

ORIGINAL ARTICLE

Effects of Vitamin-E Supplementation on Cardiorespiratory Responses in Female Athletes during Endurance Exercise in Different Phases of Menstrual Cycle

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Abstract: *Background:* Ability to perform strenuous physical work is largely dependent on the efficiency of cardiorespiratory system to take up, transport and give off oxygen for its utilization by the working muscles. Cardiorespiratory responses to exercise and alteration in physical work capacity of females during different phases of menstrual cycle have been reported. It is well established that Vitamin E (Vit-E) supplementation improves aerobic performance due to its antioxidant nature. *Objectives:* The present study was aimed to determine the effects of Vit-E supplementation on cardiorespiratory responses during endurance exercise in different phases of menstrual cycle in female athletes. *Methods:* Twenty five unmarried adult female athletes (21–25 years) were recruited in this placebo-control double-blind randomized experimental trial. Their average duration of menstrual cycle was 28–32 days. Vit-E was supplemented at a dose of 400mg.day⁻¹ for 7 days. *Results:* The pre-exercise heart rate and peak heart rate were significantly higher in the flow phase than the follicular and luteal phases during pre and post-supplemental trials. The post-supplementation values of maximum oxygen uptake (VO₂max), O₂ pulse, maximum pulmonary ventilation and endurance capacity were significantly (P<0.001) higher than the pre-supplementation values in all the phases of menstrual cycle. As far as the comparison of these parameters between the different phases of menstrual cycle is concerned, all these parameters were significantly different in the flow phase than their corresponding values in the follicular and luteal phases. From the present investigation it is concluded that Vit-E supplementation at a dose of 400 mg.day⁻¹ for 7 days significantly improved the VO₂max, maximum voluntary ventilation, O₂ pulse and endurance capacity in female athletes during different phases of menstrual cycle. *Conclusion:* Therefore, such supplementation may be recommended to improve the endurance performance of female athletes.

Keywords: Vit-E, VO₂max, O₂ pulse, 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. The cardiorespiratory fitness of an individual is represented by the maximum oxygen uptake or VO₂max [1] that is directly proportional to oxygen content of the arterial blood. Cardiorespiratory responses to exercise have been studied in female athletes and sedentary women [2-5]. Ability to perform strenuous physical exercise largely depend on the cardiorespiratory efficiency to take up, transport and give off oxygen for its utilization [6-7].

Endurance capacity that refers to an individual's capacity to do prolonged work at any given intensity, is an indicator of the locus of points of the endurance time (min) versus work intensity [8]. Individuals with higher VO₂max have the capacity to excel better in the endurance activities including the athletic events [9]. Researches indicated the alteration in physical work capacity of females during different phases of their menstrual cycle. Pulmonary ventilation increases significantly during the luteal phase whereas VO₂max and peak heart rate were highest in the post-menstrual phase and lowest during the flow phase [10-11]. However, contradictory findings indicated that VO₂max did not alter in different phases of menstrual cycle [12-13]. Majority of researches reported no changes over the menstrual cycle for the many determinants of VO₂max, such as lactate response to exercise, body weight, plasma volume, haemoglobin concentration, heart rate and ventilation [14].

It is well known fact that Vit-E is a natural antioxidant that improved the VO₂max by 9% [15] with significant correlation with circulating level of Vit-E [16]. Research suggests that Vit-E has influential role not only on aerobic parameters but also on anaerobic capacity, isokinetic strength and high intensity endurance [17]. Increased cellular concentration of Vit-E imposes greater antioxidant effect that reduces the risks of cellular injury to improve performance and delays muscle fatigue [18]. Therefore, it is logical to evaluate different cardiorespiratory parameters in female athletes during different phases of menstrual cycle with special emphasis on effects of Vit-E supplementation that is expected to play influential role in aerobic energy supply. The present study was therefore aimed to evaluate the effects of Vit-E supplementation on cardiorespiratory responses in female athletes during endurance exercise in different phases of menstrual cycle.

Material and Methods

Preparation of Subjects: Twenty five (25) unmarried normal healthy female endurance athletes of 21 to 25 years of age with similar socio-economic background were selected from different sports academies in Kolkata, India. All of them were non-smokers and had normal duration of menstrual cycle (28 – 32 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 their institute. Body height and body mass were measured with standard instrument with an accuracy of ± 0.5 cm in case of body height and ± 0.25 kg in case of body mass. 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: The present study was conducted in a self-control double-blind randomized trial. Experimental protocol was repeated during each phase of one's menstrual cycle to find out the variation in the studied parameters in different phases of menstrual cycle. Subjects reported in the laboratory early in the morning of the following days in fasting condition.

- 2nd day of the menstrual cycle (for evaluation in Flow phase)
- 10th day of the menstrual cycle (for evaluation in Follicular phase)
- 22nd day of the menstrual cycle (for evaluation in Luteal phase)

Since the subjects had normal range of menstrual cycle duration, we collected the data of different menstrual phases on the above mentioned days. Biochemical measurement of hormonal level to point out the different phases of menstrual cycle could not be undertaken due to lack of infrastructure and paucity of finance. Instead, the basal body temperature was regularly monitored to predict the ovulation that was indicated by a minimum temperature rise of 0.4 to 0.6⁰F [19]. Subjects reported in the laboratory at 9am 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]. After recording the pre-exercise heart rate, subject's endurance capacity or VO₂max was measured. The VO₂max and endurance capacity could not be measured on the same day because the subject had to sustain excessive work-load in both the protocols. Hence, the measurements of VO₂max and endurance capacity for a particular menstrual phase were measured in the same day of the menstrual phase but in the consecutive menstrual cycles. For the post-supplemental evaluation, each subject was asked to ingest the supplied Vit-E capsules at a single dose of 400mg.day⁻¹ for 7 days (prior to the above mentioned corresponding days in a particular menstrual phase). After finishing the 7 days of supplementation period, the subject reported to the laboratory in the morning of the 8th day and the similar experiments were conducted. Post-supplemental data for each phase were collected in separate menstrual cycle.

Measurement of Endurance Capacity: The exercise was conducted on a Muller's magnetic brake bicycle ergometer (Model of Max Plank Institute of Ergology, Germany). After an initial warm-up of 5min at a workload of 450 kgm.min⁻¹, the workload for the endurance trial was set at 750 kgm.min⁻¹ with a constant pedalling rate of 60 rpm.min⁻¹ that was maintained with the help of a metronome. The peak heart rate was recorded manually from the time taken for 10 carotid pulsations immediately following the cessation of exhaustive exercise [20]. Subject was considered exhausted when the peak heart rate was greater than 180 beats.min⁻¹ as well as the subject could no longer maintain the cadence of pedalling exercise due to severe exhaustion.

Measurement of Maximum Oxygen Uptake or VO₂max [21]. VO₂max was measured by an incremental bicycle exercise. After an initial warm up at 450 kgm.min⁻¹ for 5 minutes, the first incremental work load (750 kgm.min⁻¹) was set. Thereafter the intensity was increased by 100 kgm.min⁻¹ every 3 min until the subject stopped due to exhaustion. The criteria to attain VO₂max were set according to ACSM [22].

The expired gas was collected by open circuit method with the help of low resistance high velocity Collin's Triple "J Type" plastic valve that was connected with the Douglas Bag (150 L). The expired gas was collected at the last minute of the exhaustive (final) workload. The volume of expired gas was measured in a wet gasometer (Toshniwal, Germany, CAT. No. CG05.10) and the aliquots of gas samples were analyzed in Scholander micro-gas analyser according to Consolazio [23]. The peak heart rate was recorded manually from the time taken for 10 carotid pulsations immediately following the cessation of exhaustive exercise.

Statistical Analysis: 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. Student's t-test was performed to compare between the pre- and post-trial values in the same phase of menstrual cycle.

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

Results

The mean of age, body weight and body height of the subjects were 23.2 ±2.86 years, 54.0 ±2.7 kg and 162.2 ±2.6cm, respectively.

Menstrual phases		Follicular Phase	Luteal Phase	Flow Phase
Pre-Exercise Heart Rate (beats.min ⁻¹)	BS	63.67±3.9	64.00±4.3	67.93±4.1 ##
	AS	63.13±3.8	64.07±4.1	68.40±4.4 ###
VO ₂ max (mL.kg ⁻¹ .min ⁻¹)	BS	43.95±2.6	43.64±2.6	40.87±2.4 ####
	AS	49.61±2.4 *	48.90±2.9 *	46.80±2.5 * ##
Maximum Pulmonary Ventilation (L.min ⁻¹)	BS	56.05±5.3	56.31±4.4	52.75±5.4 ##
	AS	60.36±5.3 *	60.46±4.5 *	57.50±5.0 * ##
O ₂ Pulse (mL.beat ⁻¹)	BS	9.60±0.80	9.41±0.8	8.89±0.9 #####
	AS	10.92±1.10 *	10.70±1.0 *	10.48±0.8 * ###
Endurance capacity (min)	BS	35.0±1.0	34.8±0.9	32.3±1.0 #####
	AS	40.9±1.3 *	40.6±1.3 *	39.4±1.1 * ###
Peak Heart Rate (beats.min ⁻¹)	BS	188.87±3.6	188.73±3.1	185.80±2.8 ###
	AS	188.33±3.1	188.20±2.1	186.00±3.4 ###
Values are mean ± SD. BS = Before supplementation, AS = After Supplementation *P<0.001 when compared between pre and post-supplementation values in the same menstrual phase; #P<0.05, ##P<0.02, ###P<0.01, ####P<0.001 when compared between the values in different menstrual phases either in the pre or in the post- supplemental phase.				

Pre-exercise heart rate, VO₂max, O₂ 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 in the flow phase than the follicular and luteal phases during pre and post-supplemental trials. The peak heart rate was significantly lower in the flow phase than the follicular and luteal phases during pre and post-supplemental trials.

The post-supplementation values of VO₂max, O₂ pulse, maximum pulmonary ventilation and endurance capacity were significantly (P<0.001) higher in all the phases of menstrual cycle. This indicated the beneficial effect of Vit-E supplementation on the said parameters. As far as the comparison of these parameters between the different phases of menstrual cycle is concerned, all these parameters were significantly different in the flow phase than their corresponding values in the follicular and luteal phases.

Discussion

The present study revealed the effects of Vit-E supplementation on cardiorespiratory responses in different phases of menstrual cycle of female athletes. All the subjects were selected from similar environmental habitat and socio-economic background.

The study indicated that Vit-E supplementation significantly ($P < 0.001$) enhanced the $VO_2\text{max}$ during all the phases of menstrual cycle. The $VO_2\text{max}$ depicted significantly ($P < 0.001$) lower value in the flow phase than the other phases of menstrual cycle in the pre- and post-supplemental periods. The present observations are in agreement with Cureton [24] and Cureton [15] who reported 9% increase in $VO_2\text{max}$ following oral supplementation of Vit-E. Battino et al. [16] postulated that people with a higher aerobic capacity have lower circulating level of antioxidants. Jourkesh et al. [25] concluded that daily consumption of vitamin E, vitamin C, and a combination of vitamin E and vitamin C for a period of 3 weeks significantly improved aerobic power. Athletes are encouraged to include antioxidants, such as vitamin E and C, in their diet to counteract these detrimental effects of exercise. Bryant et al. [26] contradicted that 400 IU/day of vitamin E will provide adequate protection but supplementing the diet with 1 g per day of vitamin C may promote cellular damage. However neither of these vitamins, either alone or in combination, could enhance exercise performance. Beaton et al. [27] also concluded that vitamin E supplementation (30 d at 1200 IU-d-1), which resulted in a 2.8-fold higher serum vitamin E concentration ($P < 0.01$), had no effect on indices of contraction-induced muscle damage nor inflammation (macrophage infiltration) as a result of eccentrically biased muscle contractions. In the review of Takanami et al. [28] it has been mentioned that although there are few exceptions, the majority of recent well controlled studies on the subject have reported no significant effects of vitamin E supplementation on physical performance.

Exercise induced increased production of oxygen free radicals leads to an increase in mitochondrial oxygen consumption and electron transport flux that induce oxidative stress and damage in exercising muscles [29-30]. Koska et al. [31] exhibited a significant positive correlation between malondialdehyde and $VO_2\text{max}$, while red blood cell glutathione peroxidase had significant negative correlation with $VO_2\text{max}$ in elderly women. This depicts a relation of oxidative stress and antioxidant defence system to $VO_2\text{max}$ and physical activity in [31].

The maximum pulmonary ventilation was also significantly increased ($P < 0.001$) following Vit-E supplementation in all the phases of menstrual cycle. It was significantly ($P < 0.001$) lower in the flow phase than the other phases of menstrual cycle during pre- and post-supplemental trials. The oxygen pulse was significantly increased ($P < 0.001$) following Vit-E supplementation in all the phases of menstrual cycle. Comparison among the different phases of menstrual cycle, depicted that oxygen pulse was significantly ($P < 0.001$) lower in the flow phase than the other phases of menstrual cycle during pre- and post-supplemental trials. Reddy et al. [32] indicated the effectiveness of dietary supplementation of Vit-E in combating the exercise induced oxidative stress in the pulmonary tissue and that might have helped

to improve the maximum pulmonary ventilation and oxygen pulse in the present study following chronic supplementation of Vit-E. Xanne and de Jonge [14] described that although pulmonary ventilation may be increased during the mid-luteal phase.

The study indicated that Vit-E supplementation significantly ($P < 0.001$) improved the endurance capacity during all the three phases of menstrual cycle. However, comparison among different phases of menstrual cycle in the pre- and post-supplemental trials indicated significantly lower value of endurance capacity in the flow phase. Chatterjee and Bagri [33] showed a permissive role of Vit-E in enhancing the endurance capacity by overcoming the deleterious effects of oxidative damage.

The pre-exercise heart rate was significantly lower in the follicular phase, whereas peak heart rate was significantly ($P < 0.01$) lower in the luteal phase in both (pre- and post-supplemental) the trials. However, Vit-E supplementation did not influence the pre-exercise and peak heart rates in the studied population.

From the preset investigation it is concluded that Vit-E supplementation (at a dose of $400 \text{ mg}\cdot\text{day}^{-1}$ for 7 days) significantly improves the $\text{VO}_{2\text{max}}$, maximum voluntary ventilation, oxygen pulse and endurance capacity in female endurance athletes at different phases of menstrual cycle. Therefore, such supplementation may be recommended to improve the endurance performance in the identical population.

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