Influence of Menstrual Cycle on Maximal Aerobic Power of Young Female Adults

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SUMMARY
The purpose of this study was to determine the exercise response to various stages of the menstrual cycle in young female African adults.

Fifteen volunteer, sedentary young female adults with a regular 28-day menstrual cycle and no history of premenstrual syndrome or abnormality participated in this study. A repeated measure and three counter balanced cross over order design was used in data collection. The subjects engaged in a 20-metre shuttle run test (20-MST) at the 3rd (early follicular phase), 14th (ovulation) and 26th (late luteal phase) days of their menstrual cycle. Maximal aerobic endurance performance indexes (VO₂ max, run time & number of exercise laps) were recorded. One way ANOVA with repeated measures was used in data analysis.

The result revealed no significant differences in the short maximum endurance performance (VO₂ max) [F=.554, p=0.581], run laps [F=.483, p=0.622], and run time [F=.554, p=0.581]) recorded in the various phases of the menstrual cycle at p<0.05. It was concluded that exercise performance is not affected by menstrual cycle.

KEY WORDS: exercise, menstrual cycle, females; aerobic power

INTRODUCTION
The physiological changes that occur during the post-ovulatory (early to mid-luteal) phase of the menstrual cycle include an increase in the progesterone and estrogen levels. During this phase of the ovarian cycle, compared to the pre-ovulatory (follicular) phase, menstruating women at sea level typically show an increase in resting ventilation (Schoene et al, 1981; Takano, 1984; Takano, Sakai & Iida, 1981), although this is not evident in all subjects or all studies (Edwards, Wilcox, Polo & Sullivan, 1996; Regensteiner et al, 1990; Schoene et al., 1981; White et al, 1983).

The increase in resting estrogen is probably due to the action of progesterone, potentiated by the carotid body and central nervous system (Hannhart, Pickett & Moore, 1990). Concomitant with increased resting ventilation is a probable increase in ventilatory chemosensitivity, which manifests as an increase in the hypoxic ventilatory responsiveness and the hypocapnic ventilatory responsiveness (Dutton, Blanksby & Morton, 1989; Jurkowski et al, 1981; Schoene et al., 1981; Takano, 1984). The menstrual cycle also affects systemic and renal haemodynamic systems. Cardiac output and plasma volume are increased in the luteal phase (Bayliss & Millhorn, 1992; Chapman et al., 1997), and a plasma volume expansion in the mid to late luteal phase may decrease the concentration of blood haemoglobin (Chapman et al., 1997; Cullinane et al, 1995; Pahwa, Seth & Seith, 1998; Vellar, 1974). The pulmonary diffusion capacity for carbon monoxide may be higher in the mid to late luteal phase due to an increase in pulmonary capillary blood volume (Sansores et al,1995).These physiological changes could have important secondary effects on maximal exercise performance (Moore, 1997; Brutsaert et al, 2002).

There seems to be no consensus regarding the effect of menstruation on athletic performance. Several studies (Jurkowski et al, 1981; Nicklas, Hackney & Sharp, 1989; Bale & Nelson, 1985) have reported differences in physical performance during various phases of the menstrual cycle.
while several others (Redman, Scroop & Norman, 2003; Lebrun, 1993) have reported a contrary notion that physical performance does not differ during the phases of the menstrual cycle. However, most of the findings from previous studies on menstruation and exercise performance are mostly laboratory-oriented, equivocal and on non-African subjects. Therefore, this study investigated the exercise performance during various stages of the menstrual cycle among young black African subjects using the 20-meter (field test) shuttle run test.

METHODOLOGY

Subjects

The population for the study was the first year female students of the Kano State College of Health Sciences, Kano, Nigeria. Only those who volunteered and were between the ages of 18 and 22 years were recruited. Prior to the test, the subjects were monitored for 3 months and only those with a 28-day regular menstrual cycle were recruited for the study. Fifteen subjects met the requirement: they were non athletes (sedentary), non users of any contraceptive, with no history of menstrual abnormality (irregular menstruation or missed menses, severe menstrual pain, abnormal bleeding pattern), premenstrual syndrome and apparently healthy with no urino-genital infection. The subjects were fully informed about the experimental procedure, risk and protocol, and gave their informed consent in accordance with the American College of Sports Medicine (ACSM) guidelines (ACSM, 1991). Also, the ethical approval of the institution’s authority was obtained.

Design of the study

The repeated measures design was used (counter balanced cross over order).

Menstrual cycle monitoring procedure

The subjects provided details of their prior menstrual history as far back as possible. The subjects then monitored their basal body temperature each morning before getting out of bed (Weschler, 2002) for 3 months before their first study day using the mercury-in-glass clinical thermometer (Goshen clinical thermometer) by Zhoushan Tongxin Instruments Co., Ltd, China. Ovulation was indicated by a sustained increase in basal body temperature averaging ≥0.3°C (Guyton & Hall, 2006; Horton et al, 2002). Menstrual cycle length was estimated from the first day of menses (day 1) to the day preceding the next menses using a typical cycle length of 28 days and ovulation at day 14. (Guyton & Hall, 2006; Horton et al, 2002).

Pretest procedure

The subjects’ regular diet history was taken and all subjects were advised to maintain an estimated diet composition of 25% fat, 15% protein, and 60% carbohydrate 3 days to each test day. Exercise testing occurred after 3 days of diet control and after an overnight fast (12-13 hrs). All subjects were advised to refrain from vigorous activities 24 hours prior to test days.

Anthropometric measurement

The subjects’ weight, height and body mass index (BMI) were measured and derived respectively using a standardized anthropometric protocol (International Society for the Advancement of Kinanthropometry (ISAK), 2001).

Physiological measurement

The subjects’ systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) were measured on the right arm as described by Walker et al (1992) using a semi-automated BP monitor (Omron digital BP monitor model 11 EM-403c, Tokyo Japan). The measurement was done in the morning between 9am and 10 am each test day.

Exercise Test Procedure

An exercise test was conducted between 8 am and 10 am, at an environmental temperature of between 23 to 25°C and altitude of 481m. On arrival at the field and following 10 minutes’ rest in a sitting position; the subjects’ SBP, DBP and HR were measured. They warmed up for about 5 minutes (easy jogging and stretching exercises) and got ready for the 20-metre shuttle run test (20-MST).

The 20-MST was conducted on a levelled 20-metre marked course with chalk at each end. The test was performed in accordance with a one-minute protocol (Ledger & Gadoury, 1989) using the Progressive Aerobic Cardiovascular Endurance Run (PACER) tape. The number of laps and time completed by each subject was recorded as their predicted cardiorespiratory fitness score using the formula of Reunsbottom, Brewer and Williams (1998) as follows:

\[ VO_2 \text{ max} = 14.4 + 3.48 \text{ (minutes completed)}. \]

The tests were conducted on the 3rd (mid flow), 14th (ovulation), and 26th (pre-flow) days of the menstrual cycle in a crossover counterbalanced order. As a result of counterbalancing, some of the subjects underwent the first exercise test during the midflow phase, some in ovulation and others underwent their first test during the luteal phase and then the crossover test. During the exercise tests (3rd, 14th & 26th days of cycle), the subjects had a new
sanitary pad (sanitary napkins) in situ. The purpose of the pad on all test days was to neutralize the effect and inconvenience of carrying pads during the flow period.

**Statistical analysis**

Following data collection, the variables of interest were statistically analyzed. Mean and standard deviation were determined for all variables. Exercise performance (VO\(_2\) max, run time, and number of laps) were statistically analyzed using repeated measures of ANOVA. The statistical analysis was done using the Statistical Package for the Social Sciences (SPSS, version 15.0, Chicago IL, USA). The probability level for all the above tests was set at 0.05 to indicate significance.

**RESULT**

Fifteen females participated in this study. Their baseline (mean ± SD) age, weight, height, BMI, SBP, DBP and HR were (19.2 ± 1.37 years), (55.47 ± 1.7 kg), (147.00 ± 2.35 cm), (24.55 ± 1.00 kg/m\(^2\)), (122.53 ± 2.42 mmHg), (78 ± 1.81 mmHg) and (69 ± 1.23 beats/minute), respectively. Table 1 shows the mean and SD of run time (T), number of laps (L) and VO\(_2\) max for the various stages (3\(^{rd}\) [1], 14\(^{th}\) [2] and 26\(^{th}\) [3] days) of cycle.

The result of this study indicated no significant difference on short maximum endurance performance in the various phases of the menstrual cycle. Table 2 shows no significant effect of various menstrual cycle stages (3\(^{rd}\), 14\(^{th}\) and 26\(^{th}\) days of cycle) on the number of exercise run time (F=.554, p=0.581); numbers of exercise laps (F=.483, p=0.622) and VO\(_2\) max (F=.554, p=0.581).

**DISCUSSION**

Alterations in athletic performance experienced during different phases of the menstrual cycle are subject to considerable individual variability, nutrition, psychological stress, body composition, acute and chronic endocrine alteration and types of exercise (Bailey et al., 2000; Gollnick 1998; Davis and Bailey, 1997; VanHall et al, 1995; Hackney et al, 1994; Lebrun, 1993; Tarnopolsky et al, 1990; Nicklas et al, 1989). Some women have absolutely no noticeable change in their performance ability at any time during their menstrual cycle, yet others have considerable difficulty in either the pre-flow or the early flow phases or during both. The number of women who reported impaired performance during the flow phase is approximately the same as those who experienced no difficulty. Some female athletes have repeatedly set world records during the flow phase (Wilmore & Costill, 1994). Adding to the confusion, much of the information available is based on subjective statements made by athletes during informal surveys, with study methodological aberrations, exercise status and experience of subjects, and other psychosocial and health factors that could not be substantiated. However, the subjects’ cardiovascular and physical characteristics as reported in this study fall within the normal range for their age and sex (Wilmore & Costill, 1994).
This study was designed to assess the influence of the menstrual cycle on maximal aerobic power of young female adults. The results of this study indicated no significant effect of menstrual cycle stages (mid-flow – 3rd day, ovulation – 14th day and pre-flow stages – 26th day) on endurance (run time, numbers of laps and VO₂ max) parameters. The results of the present study corroborated the findings of previous studies (Bailey, Zacher, & Mittleman, 2000; Beidleman et al, 1999; McCracken, Ainsworth & Hackney, 1994; De Souza et al, 1990). Brutsaert et al (2002) investigated the effects of the menstrual cycle phases on endurance exercise performance at a high altitude (3600m). In their study, thirty sedentary women exercised during the mid-follicular (day 7–9) and mid-luteal (day 21–23) phases. The subjects performed an incremented series of increasing workloads starting at 30 W and increasing by approximately 20 W every 3 minutes until volitional fatigue on a cycle ergometer. Their result indicated that menstrual cycle (mid-luteal & mid-follicular) phases have no effects on maximal exercise performance as measured by their VO₂ max. However, they reported a 4% increased maximum work output in the luteal phase.

Another similar study with a similar report was conducted by Redman et al (2003), who compared exercise status during the mid-follicular (FP) and luteal (LP) phases of the menstrual cycle of a single group of young sedentary women. Fourteen females ([mean age ± (SD) = 21.8(4.0) years and peak oxygen uptake VO₂peak < 45 ml.kg⁻¹.min⁻¹]) performed both incremental exercise to exhaustion and steady-state submaximal cycle ergometer exercise. With the incremental exercise test, time to exhaustion, maximal power output and total work done were not different between the two phases at p < 0.05. However, they concluded that exercise capacity is unaffected by cycle phase.

Several reports (Moore, 1997; Edwards et al., 1996; Regenstein et al., 1990; Nicklas et al., 1989; Bale & Nelson, 1985; Brooks-Gunn, Gargiulo & Warren, 1986) are in disagreement with the findings of this study. Jurkowski et al (1981) investigated the effect of menstrual phases on exercise performance. Nine healthy females, aged 20 - 24 years, exercised at 33, 66 and 90% maximum power output in the mid-luteal and mid-follicular phases of their cycle. They observed nearly a 100% increased exercise time to fatigue during the luteal phase (2.97 ± 0.63 min) compared with the follicular phase (1.57 ± 0.32 min) during cycling at 85-90% VO₂ max. Similarly, Nicklas et al (1989) exercised 6 eumenorrheic females (26.3±2.4 years) to exhaustion (70% VO₂ max) on a cycle ergometer in the mid-luteal and mid-follicular phases of their menstruation. They observed a small but significant increase in exercise time to fatigue during the mid-luteal phase (139.2 ± 14.9 min) compared with the mid-follicular phase (126 ± 17.5 min). The findings of Jurkowski et al (1981) and Nicklas et al (1989) suggest that endurance performance is greater in the luteal phase, indicating that menstrual phases affect exercise performance.

The reasons for the disparity in findings between this study and other might not be unconnected with the types of exercise used. Previous studies were laboratory-oriented while the present study utilized field exercise. The effect of interpersonal and interracial differences could not be ruled out. Also, the physical activity level of the subjects is worth considering. Studies have shown the influence of genetic, environmental, socioeconomic, exercise, cultural, obesity and nutritional factors on menstruation. (American Academy of Pediatrics, Committee on Adolescence, American College of Obstetricians and Gynecologists, and Committee on Adolescent Health Care, 2006; Apter & Hermanson, 2002; Masterson, 1999; Gindoff, 1989). Another factor worth considering is the methodological differences. In the present study, basal body temperature and calendar charting methods were used in the monitoring and assessment of menstrual cycle phases. This method has been recommended by various investigators in the assessment of basal body temperature (Shann & Mackenzie, 1996; Brennan et al, 1995; Yetman et al, 1993; Chamberlain et al, 1991; Weisse et al, 1991). However, some studies (Westerlind & Williams, 2007; Redman et al, 2003; Horton et al, 2002; Bailey et al, 2000) have used a hormonal (estrogen and progesterone concentration) method in the assessment of menstrual cycle phases.

In conclusion, the results of this investigation indicate that maximal aerobic performance is not influenced by menstrual cycle phase. However, a major limitation to this study is the few participants. This factor warrants more attention in future studies.

**RECOMMENDATION**

The result of this study suggests that the three phases of the menstrual cycle investigated do not affect short maximal aerobic performance. Physiotherapists, sports medical scientists/physicians, trainers/managers, physical educators and coaches who want to use sedentary females for a study or start an aerobic exercise programme, should feel confident to do so in any of the phases of the menstrual cycle provided there are no menstrual abnormalities and disturbances.
References


Lamina, Hanif, Mohammed


