Original Article

Effect of female sex hormones on cardiorespiratory parameters

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Abstract

Introduction: Female sex hormones, estrogen and progesterone regulate various phases of the menstrual cycle. Hormonal changes tend to affect various parameters of physical fitness. Maximum oxygen uptake (VO_2 max) is a measure of aerobic power. This study was planned to assess effect of different phases of menstrual cycle on cardiorespiratory parameters like pulse rate, respiratory rate and VO_2 max. **Methods:** 100 female medical students in the age group of 17-22 years were studied for three consecutive menstrual cycles. Weight, resting pulse rate, respiratory rate and VO_2 max were measured during premenstrual phase (20^{th}-25^{th} day) and postmenstrual phase (5^{th} to 10^{th} day). **Results:** It was observed that there was a significant increase in body weight, pulse rate, and respiratory rate during premenstrual phase. There was a decrease in VO_2 max during the premenstrual phase. **Conclusion:** This study indicates that there is decreased cardio-respiratory efficiency during premenstrual phase.

Keywords: Menstrual cycle, VO_2 max, weight, pulse rate and respiratory rate

Introduction

In females, reproductive cycles are one of the most important biological rhythms. As a result, from menarche to menopause, she is exposed to cyclical changes of endogenous sex hormones, i.e., estrogen and progesterone. These hormones regulate various phases of the menstrual cycle. Postmenstrual phase is estrogen dependent, and premenstrual phase is progesterone dependent. Estrogen and progesterone, in turn, are regulated by a complex feedback system of pituitary hormones and hypothalamus.

Hormonal changes during menstrual cycle tend to affect various parameters of physical fitness. They affect the metabolism of energy substrate, body water, and electrolyte homeostasis. Thermoregulation and minute ventilation are also affected.[1] Some researchers have also recorded changes in vital parameters such as pulse rate and respiratory rate during different phases of menstrual cycle.[2] All these parameters do affect physical fitness status of the female. Maximum oxygen uptake (VO_2 max) which is a measure of aerobic power refers to the maximum amount of oxygen that can be utilized in 1 min during intense or submaximal exercise. It is considered to be the most reliable indicator of cardiorespiratory efficiency.[3]

As over the past number of decades, there has been an increase in female participation in all fields including sports and laborious work. Therefore, a lot of scientific research is going on to study female performance in various phases of the menstrual cycle. However, results of these studies are not uniform. Effect of intense training on menstrual cycle has been extensively studied, but the relationship between phases of the menstrual cycle and many types of physical performances is still unclear. Previous studies have shown inconsistent results on VO_2 max during different phases of menstrual cycle. Some studies were not able to detect any significant difference in VO_2 max,[4] whereas others have shown difference in VO_2 max in different phases of menstrual cycle.[5] Therefore, this study was planned to assess effect of different phases of menstrual cycle on

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cardiorespiratory parameters such as pulse rate, respiratory rate, and VO_2 max.

Subjects and Methods

The present study was a cross-sectional study. Participants were 100 female medical students in the age group of 17–22 years. The Institutional Ethical Committee approval was obtained for the study.

Female medical students having regular menstrual cycle (24–35 days) were included in the study. Females with irregular menstrual cycles, those having any systemic disease, and those undergoing hormone therapies were excluded from the study.

Weight, resting pulse rate, respiratory rate, and VO_2 max were measured during premenstrual phase (20^{th}–25^{th} day) and postmenstrual phase (5^{th}–10^{th} day) for consecutive three cycles. All parameters were recorded at 8.30 a.m. before breakfast.

After recording resting pulse rate and respiratory rate, VO_2 max was measured by Queen's College step test as follows.

- Participants were asked to step up and down on a bench of 33 cm height at a rate 22 steps/min. This exercise was continued for 3 min. Five seconds after stopping exercise, pulse rate was measured for 15 s and was computed for 1 min (postexercise pulse rate), and with the help of the following formula, VO_2 max was calculated:[6]
  VO_2 max (ml/kg/min) = 65.81− (0.1847 × postexercise pulse rate)
- All parameters were recorded for three cycles. Average readings of the three cycles were taken for statistical analysis.

Results were statistically analyzed using Student's paired *t*-test.

Results

Table 1 shows weight, pulse rate, and respiratory rate during pre- and post-menstrual phase in the study group. It was observed that there was an increase in body weight, resting pulse rate, and respiratory rate during premenstrual phase. These changes are statistically significant.

As seen in Table 2, it was observed that VO_2 max was significantly less in premenstrual phase.

Discussion

Table 1 shows weight, pulse rate, and respiratory rate values during pre- and post-menstrual phases in the study group. It was observed that there was a significant increase in body weight, pulse rate, and respiratory rate during premenstrual phase.

Table 1: Comparison of weight, resting pulse rate and respiratory rate in premenstrual and postmenstrual phase in study group

Parameter (*n*=100)	Premenstrual Phase	Postmenstrual Phase	*t* Value	*P* Value
Weight in kgs (Mean±SD)	56.09±10.10	55.40±10.24	4.25	<0.001*
Resting pulse rate per min (Mean±SD)	80.77±4.82	78.16±5.26	4.71	<0.001*
Respiratory rate per min (Mean±SD)	18.60±1.84	17.97±1.79	2.95	<0.01*

* Statistically significant

Table 2: Comparison of VO_2 max in premenstrual and postmenstrual phase in study group

Parameter (*n*=100)	Premenstrual Phase	Postmenstrual Phase	*t* Value	*P* Value
VO_2 max in ml/kg/min. (Mean±SD)	36.05±1.76	38.08±1.75	15.28	<0.0001*

* Statistically significant

Increase in circulating blood volume due to fluid retention and thermogenic action of progesterone after ovulation could be the reason for increase in pulse rate during premenstrual phase. Similar findings were noted by Christina *et al.*[7] and Olayaki *et al.*[8] However, Hirshoren *et al.*[9] have found no effect of the sex hormones on the heart rate in different phases of the menstrual cycle.

Increase in respiratory rate during premenstrual phase could be due to progesterone as it stimulates respiration by acting on respiratory centers and also through peripheral chemoreceptors. Similar results were observed by Sunyal *et al.*[10] and Bandyopadhyay and Dalui.[11] Bayliss *et al.*[12] have reported that this action of progesterone is mediated through steroid receptors in the central nervous system.

In the present study, we have found that values of maximum oxygen consumption (VO_2 max) in premenstrual phase were decreased as compared to postmenstrual phase [Table 1].

Redman *et al.*[13] studied the effects of synthetic progestins on the fitness status of young sedentary women. There was a significant effect on exercise status in different phases of menstrual cycle possibly through an effect on stroke volume and a shift in the principal energy substrate used during exercise from carbohydrate to lipid.

In the present study, our findings are similar to the study conducted by Lebrun *et al.*[14] They have also found that there was a decrease in VO_2 max in premenstrual phase compared to postmenstrual phase. Girija and Veeraiah have also documented similar results.[2] Postmenstrual phase is estrogen dependent, and premenstrual phase is progesterone dependent. We have obtained

readings showing better oxygen consumption in postmenstrual phase which indicates that estrogen has some favorable effect on oxygen consumption and progesterone must be having some unfavorable effect on the same. Probably estrogen-progesterone ratio must be an important factor deciding maximum oxygen consumption. Progesterone causes more fluid retention on its own. It also activates renin-angiotensin system,[15] thereby increasing plasma volume and leading to hemodilution. Thus, it probably decreases oxygen carrying capacity and therefore must be responsible for decrease in oxygen consumption by muscles. Increased plasma volume brought about by progesterone can increase load on heart temporarily and can reduce its performance.

Progesterone increases minute ventilation. The seat of action of progesterone is thought to be either on respiratory centers or on peripheral chemoreceptors or a combination of both.[10] This may result in more consumption of energy by respiratory muscles that are otherwise available for other muscular activities. Increased minute ventilation may give greater feeling of breathlessness to the individual which may reduce exercise performance.[16]

In short, our study showed that in the premenstrual phase, there is a gain in body weight, increase in pulse rate, and increase in respiratory rate. It was also observed that during the premenstrual phase, there is a decrease in VO_2 max. All these results indicate that there is decreased cardiorespiratory efficiency during the premenstrual phase. However, there are no studies showing the effect of estrogen and progesterone on muscle blood flow and oxygen utilization by muscles *in vivo* or *in vitro* directly. Such studies may confirm our findings.

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Conflicts of interest

There are no conflicts of interest.

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