Endurance Capacity and Cardiorespiratory Responses in Sedentary Females During Different Phases of Menstrual Cycle

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Citation

Bandyopadhyay A, Dalui R. Endurance Capacity and Cardiorespiratory Responses in Sedentary Females during Different Phases of Menstrual Cycle. *Kathmandu Univ Med J* 2012;10(4):25-29.

ABSTRACT

Background

Alteration in physical work capacity of females during different phases of menstrual cycle has been reported in different populations. Pertinent data is unavailable in Eastern Indian population.

Objectives

The present study was aimed to determine the endurance capacity and cardiorespiratory responses during different phases of menstrual cycle in young sedentary females of Eastern region of India.

Methods

Forty five unmarried young healthy sedentary females (21–25 years) were recruited in the present investigation. Duration of their menstrual cycle was 28–30 days. Cardiorespiratory parameters including the endurance capacity was determined by treadmill running with constant monitoring of heart rate by Polar heart rate monitor.

Results

The pre-exercise heart rate was significantly higher ($P<0.02$) in the luteal phase. The peak heart rate was significantly lower ($P<0.02$) in the flow phase than the follicular and luteal phases. VO_{2max}, O_2 pulse, maximum pulmonary ventilation and endurance capacity were significantly lower in the follicular phase. However, the endurance capacity was significantly lower in the flow phase. Pre-exercise systolic and diastolic blood pressure did not exhibit any significant variation in different phases of menstrual cycle.

Conclusion

Therefore, from the present observations it may be concluded that pre-exercise heart rate and respiratory rate are significantly higher in the luteal phase whereas VO_{2max}, O_2 pulse, maximum pulmonary ventilation, endurance capacity and peak heart rate were significantly lower in the follicular phase.

KEY WORDS

Endurance capacity, VO_{2max}, pulmonary ventilation, menstrual cycle

INTRODUCTION

Physical exercise is associated with increase in the rate and depth of ventilation along with an increase in the heart rate, stroke volume and cardiac output to meet the excess metabolic demand of the exercise. Cardiorepsiratory responses to exercise have been studied in female athletes and sedentary women.[1-4] Ability to perform strenuous physical exercise largely depend on the cardiorespirstory efficiency to take up, transport and give off oxygen for its utilization.[5,6] Moreover, many literatures depicted that the body composition of an individual deals largely with the physical performance level since the lean body mass plays the role of energy supplier during strenuous physical activity.[7-10] Moreover, the selection of ergometer is another important aspect to conclude the performance ability of an individual since different ergometers involve different body musculature.[11]

The increasing participation of women in competitive sports has drawn attention of scientists to understand effect of menstrual cycle on athletic performance.[12] Researches indicated contradictory findings regarding changes in physical work capacity of females during different phases of their menstrual cycle. Pulmonary ventilation increases significantly during the luteal phase whereas cardiorespiratory fitness and peak heart rate were highest in the post-menstrual phase and lowest during the flow phase.[13,14] However, contradictory findings indicated that cardiorespiratory fitness did not alter in different phases of menstrual cycle.[15,16] Many studies suggested that different phases of menstrual cycle do not affect the physical performance.[17-20] While others reported significant impact of different phases of menstrual cycle on the determinants of exercise performance, such as lactate response to exercise, body weight, plasma volume, haemoglobin concentration, heart rate and pulmonary ventilation.[21-23]

The endocrine profile of female hormones is cyclical during their sexual cycles. It is necessary to enquire into the role of such cyclical endocrine profile in maintaining psychic and physical harmony to extract optimum work. A study was conducted in 40 South Indian females to evaluate their physical work capacity during different phases of menstrual cycle.[12] Pertinent studies in Eastern Indian females are unavailable with special reference to the impact of body composition on physical work capacity. The present study was therefore conducted to evaluate the endurance capacity and cardiorespiratory responses in sedentary females of Eastern Region of India during different phases of menstrual cycle.

METHODS

Forty five unmarried healthy sedentary females of 21 to 25 years of age with similar socio-economic background were selected from the post-graduate section of the University of Calcutta, Kolkata, India. All of them were non-smokers and had normal duration of menstrual cycle (28–30 days). They were not under any medication during the study period. Age of each subject was calculated from the date of birth as recorded in the University Register. Body height and body mass were measured with standard instrument with an accuracy of $\pm$0.5 cm in case of body height and $\pm$0.25 kg in case of body mass. The basal body temperature was regularly monitored to predict the ovulation that was indicated by a minimum temperature rise of 0.4 to 0.6^{0}F.[19] Subjects reported in the laboratory at 9 am on the days of evaluation after a light breakfast. They were asked to refrain from any energetic activity on that day. They took complete rest on an easy chair for half an hour so that cardiopulmonary parameters could reach a steady state.[20] A heart rate monitor was secured on the chest surface of the subject for constant monitoring of heart rate. The pre-exercise blood pressure was also measured.

The entire experimental protocol was explained to them to allay their apprehension. Ethical permission and written informed consent from each participant were taken for conducting the study.

Experimental protocol was repeated during each phase of one's same menstrual cycle to find out the variation in the studied parameters in different phases of menstrual cycle. The days for experimental trial during different phases of the menstrual cycle were selected according to Doskin VA et al.[18]

- 3rd day of the menstrual cycle (for evaluation in Flow phase)
- 10th day of the menstrual cycle (for evaluation in Follicular phase)
- Between 20th and 24th day of the menstrual cycle (for evaluation in Luteal phase)

Prediction of VO_{2max} [24]

Queen's College step test was performed to predict the VO_{2max}.

Determination of Endurance capacity

Work-load selection

After an initial warm-up of five min at a speed of 3 km hr^{-1}, exercise consisted of treadmill running at a heart rate of 135–140 beats min^{-1}. This heart rate was chosen as an estimate of 70% of maximal age predicted heart rate or HRmax. The corresponding treadmill speed was 8–10 km/h^{-1} without any inclination or slope. Subject was considered exhausted when severe signs of exhaustion were supervened and she could no longer continue the exercise in spite of decreasing the speed of the treadmill.

Determination of Maximum Pulmonary Ventilation

Low resistance high velocity Collin's triple ''J type'' plastic valve was used for the collection of gas by open circuit method.[23] The valve was connected with the Douglas

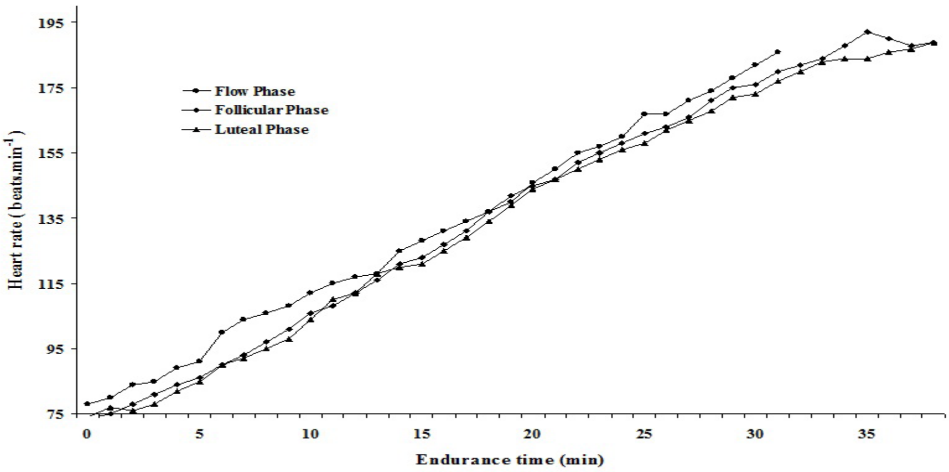

Figure 1. Changes in heart rate during endurance exercise in different phases of menstrual cycle.

Bag (150 l) by a standard corrugated rubber tube and the expired gas was collected in the last minute of the endurance exercise. The expired gas was measured in a wet gasometer (Toshniwal, Cat No CG 05.10) to determine the maximum pulmonary ventilation.

All the data have been presented as mean±SD. Analysis of variance (ANOVA) was used to compare the difference between means observed in different phases of menstrual cycle.

The entire experiment was conducted at a room temperature varying from 30–34^{0}C and the relative humidity ranging between 67–70%.

RESULTS

The mean of age, body weight and body height of the subjects were 23.4 ±2.45 years, 55.26±3.28 kg and 163.01 ±4.34 cm, respectively. Pre-exercise heart rate, respiratory rate, systolic and diastolic blood pressure, VO_{2max}, O_2 pulse, maximum pulmonary ventilation, endurance capacity and peak heart rate of the subjects are presented in table 1. The pre-exercise heart rate was significantly higher (P<0.02) in the luteal phase. The peak heart rate was significantly lower (P<0.02) in the flow phase than the follicular and luteal phases. VO_{2max}, O_2 pulse, maximum pulmonary ventilation and endurance capacity were significantly lower in the follicular phase. Working heart rates recorded in each min during endurance exercise in different phases of menstrual cycle were represented in fig 1.

Table 1.Cardiorespiratory parameters of the subjects in different phases of menstrual cycle.

Menstrual phases	Flow Phase	Follicular Phase	Luteal Phase
Pre-Exercise Heart Rate (beats.min-1)	75.00±4.1	72.64±3.9	78.87±4.3*
Systolic blood pressure (mm of Hg)	114±6.0	112±6.4	110±7.0
Diastolic blood pressure (mm of Hg)	80±6.0	78±6.4	76±7.0
Respiratory rate	18.69±2.19	18.06±2.57	20.51±2.40**
VO2max (mL.kg-1.min-1)	36.87±2.9 **	39.95±2.4	39.64±2.4
Maximum Pulmonary Ventilation (L.min-1)	50.75±5.4 *	58.05±5.3	58.31±4.4
O2 Pulse (mL.beat-1)	8.89±0.9 **	9.60±0.80	9.41±0.8
Endurance capacity (min)	31.3±1.0 **	38.0±1.0	37.8±0.9
Peak Heart Rate (beats.min-1)	185.80±2.8 *	188.87±3.6	188.73±3.1

Values are mean ± SD; *P<0.02, **P<0.001

DISCUSSION

There is a conceptual fact that the cardiac output is proportionate to the VO2max.[25,26] The maximum stroke volume is achieved at an oxygen consumption of 40% of VO_{2max} and mean pulse rate of 110/min.[27] Therefore the further increase in cardiac output with increase in workloads is solely attributed to the increase in heart rate that is limited to 170–180 beats.min^{-1} beyond which the diastolic period decreases leading to less filling of the heart.[27] So pulse rate is an estimate of the limit to which cardiac output can be increased.[12]

VO_{2max} has been globally accepted as the determinant of maximal performance capacity and it is primarily controlled by cardiovascular transport rather than pulmonary capacity since cardiovascular adjustment plays the chief role in oxygen transport.[28] Linear relationship among pulse rate, cardiac output and maximum oxygen consumption is also established.[26,27]

On the basis of these principles Wahlund proposed the concept of PWC_{170} which was later modified by Watson and Donovan.[23, 25,29] But, procedure for determination of PWC_{170} involves bicycle exercise that does not involve the whole body musculature. Considering this fact, to involve the activity of entire body musculature, in the present study the exercise in treadmill has been preferred.

Endurance capacity, O_2 pulse, peak heart rate, VO_{2max} and maximum voluntary ventilation were significantly lower in the luteal phase although these parameters did not show any significant difference between the exercise trials in follicular and flow phases (table 1). Similar findings are evident in case of working heart rates during the different phases of menstrual cycle (Fig 1). Pre-exercise heart rate was significantly higher (P<0.02) in the flow phase. Such increase in resting heart rate during luteal phase was probably because of increased sympathetic activity resulted from inflated cardiovascular response to hormonal changes.[18] The preliminary links in the O_2 transport chain are cardiovascular and respiratory system. Increased pre-exercise respiratory rate during luteal phase might be attributed to increased progesterone induced enhancement in sensitivity of respiratory centers to CO_2 during endurance exercise.[12,30] The decreased mechanical efficiency of the respiratory system due to this leads to increased O_2 consumption by respiratory muscles themselves, leading to a point nearer to critical ventilation.[31] This might be the cause of higher value of pulmonary ventilation during the luteal phase.

Elevated sympathetic activity during luteal phase intensifies the increment in HR during exercise that in turn reduces the cardiac output.[17] Existence of higher heart rate and respiratory rate during luteal phase may be due to the fact that aerobic capacity or work done is directly proportional to the cardiac output that is met with the exaggerated HR and RR responses to exercise stimulus through sympathetic activity.[17] Thus the cardiovascular system and respiratory system are the links in limiting O_2 transport during luteal phase and that might be the cause of existence of highest value of VO_{2max} in the luteal phase.

The endurance capacity was significantly lower in the flow phase as also reported in terms of PWC_{170} in Japanese, Western and Indian population from other provinces.[17,18,32,33] However the findings were contradictory to the findings of Doolittle et.al.[34,35]

Various psychophysiological factors are also responsible for altered exercise performance during different phases of menstrual cycle. Neurological constituents which acquire somatic manifestations are the psychic factors whereas fluid retention in the muscles is physiological factors which cause pain, discomfort and decreased muscular contraction.[33,36] According to Girija B et al Indian social perspectives are also to some extent act as a stigma to menstruating women and this may also be considered as a factor to decrease the performance.[12] They also hypothesized that estimation of female sex hormones during different phases and its correlation to working capacity may reveal more facts.

The present observations corroborated with the earlier studies in Indians, Japanese and Western populations.[17,32,33,36] However, the pre-exercise systolic and diastolic blood pressure did not exhibit any significant variation in different phases of menstrual cycle.

CONCLUSION

Therefore, from the present observations it may be concluded that pre-exercise heart rate and respiratory rate are significantly higher in the luteal phase although systolic blood pressure, diastolic blood pressure and working heart rates did not change during different phases of menstrual cycle. On the other hand, VO_{2max}, O_2 pulse, maximum pulmonary ventilation, endurance capacity and peak heart rate were significantly lower in the follicular phase.

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