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*Short communication*

# Effects of the menstrual cycle phase on the blood lactate responses to exercise

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**Abstract.** The effects of menstrual cycle phase on the blood lactate response to exercise were examined in eumenorrheic women (n=9). Exercise tests were performed at the mid-follicular and mid-luteal points in the menstrual cycle (confirmed by basal body temperature records and hormone levels). Blood lactates were measured at rest and during the recovery from exercise. Resting lactates were not different between the exercise tests; however, recovery lactates were significantly ($p<0.05$) lower in the luteal compared to the follicular phase. The mechanism for these differences is unclear, but may be related to an estrogen mediated increased lipid metabolism inducing a concurrent reduction in carbohydrate metabolism. The present findings question the use of blood lactate monitoring as a suitable technique to measure exercise intensity in eumenorrheic women.

**Key words:** Eumenorrheic - exercise performance - metabolism - hormones

## Introduction

Research has demonstrated that some aspects of metabolism differs between the phases of the menstrual cycle in women. Specifically, resting lipid oxidation and glycogen storage are higher in the luteal than follicular phase of the menstrual cycle (Bunt 1990; Hackney 1990). These metabolic phenomenon are attributed to the enhanced blood estrogen concentrations that occur at ovulation and throughout the luteal phase, as compared to the follicular phase of the menstrual cycle (Bunt 1990). Additionally, relative to submaximal exercise, lipid mobilization and oxidation also seem to be elevated during the luteal phase (Hackney et al. 1991; Nicklas et al. 1989). Collectively, these physiological alterations could influence the blood lactate responses to exercise. However, the existing research is contradictory on the issue. Some studies suggest lower blood lactate level occur in response to exercise during the luteal phase (Jurkowski et al. 1981), but other studies report no differences in the lactate response between phases of the menstrual cycle (Dombovy et al. 1987). In athletics blood lactate is commonly used as a marker of performance and to monitor exercise intensity. Fluctuations in the lactate response to a standardized exercise load when all other factors are controlled would indicate that blood lactate levels may be a questionable "physiological response marker" in eumenorrheic women. We conducted the present study to investigate this last point. Our purpose was to determine if the blood lactate levels in response to intensive running differed at the mid-luteal (ML) and mid-follicular (MF) phases of the menstrual cycle in menstruating women.

## Methods

*Subjects.* Nine eumenorrheic women (age range 18-32 yr) gave written informed consent to participate in this study. Eumenorrheic status was determined from medical history questionnaires and the monitoring of daily basal body temperature for 2 months prior to participation. All subjects were physically active (maximal oxygen uptake [VO2max] = 46.0 $\pm$ 2.6 ml/kg/min) at the time of the study; however, they were not classified as competitive athletes.

*Procedures.* For the study, subjects ran on a motor driven treadmill at the MF (6-9 days after menses) and ML (6-9 days after ovulation) points in their menstrual cycle. The days corresponding to the ML and MF points were determined from a review of basal body temperature records. Menstrual phase was also confirmed using hormonal (estrogen - progesterone) analysis of urine samples collected the morning of each exercise test. The treadmill run employed an incremental, continuous protocol with minutes 1-10 minutes at 35% of $VO_2$max, 11-20 at 60% $VO_2$max, and 21-30 at 75% $VO_2$max. At the end of the 30 minutes of running the intensity was increased to ~90% $VO_2$max and the subjects exercised until exhaustion. This exercise protocol was selected in an attempt to mimic an athletic performance/training situation. The running speeds necessary to elicit the relative intensities of $VO_2$max were determined from a regression analysis of running speed versus $VO_2$ responses to a graded exercise test to exhaustion (performed approximately 1 week prior to the study beginning).

The order of menstrual phase testing (ML *vs* MF or MF *vs* ML) was randomized and the time of day for conducting the exercise trials was standardized. Furthermore, subjects were asked to replicate their dietary, physical activity, sexual, and employment activities for the 24 hours prior to each exercise trial.

Blood samples were collected via veni-puncture at rest (immediately prior to exercise) and at ~3 minutes and 30 minutes into the recovery

from the exercise. The recovery from exercise was passive in nature (seated position). Collected plasma was separated and stored frozen at -50°C for later analysis. The analysis for lactate was performed with a Kodak DT-60 automated blood analyzer. All samples were determined in duplicate.

*Statistical Analysis.* Statistically the data were analyzed with a Freidman analysis of variance with a Fisher post-hoc testing applied to test mean differences The alpha-level set at $p \leq 0.05$. All reported values are means $\pm$ SEM.

## Results

Running time to exhaustion was not different ($p > 0.05$) between the MF (32.5 $\pm$ 0.5 min) and ML (32.4 $\pm$ 0.5 min) exercise trials. Additionally, resting lactate levels did not differ between the phases of the menstrual cycle (MF = 1.6 $\pm$ 0.2 mmol/L, ML = 1.7 $\pm$ 0.3 mmol/L). However, the recovery lactates were significantly different at ~3 and 30 minutes post recovery from the exercise. The ML lactate levels were lower ($p < 0.05$) than the corresponding MF lactate levels (~3 min = 5.4 $\pm$ 1.2 *vs* 8.7 $\pm$ 1.8 mmol/L; and 30 min = 2.4 $\pm$ 0.4 *vs* 4.0 $\pm$ 1.3 mmol/L, for ML and MF respectively). Hematocrits (micro-capillary tube method) were also examined from the blood samples, and utilized to assess plasma volume shifts (Van Beaumont, 1972). No significant differences were observed between the calculated plasma volume shifts during the MF and ML exercise trials.

## Discussion

The findings from this study support the notion that the changes in blood lactate responses to exercise are affected by the phase of the menstrual cycle. Jurkowski et al. (1988) found similar responses for peak lactate levels following exhaustive exercise, although, Jurkowski's data are somewhat confounded by the fact that the time to exhaustion differed between the phases of the menstrual cycle (i.e., the work performed was not equal). In contrast, our findings are in direct opposition to those of Dombovy et al. (1987) who reported no menstrual cycle effects on lactate responses to exercise. The reason for the differences between the studies is uncertain, although it is most probably due to the experimental protocols employed: That is, in the case where no differences were observed the investigators possibly did not rigorously control their subjects concerning; (1) activities prior to experimental sessions (e.g., diet, physical activity ...etc.), and (2) the determination of the menstrual cycle phase day upon which testing was to take place.

The physiological mechanism inducing these blood lactate differences is unclear from the present data. Substrate (glucose - glycogen) unavailability does not seem a likely reason as the amount of carbohydrate ingested was replicated prior to each exercise test. Furthermore, research has demonstrated enhanced resting muscle glycogen levels actually exist in the luteal phase (Hackney, 1990). A more probable explanation is a preferential metabolism of lipid which results in a reduction in the degree of carbohydrate metabolized. Estrogens are associated with enhance lipolysis, and an elevated lipid metabolism will suppress glycolytic activity (Bunt 1990). Previously published data from this study showed an enhanced lipid oxidation occurred in the luteal versus follicular exercise trial (Hackney et al. 1994). Thus, we speculate that our reduced lactate responses are a consequence of an estrogen mediated enhanced lipid metabolism during the luteal exercise.

From a practical perspective, the present findings suggest that blood lactate monitoring may be a questionable technique to measure exercise intensity in eumenorrheic women.

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