) followed by Student Newman Keul's multiple comparison tests.

Weight category	Phase	Mean	Std. Deviation	Friedman's test	p-value
Overall (n=60)	Menstrual	78.77	9.818	18.111	<0.001**
	Follicular	82.33	10.865		
	Luteal	92.08	14.254		
Normal (n=20)	Menstrual	76.2	10.7	23.27	<0.001***
	Follicular	76.95	8.93		
	Luteal	100.35	16.14		
Overweight (n=20)	Menstrual	79.2	8.99	6.462	0.04
	Follicular	87.9	9.31		
	Luteal	91.9	8.97		
Obese (n=20)	Menstrual	80.5	9.66	0.538	0.764
	Follicular	82.15	11.71		
	Luteal	84	12.22		

[Table/Fig-2]: Exercise efficiency of the participants across different phases of menstrual cycle. Values are given as mean ± SD.
(*p<0.05, **p<0.01,***p<0.001). Statistical analysis was done using One-way Analysis Of Variance (ANOVA) followed by Student Newman Keul's multiple comparison tests.

Phase	Weight category	Mean	Std. Deviation	F statistic	p-value
Menstrual	Normal	44	21.62	2.236	0.116
	Overweight	41.00	14.105		
	Obese	33.50	10.894		
Follicular	Normal	45.50	13.563	2.337	0.106
	Overweight	36.50	12.680		
	Obese	39.50	13.945		
Luteal	Normal	41.00	17.137	0.563	0.573
	Overweight	38.50	12.258		
	Obese	36.50	9.881		

[Table/Fig-3]: Respiratory efficiency across different weight categories within phases of menstrual cycle (respiratory blast test). Values are given as mean ± SD.
(*p<0.05, **p<0.01, ***p<0.001). Statistical analysis was done using One-way Analysis Of Variance (ANOVA) followed by Student Newman Keul's multiple comparison tests.

Phase	Weight category	Mean	Std. Deviation	F statistic	p-value
Menstrual	Normal	32	9.52	9.82	<0.001***
	Overweight	43.00	5.938		
	Obese	30.00	13.179		
Follicular	Normal	42.50	7.345	7.38	0.001
	Overweight	40.00	6.882		
	Obese	33.25	9.216		
Luteal	Normal	41.00	7.881	1.43	0.248
	Overweight	36.00	12.204		
	Obese	37.00	9.090		

[Table/Fig-4]: Respiratory efficiency across different weight categories within phases of menstrual cycle- endurance test. Values are given as mean ± SD.
(*p<0.05, **p<0.01, ***p<0.001). Statistical analysis was done using One-way Analysis Of Variance (ANOVA) follwed by Student Newman Keul's multiple comparison tests.

cycle among three groups of individuals. Overall the obese & overweight females had a decreased value for blast test compared to the normal individuals [Table/Fig-3]. Significant difference was observed in endurance test among follicular and luteal phase of normal females but there is no change in overweight and obese [Table/Fig-4]. Significant difference was observed in PEFR among luteal phase in normal and overweight individuals but there is no change in obese females. Overall obese individuals have a significant low PEFR compared to normal and overweight and obese individuals [Table/Fig-5].

Phase	Weight category	Mean	Std. Deviation	F statistic	p-value
Menstrual	Normal	311	42.17	0.367	0.694
	Overweight	302.50	37.819		
	Obese	298.50	58.784		
Follicular	Normal	335.50	50.625	0.363	0.698
	Overweight	326.50	48.262		
	Obese	323.00	44.615		
Luteal	Normal	356.00	45.929	3.217	0.047
	Overweight	326.00	50.304		
	Obese	308.60	77.983		

[Table/Fig-5]: Respiratory efficiency across different weight categories within phases of menstrual cycle- PEFR. Values are given as mean± SD.
(*p<0.05, **p<0.01, ***p<0.001). Statistical analysis was done using One-way Analysis Of Variance (ANOVA) followed by Student Newman Keul's multiple comparison tests.

DISCUSSION

The menstrual cycle is the second most important biological rhythm, created by the interplay between hypothalamus, hypophysis, and ovarian hormones. It is divided into three phases follicular, ovulatory and luteal based on ovarian function [23]. The three phases of menstrual cycle are influenced by the varying levels of the hormones oestrogen and progesterone. The follicular phase is characterised by increase in the oestrogen and progesterone level while in the ovulatory phase, an increase in the oestrogen level and decrease in progesterone level is observed. During the luteal phase, there is a consistent increase in the oestrogen and progesterone level [24]. Other than the reproductive functions, oestrogen and progesterone have multiple actions on body systems [25]. These have potential effects on exercise capacity and performance through mechanisms like substrate metabolism, cardio respiratory function, thermoregulation and psychological factors.

In the present study the exercise efficiency showed a significant increase in the luteal phase in the normal and overweight females but not in obese. It was reported that the ratio of oestrogen/progesterone was higher in luteal phase which may favour exercise performance [26]. Earlier studies have reported that women can perform better in endurance activities in their luteal phases of menstrual cycle, since they are able to increase fat metabolism and due to enhanced fat breakdown. Women are able to inhibit the use of glycogen and less lactate builds up in the muscle and therefore is able to sustain a relatively high intensity of exercise for longer duration. Studies have shown females to have an enhanced comfort level while doing exercise in luteal phase [27].

In the present study respiratory efficiency was assessed along with the exercise efficiency in three phases of menstrual cycle in normal, obese and overweight individuals. There was no significant difference observed in the blast test among the menstrual, follicular phase and luteal phase of the menstrual cycle. Overall the obese and overweight females had a decreased value for blast test compared to the normal individuals. There was significant increase in endurance test values in follicular and luteal phase of normal females but no change was observed in overweight and obese females. Earlier studies reported that the increase in expiratory resistance during follicular phase of the menstrual cycle is due to the changes in pulmonary system of females. The increased ventilation observed in luteal phase is related to high progesterone levels which bring about an increased inspiratory muscle endurance and bronchial smooth muscle relaxation [28]. Further enhanced levels of oestrogen increases free fatty acid availability and oxidative capacity in exercise, favouring endurance performance [29].

Conflicting reports exists on pulmonary functions in different phases of menstrual cycle [30]. There are reports of changes in pulmonary function in luteal phase of menstrual cycle, an increase in minute ventilation in luteal phase as compared to menstrual and follicular phases and that in luteal phase an increased progesterone secretion leads to hyperventilation [31]. Progesterone induces hyperventilation through both the central medullary and peripheral receptors. The respiratory response to progesterone is mediated at hypothalamic sites through an oestrogen (E2) dependent Progesterone Receptor (PR) mediated mechanism requiring RNA and protein synthesis. The neural mechanisms underlying the stimulation of respiration by progesterone are similar to those mediating its reproductive effects [32]. The low values of PEFR observed in the menstrual and follicular phase may be due to the reduced levels of progesterone causing an increase in the bronchial tone [33]. Significant increase was observed in PEFR in luteal phase among normal and overweight individuals but there is no change in PEFR in obese females. The increased levels of progesterone in luteal phase helps in relaxing bronchial smooth muscle which reduces the contraction of respiratory muscles which can account for the increased flow rate [33]. Overall obese individuals have a significant low PEFR compared to normal and overweight individuals. The significant increases in the cardio-respiratory efficiency observed in the luteal phase may be due to enhanced secretion of oestrogen and progesterone effect on these phases. In the present study, a significant increase in the cardio-respiratory efficiency was observed in normal individuals whereas a decrease in both exercise and respiratory efficiency was observed in overweight and obese individuals in menstrual, follicular, luteal phases of menstrual cycle. Obesity produces an increment in total blood volume and cardiac output that is caused in part by the increased metabolic demand induced by excess body weight. Hence the cardiac workload is greater in such persons irrespective of the level of activity [34]. It was reported that higher the BMI, lower the fitness as obese subjects have less fitness than normal [35]. In the present study we have observed similar results. The overall decrease in the fitness capacity in the overweight and obese individuals might be the cause for no significant change observed in the exercise efficiency and respiratory efficiency in overweight and obese female undergraduate students in the menstrual, follicular and luteal phases of menstrual cycle.

CONCLUSION

We have observed significant increase in cardiac and respiratory efficiency in the luteal phase of the menstrual cycle in normal weight individuals. Lower fitness levels were observed in overweight and obese females. Therefore practice of regular exercise and intake of healthy diet which help in reducing the weight and in turn the BMI will help in enhancing the physical fitness of the individuals.

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