Vascular Volume Dynamics During Ergometer Exercise at Different Menstrual Phases*


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Summary. Five female Caucasians performed cycle ergometer exercise in a hot environment (32 °C dry bulb, 30 °C wet bulb) both early in the follicular phase and in the middle of the luteal phase of the menstrual cycle. During each menstrual phase, the exercise was performed once following hyperhydration and once after 24-h fluid deprivation. More rapid increases in hemoglobin concentration and osmoconcentration, as well as decreases in plasma volume, were observed during exercise in the follicular phase, more notably following hypohydration. The data suggest that the phase of the menstrual cycle as well as the preexercise fluid status of the subject may be important determinants of vascular volume dynamics during exercise.

Key words: Exercise – Menstrual cycle – Hemoglobin – Osmolality – Plasma volume

Introduction

Fluctuations in ovarian hormones during the menstrual cycle influence levels of hormones which control the volume and contents of the vascular space. For example, 17-β-estradiol has been reported to increase the production of renin substrate (Helmer and Griffith 1952), while progesterone acts in the kidney to antagonize the action of aldosterone (Laidlaw et al. 1962). In the latter case, an exaggerated increase in aldosterone concentration occurs which may affect the action of antidiuretic hormone (ADH) (Bonjour and Malvin 1970).

In resting subjects, the luteal phase has been associated with decreases in hemoglobin concentration [Hb] and hematocrit (Hct) (Vellar 1974) as well as reductions in Na⁺ concentration in sweat (Lieberman 1966), and in renal Na⁺ excretion (Thorn et al. 1938). Menstruation in these latter subjects was characterized by an increased excretion of electrolytes and water and a reduction in body weight.

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Given these effects in nonexercising women, one might suspect differences in the vascular response to heat exposure or exercise during the menstrual cycle. Most frequently, heat exposure during the luteal phase of the menstrual cycle has been associated with a higher rectal temperature ($T_{re}$) and a longer delay in sweating onset compared to the follicular phase (Bittel and Henane 1975, Haslig and Hertzman 1965). However, more efficient thermoregulation during the luteal phase has also been reported (Senay 1973). With a variety of other measures, however, few differences in either resting values or those obtained during exercise have been described as a function of the menstrual phase (Avellini et al. 1980, Frye and Kamon 1981, Fortney and Senay 1979).

The inability to detect changes in pre-exercise or exercise responses during the menstrual cycle may be due to several causes. One is that the length of the cycle differs among women. Thus, determining the different cycle phases by counting days since the commencement of menses results in studying women with different hormonal levels. For similar reasons, using an increase in basal body temperature to indicate the initiation of the luteal phase does not predict accurately ovarian hormonal levels. Direct assessment of $E_2$ and $P_4$ concentrations would seem to be necessary. Further, the detection of differences in exercise during the different menstrual phase might be maximized if the exercise responses were measured once when $E_2$ and $P_4$ are low and again when these ovarian hormonal levels are elevated.

This was done in the present study by assessing vascular volume dynamics during cycle ergometer exercise in the heat both early in the follicular phase and in the luteal phase. Further, the fluid status of the subject was altered so that exercise was performed once with the subject hyperhydrated and once hypohydrated during each major phase. This allowed an assessment of whether the phase of the menstrual cycle could explain our previous disparate results in women compared to men following this fluid status manipulation (Gaebeltein and Senay 1980, 1982). Preexperimental differences among subjects in training state and degree of heat acclimation were controlled by having subjects perform the exercise for several days prior to the fluid status manipulation.

Methods

Subjects

Five female Caucasians, none using pharmacologic contraceptives, participated in the study. The women were from 24 to 33 years old and weighed between 49 and 75 kg. Informed consent was obtained from each person prior to experimentation, and the tenets of the Declaration of Helsinki were followed during these procedures.

Training

The protocol for this study required that each subject undergo both training and testing once during the follicular and once during the luteal phase of her menstrual cycle. To accomplish this, training was commenced either shortly after the beginning of menses or at least 10 days following its cessation, respectively. During training, subjects were exposed to 60-min sessions on 3 consecutive