

**Original article:**

**Study of physical performance capacity during phases of menstruation in young female athletes**

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**Abstract**

**Context:** The study of fluctuations in athletic performance attributable to the menstrual cycle has been an area of considerable interest and controversy for well over half a century. Hence, the present study was done to evaluate the Physical performance capacity during phases of menstruation in young female athletes. The present study was done to evaluate the Physical performance capacity during phases of menstruation in young female athletes.

**Settings and Design:** The present study was a cross-sectional study consisting of 30 female healthy athletes of 17-20 years of age.

**Materials and Methods:** This study was conducted in the Department of Physiology, Mysore medical college and research institute, Mysore, after the institutional ethical clearance and written consent from each participant. Physical performance capacity was measured using Harvard step test. Physical fitness parameters to assess the Physical performance capacity like Physical fitness index (PFI) and VO<sub>2</sub> max (maximum oxygen uptake) were measured during all the three phases of menstrual cycle.

**Results:** The parameters were analyzed for statistical significance using Students 't' test and p<0.05 was considered the level of significance. There was no significant changes in Physical Fitness Index (PFI) and VO<sub>2</sub> max during all the phases of menstrual cycle.

**Conclusions:** This study showed that female athletes competing in strength specific sports need not adjust to menstrual cycle phase to maximize performance and they can participate in sports events during all the phases of menstrual cycle.

**Keywords:** Physical performance capacity, Physical fitness index (PFI), VO<sub>2</sub> max

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**Introduction**

Physiological and Biochemical changes which occur during the course of the menstrual cycle are mostly the result of complex interactions essentially involving the hypothalamo-hypophyseal-ovarian axis and the uterus. Almost all the changes are phase related and dependent on a variety of sensitive regulatory mechanisms.

The study of fluctuations in athletic performance attributable to the menstrual cycle has been an area of considerable interest and controversy for well over half a century.<sup>1</sup> The female sex steroid hormones

estrogen and progesterone have a potential effects on exercise capacity and performance through numerous mechanisms, such as substrate metabolism, cardiorespiratory function, thermoregulation and ventilation other than the reproductive axis.<sup>2</sup> Female athletes, coaches, medical professionals and researchers have long been concerned about the potential impact of the menstrual cycle fluctuations in the female sex steroid hormones on components of athletic performance.<sup>3</sup> Adult females show a wide range of physiological and biochemical changes

during phases of menstrual cycle related to varying hormonal levels.

Although there is abundant research addressing how exercise affects performance, less is known about how menstruation affects women's performance in exercise and athletics. Hence, the present study is undertaken to find out whether there are any changes in the Physical performance capacity in young female athletes during phases of the menstrual cycle.

### **Athletic activity and Menstruation**

Athletic performance depends on many diverse adaptations in the cardiopulmonary and respiratory systems, in addition to various musculoskeletal and biomechanical considerations. At the microscopic level, many important cellular and enzymatic adaptations take place in response to both the type and the amount of training. Genetic predisposition, interindividual variability in size, shape and body composition and numerous psychological components (affect, perception, cognition) further complicate the overall picture. Although often neglected as a part of preparation for competition, adequate nutrition and hydration are critical to successful performance. Improvements in equipment and sport specific technique also must be factored in. Furthermore, athletic achievements in one area of sport do not necessarily predicate a similar outcome in another sport.

### **The female athlete**

The female athlete has a unique physiology and a kaleidoscope of changing hormonal profiles throughout her biological life cycle. Patterns of male and female sex steroids after the onset of puberty are largely responsible for gender differences in morphology, aerobic and anaerobic capacity, strength and bone density, although sociocultural influences cannot be ignored. In studies that compare male and

female athletes, it also is critical that the subjects are not only matched for initial fitness levels, but also exercised at a comparable proportion of their maximal aerobic fitness. Nevertheless, the relative health benefits of physical activity and training in girls and women are similar to those of their male counterparts.<sup>4</sup> It then becomes of interest, particularly for competitive female athletes in the reproductive age group, to consider potential differential effects of these hormones in the context of athletic performance.<sup>5</sup>

### **Physical performance capacity**

In human physiology, the functional capacity of the various systems determines the physical performance. Men and women participation in physical activity improves the functional capacity of the various systems.<sup>6</sup>

Physiologists have been interested in studying cardiopulmonary responses to physical exercise and measuring work capacity of healthy individuals as indices of physical fitness of population groups.<sup>7</sup> According to Astrand, assessment of physical performance is by two ways<sup>8</sup>- a) Physical fitness tests with scoring of actual performance in situations that represent basic performance demands. B) studies of cardiopulmonary function at rest or during exercise.

The chief criteria for the exercise employed for this purpose are, it should be exhausting, it should require no skill and it should put the cardiorespiratory system under real stress. Taking the above criteria into consideration, several tests of physical fitness like step test, treadmill etc. have been used by several sports physiologists to determine the physical fitness, Physical performance capacity and physical fitness index other than the routine exercise.

### **Tests of maximal aerobic power**

Aerobic power is widely studied and is the most popular criteria for physical fitness. The reason for this is that it can be measured quantitatively.

The maximal aerobic power is defined as the highest oxygen uptake an individual can attain during physical work at sea level. Physical activity ranging from repeated work periods of a few seconds duration upto hours of continuous work may involve a major load on the oxygen transport organs and thereby induce a training effect. Three tests to measure maximal aerobic power are available – 1) running on a treadmill 2) Exercising on a Bicycle ergometer 3) Step test.

### **Harvard step test**

The Harvard step test was introduced by Brouha et al. in 1943<sup>9</sup> from Harvard fatigue laboratory in USA to select army personnel during world war II. Later with the development of sports, exercise physiology and ergonomics, this HST has been given much attention to select highly physically active persons who will be capable of doing hard work so that they can be recruited in various sports and games or appropriate industrial occupations. Further that HST has become well known to study cardiovascular fitness by American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD) who recommended this test to study health related physical fitness programme in youth. It may be mentioned that the original HST had been designed to select highly physically active subjects which is found to be not suitable for normal healthy persons of sedentary habit, in many countries. As a result a number of modified HST's has been recommended by a number of workers either by lowering step height or frequency of up-down per minute or by

altering the duration of exercise instead of maximum period of 5min.

The Harvard step is a submaximal fitness test, as it predicts cardiovascular fitness (endurance) from the rise of heart rate during moderate exercise, rather than exercise to exertion. Many different versions of the step test are available for use. Probably the most commonly used is the 5min step test. Here, heart rate may be counted most easily by pressing the fingertips on the arteries of the wrist. When the pulse rate is taken, each client is asked to step up and down on a bench of 41 cm high for males and 33cm high for females (standard gym bench) at a rate of 22 steps a minute for women (up,up, down, down) and a 24 steps for men. The same foot must start the step up each time. The pulse rate is taken exactly one minute after the last step is completed.

The step is based upon the idea that a client with a higher level of cardiovascular fitness will have a smaller increase in heart rate, and that following the exercise, the heart rate will return to normal faster than a client who has much lower level of cardiovascular fitness. This is known as pulse recovery rate. The recovery rate can be used to predict  $VO_2$  max.

Taddomino DA et al., 1951,<sup>10</sup> classified the step test into two types: 1) long form 2) short form. In the long form the pulse is counted to 1 to 1½, 2 to 2½ and 3 to 3½ minutes after the exercise. In the short form the pulse is taken only once, 1 to 1½ minutes after the exercise. He further proposed the scoring pattern for the long term and short term. The PFI is calculated with this formula

For short form, the scoring formula is as follows:

$$\text{PFI} = \frac{\text{Duration of exercise in seconds} \times 100}{5.5 \times \text{Recovery pulse 1- 1}\frac{1}{2}\text{min after exercise.}}$$

### **VO<sub>2</sub> max**

VO<sub>2</sub> max is the maximum capacity to transport and utilize oxygen during incremental exercise (Harvard step test) (The derivation is V- volume per time, O<sub>2</sub> – oxygen, max – maximum). It is also called maximum oxygen consumption or maximal oxygen uptake.<sup>11</sup> Expressed either as an absolute rate in litres of oxygen per minute (l/min) or as a relative rate in milliliters of oxygen per kilogram of bodyweight per minute (ml/kg/min), the later expression is often used to compare the performance of endurance sports athletes. It is also known as aerobic capacity, which reflects physical fitness of a person.

### **Determining VO<sub>2</sub> max**

VO<sub>2</sub> max can be determined through a number of physical evaluations. These tests can be direct or indirect. Direct testing requires sophisticated equipment to measure the volume and gas concentrations of inspired and expired air. Indirect testing is much more widely used by coaches as it requires little or no expensive equipment

### **Methods of indirectly assessing aerobic power**

Tests for direct assessment of VO<sub>2</sub> max is limited in that the test is difficult, exhausting and often hazardous. For this reason, several indirect methods for predicting VO<sub>2</sub> max from submaximal exercise data have been developed.

#### 1) Astrand – AsrandNomogram<sup>12</sup>

This was originally constructed from data gathered on young (18 to 30 years), healthy, physical education students, and it is based on the idea that heart rate during

submaximal exercise increases approximately linearly with oxygen uptake and the nomogram was said to be more accurate if heart rates between 125 and 170 beats per minute were used to make predictions of VO<sub>2</sub> max. For subjects older than 25 years, age correction factors must be used.

### **Subjects and Methods**

Ethical clearance for the study protocol was obtained from the institute ethical committee. 30 healthy female athletes of age group 17-20 years were selected randomly from a group of participants.

Informed consent was obtained from each subject. Those subjects with history of regular menstrual cycle were included. Subjects with history of menorrhagia, any gynaecological problems, who are taking oral contraceptives or any other medications, who smoked and consumed alcohol were excluded from the study.

Thus the health of the subject was assessed by noting the present, past, family and personal history and also by a thorough general and systemic examination.

The subjects were explained about the importance and procedure of the study. The subjects were asked not to change their life style during the period of study.

All the exercise data was collected from 7am to 9am. Data on physical characteristics such as age, height using stadiometer, weight using weighing scale and

body mass index (BMI) was obtained. BMI was calculated as  $\text{weight(kg) / height(m)}^2$ .

The study involved noninvasive procedures with no financial burden on the subjects. The details of the procedure of exercise test were explained to the subjects and actually demonstrated before in order to allay apprehension.

The physical fitness parameters like PFI and  $\text{VO}_2$  max were recorded to assess the Physical performance capacity. The recordings of the physical fitness parameters were made on specified days in the menstrual cycle in 3 phases, menstrual phase – from 1<sup>st</sup> to 5<sup>th</sup> day of the cycle, follicular phase – from 8<sup>th</sup>

to 12<sup>th</sup> day of the cycle, luteal phase – from 20<sup>th</sup> to 25<sup>th</sup> day of the cycle.

#### **Recording of physical fitness parameters.**

The following physical fitness parameters with particular reference to cardio-respiratory function to assess physical performance capacity were recorded in each subject.

- a) Physical fitness index of each subject was recorded by using Harvard step test.<sup>13</sup> Each subject completed 'up' and 'down' task (22 steps per min) on an 16 inch bench for 3 minutes or until exhaustion whichever ever is early. The PFI was calculated as follows :

$$\text{PFI} = \frac{\text{Duration of exercise in seconds} \times 100}{5.5 \times \text{Recovery pulse 1- 1}\frac{1}{2} \text{ min after exercise.}}$$

- b)  $\text{VO}_2$  max was indirectly assessed by the astrand-astrand nomogram method from submaximal exercise data obtained using Harvard step test.

#### **Results**

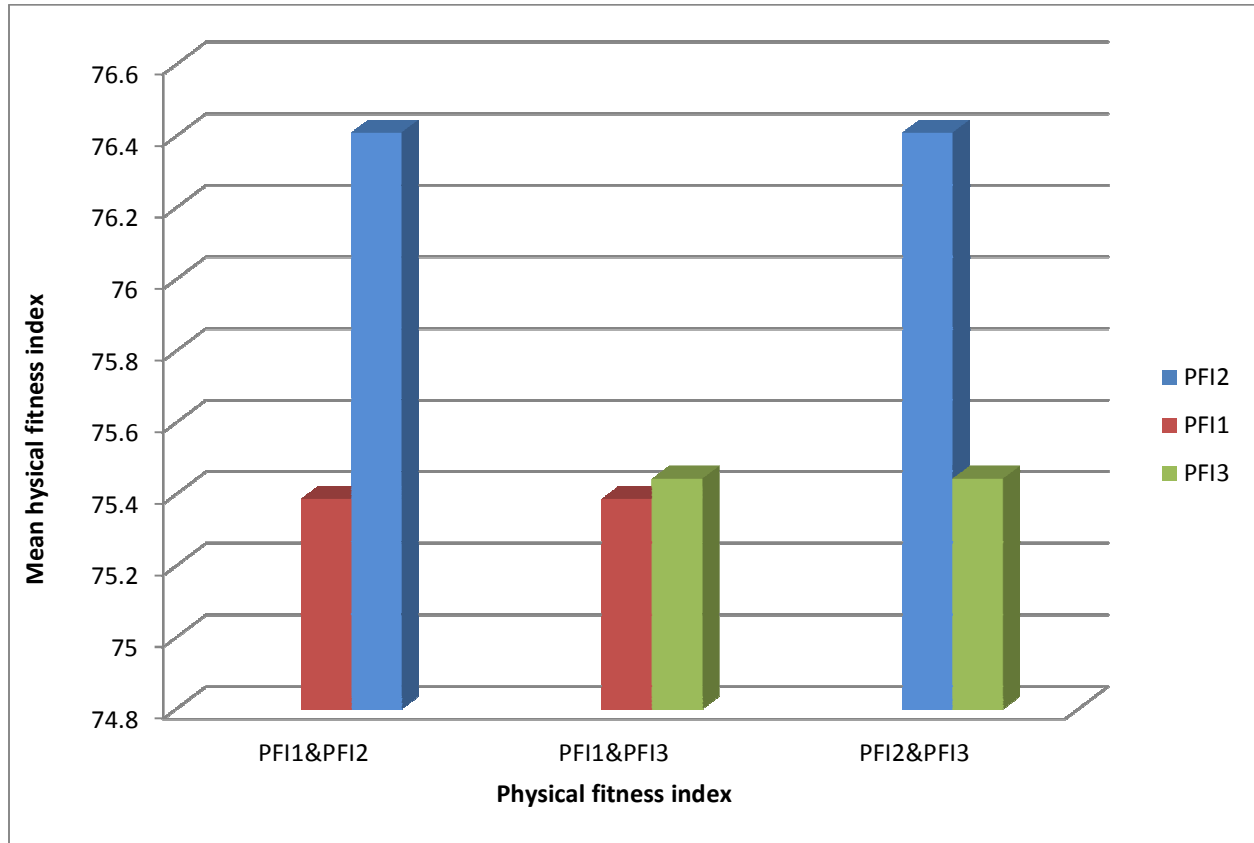
In the present study, the physical performance capacity was assessed by PFI and  $\text{VO}_2$  max during follicular, luteal and menstrual phases of the menstrual cycle. The data collected have been statistically analysed using student 't' test.

#### **Anthropometric measurements:**

The participants recruited were almost of the same height, weight, age and BMI without exhibiting a statistically significant difference.

#### **PFI**

Comparison of changes in the PFI during follicular, luteal and menstrual phases of the menstrual cycle showed statistically no significant changes.



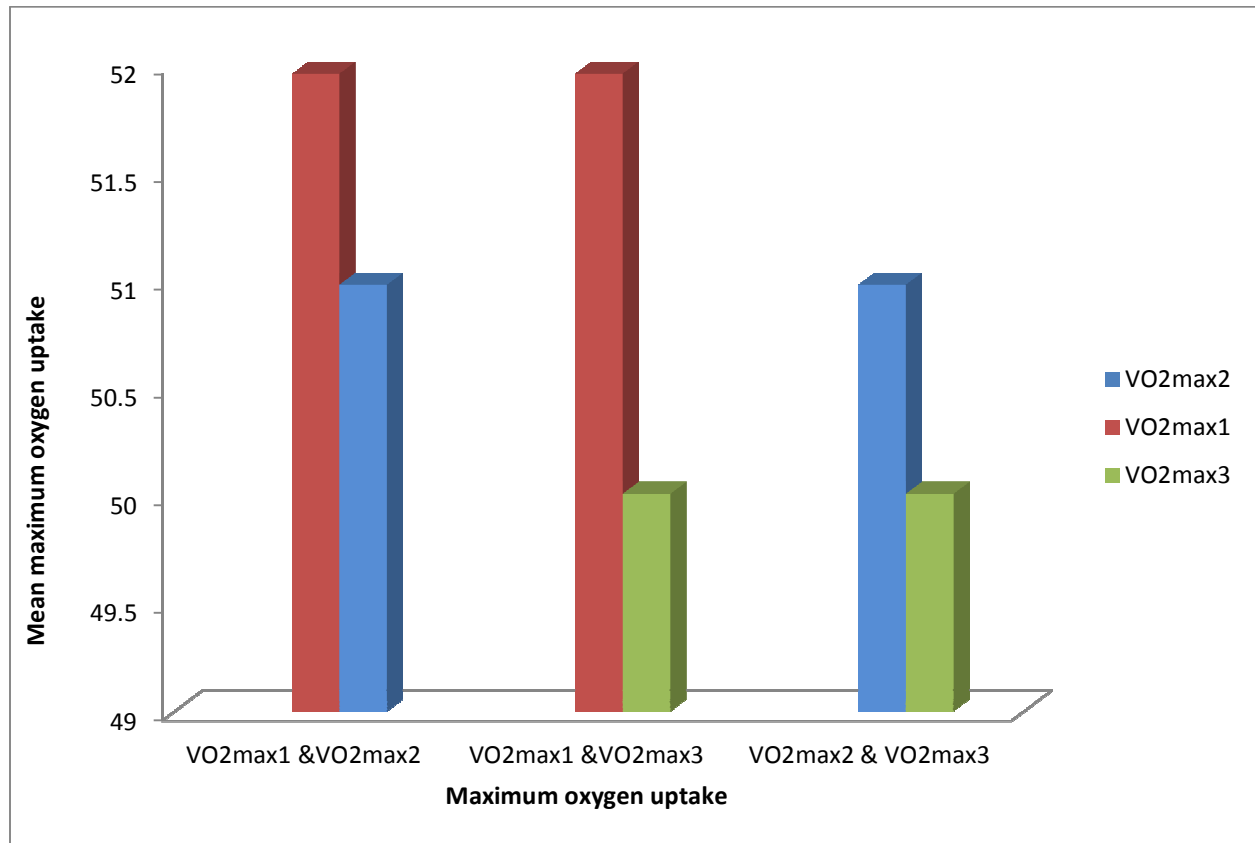
### VO<sub>2</sub> max

Comparison of changes in the VO<sub>2</sub> max during follicular, luteal and menstrual phases of the menstrual cycle showed statistically no significant changes.

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### Discussion

The typical menstrual cycle is of 28 days and first day of the menstrual bleeding considered to be the first day of menstrual cycle, followed by the proliferative phase from 6<sup>th</sup> to 14<sup>th</sup> day, then secretory phase is from 15<sup>th</sup> to 28<sup>th</sup> day. Ovulation usually occurs 14 days before the beginning of next menstrual cycle and this can be best predicted by Basal body temperature, Cervical smear, Endometrial biopsy, Serum progesterone estimation and Urinary LH measurement. In the present study BBT is used to predict the ovulation.

During the course of menstrual cycle some predictable and measurable variations in the concentration of female sex hormones exists i.e., Estrogen and Progesterone. This change in hormonal pattern will have an impact on athletic performance.

In turn athletic performance also depend upon physiological, biochemical and psychological factors. The main physiological factors includes cardiovascular changes and respiratory changes.

During the proliferative phase the important hormones are estrogen and progesterone. As the estrogen concentration is higher than progesterone, this phase is also known as estrogen phase. The level of estradiol secretion rate is 36µg/d in the early follicular phase and reaches a peak level of 380µg/d just before ovulation and 250µg/d during the mid-luteal phase.<sup>14</sup>The estrogen apart from reproductive function has many beneficial effect on the body such as cardiovascular system, bone, brain and the substrate metabolism. The main function on the cardiovascular system includes increase in the capillary wall strength, vasodilatory effect on

vascular smooth muscle in coronary arteries and peripheral vascular beds. In addition it also lowers the cardiovascular response to stress.<sup>3</sup>

The present study conducted on young female athletes during follicular phase of the menstrual cycle to assess Physical performance capacity by evaluating PFI and VO<sub>2</sub> max showed no statistically significant changes. The mean value and S.D of PFI and VO<sub>2</sub> max during follicular phase is 75.33±6.28 and 51.72±5.43 respectively. Therefore the beneficial effect of estrogen during proliferative phase of menstrual cycle has no significant effect on PFI and VO<sub>2</sub> max.

During the secretory phase the important hormones are estrogen and progesterone. As the progesterone concentration is higher than estrogen, this phase is also known as progestational phase. Progesterone is secreted by the corpus luteum and in small amounts in the follicle. During the early follicular phase, the progesterone level is 0.9ng/ml, steadily increases in the late follicular phase and then attains a peak value of approximately 18ng/ml in the late luteal phase.<sup>14</sup> Progesterone is known to affect thermoregulation, ventilation and substrate metabolism. Higher level progesterone in the luteal phase acts directly on the medullary respiratory center where it lowers the threshold level and also increase its excitability resulting in greater minute ventilation and maximal exercise response. Thereby in untrained athletes this has shown to significant especially who experience subjective dyspnoea whereas in trained athletes no correlation actually exists between ventilation and progesterone levels.<sup>3</sup>

The present study conducted on young female athletes during luteal phases of the menstrual cycle to assess Physical performance capacity by evaluating PFI and VO<sub>2</sub> max showed no statistically significant

changes. The mean value and S.D. of PFI and VO<sub>2</sub> max during luteal phase is 76.40±6.71 and 50.23±5.48 respectively.

During the menstrual phase, the estrogen and progesterone levels are decreased especially progesterone at the end of the ovarian cycle. This phase has no beneficial effect either on cardiovascular system or respiratory system. During this phase the PFI and VO<sub>2</sub> max showed no statistically significant changes. The mean value and S.D. of PFI and VO<sub>2</sub> max during menstrual phase is 76.60±5.20 and 49.24±4.77 respectively.

The sex hormones estrogen and progesterone with varying hormone levels of concentration during different phases of the menstrual cycle have a complex interactions on the body. The net physiological effects of both the hormones can be either opposing or synergistic to bring about the beneficial effects on the body.

In the present study, the net effect of estrogen and progesterone on PFI measured by using Harvard step test and VO<sub>2</sub> max measured by using AstrandNomogram to assess Physical performance capacity during follicular, luteal and menstrual phases showed no statistically significant changes. Our results are consistent with study by Sudatta Das et al.<sup>15</sup> in which there was increase in PFI in luteal phase was reported but not statistically significant. The results revealed that Physical performance capacity was not affected by menstrual cycle phases. Menstruation has only a minimal effect on performance.<sup>16</sup>

PratimaChatterjee et al.<sup>17</sup> reported there was no statistically significant changes in VO<sub>2</sub> max during the different phases of menstrual cycle.

This suggests that regularly menstruating female athletes competing in strength specific sports need



not adjust for menstrual cycle phase to maximize performance. In spite of physiological ups and downs of the menstrual cycle, female athletes have developed ways to compensate for any disadvantages. World records have been set during all phases of the menstrual cycle.

### Conclusion

1. In our study, PFI and  $VO_2$  max showed no statistically significant changes during all the three phases of menstrual cycle.
2. This study suggests that there was no changes in the Physical performance capacity during different phases of menstruation. Hence, a regularly

menstruating female athletes competing in strength specific sports need not adjust to menstrual cycle phase to maximize performance.

3. Also the physical performance capacity can be greatly influenced by the inter-subject variability, nature of exercise, nutrition status, hydration, psychological conditions and genetic variations apart from physiological and biochemical changes.

### Limitations of the study

The limitations of the present study are reduced population and lack of measurement of other physical fitness parameters.

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