

## **The menstrual cycle, its effects on exercise metabolism and nutritional recommendations**

### **Introduction**

A regular menstrual cycle lasts an average of 28 days and consists of two phases: the follicular phase and the luteal phase.<sup>1</sup> Estrogen acts as a master regulator of energy storage and use, affecting multiple bioenergetic systems in the brain and body.<sup>2</sup> Additionally, the hormonal fluctuations throughout the menstrual cycle may have important implications for exercise capacity and nutrition. Therefore, optimizing a nutritional strategy for athletic performance should take into account these hormonal influences.<sup>3</sup>

### **Background**

The menstrual cycle is a term used to describe the sequence of events that occur within a woman's body as it prepares for the possibility of pregnancy every month. The menstrual cycle has two phases: the follicular phase and the luteal phase (Fig. 1). The follicular phase makes up the first 10-15 days of the cycle. The luteal phase occurs after ovulation, and normally lasts for about 14 days, ending in menstruation if pregnancy does not occur.<sup>4</sup>

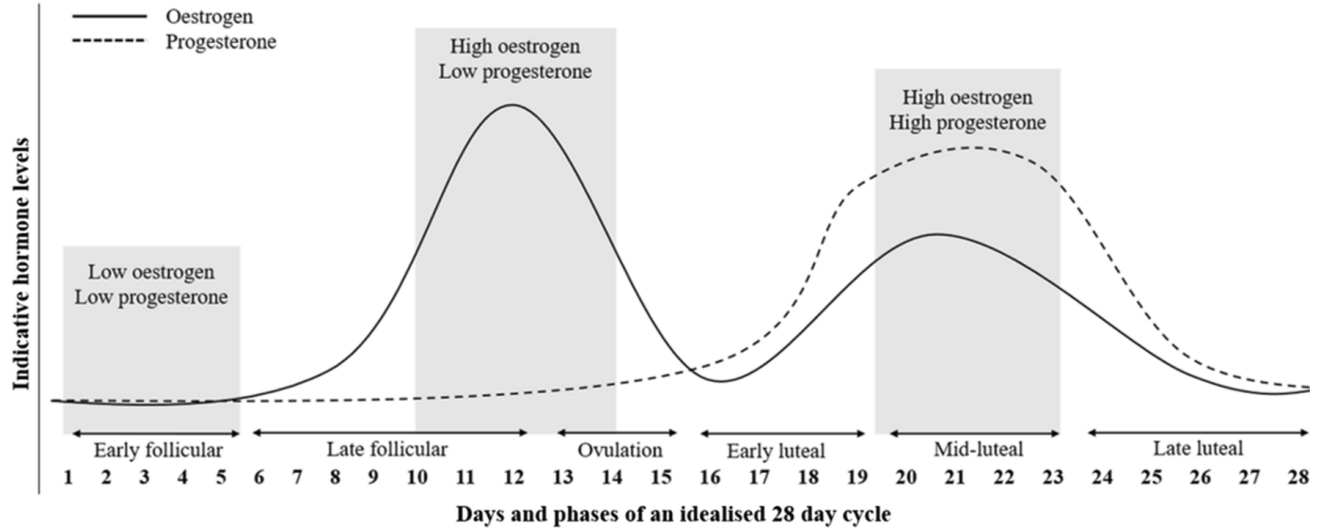
#### *The Follicular Phase*

During the early follicular stage, normally between days 1-7, there is marked low estrogen and progesterone. In the late follicular stage, normally between days 7-13, there is a sharp rise in estrogen while progesterone remains low.<sup>1,3</sup> Ovulation typically occurs shortly after this, between days 14-15. During ovulation, estrogen peaks reaching its highest levels of the cycle, while progesterone levels remain relatively low.<sup>1,3</sup>

#### *The Luteal Phase*

In the early luteal phase typically between days 16-19 estrogen levels drop significantly, and progesterone begins to rise.<sup>1,3</sup> During the mid-luteal phase, days 19-23, estrogen begins to rise again, and progesterone peaks at its highest levels of the cycle.<sup>1,3</sup> In the late luteal phase, normally between days 24- 28, both estrogen and progesterone taper off and return to low levels.<sup>5</sup>

These hormonal fluctuations affect energy expenditure, thermoregulation, fat metabolism, protein metabolism, and overall caloric needs (Fig. 2).<sup>6</sup> A growing body of evidence suggests adapting food intake to reflect normal physiologic changes during the menstrual cycle can help optimize sport and exercise performance.<sup>1,3</sup>

**Figure 1: Graphical representation of hormonal fluctuations during the menstrual cycle<sup>3</sup>**

## Findings and Recommendations

**Adequate caloric intake** should be ensured for women with increased physical activity levels, to support normal cellular and hormonal function and to meet energy demands. Specifically, during the luteal phase of the menstrual cycle, there is a 2.5%-11% increase in resting energy expenditure (REE).<sup>1</sup> In addition, a recent research study of 52 female NCAA collegiate athletes, conducted by Shriver LH, Betts NM, and Wollenberg G, found the majority of participants were not meeting energy demands, with 75% of participants failing to meet carbohydrate intake recommendations as well.<sup>7</sup> Inadequate caloric intake may disrupt normal menstruation, and if chronic, bone mass, leading to impaired performance, increased injury risk, and increased risk of osteoporosis.<sup>1</sup> Calorie needs should be given special consideration, particularly during the luteal phase of the menstrual cycle, to ensure energy availability for proper hormone function and to support overall physical activity demands.<sup>1</sup>

**Carbohydrates** are an important fuel source for moderate-high intensity physical activity and sufficient intakes are required for optimal performance.<sup>1</sup> Carbohydrate recommendations for healthy individuals fall within the acceptable macronutrient distribution range (AMDR) of 45-65% of total calories per day comprising carbohydrates.<sup>1</sup> For athletes specifically, there are additional daily recommendations of 5-12 grams of carbohydrates per kilogram of body weight.<sup>1,8</sup> During the follicular phase of the menstrual cycle (days 1-15) there is an increase in carbohydrate oxidation in the body.<sup>1</sup> As a result, increasing carbohydrate intake pre-exercise may confer improvements in performance.<sup>3</sup> Further, *during* extended bouts of aerobic activity, the consumption of 30-60 g/hour of a 6% carbohydrate solution during either phase of the menstrual cycle can convey performance advantages.<sup>1</sup> The importance of carbohydrate consumption extends into the recovery window as well. During the follicular phase, female athletes should prioritize adequate carbohydrate consumption post-exercise as glycogen restoration capacity is maximized.<sup>1</sup> Overall, supporting exercise demands during the follicular phase requires more carbohydrates specifically in the pre- and post- exercise window to maintain consistent performance.

**Fats** help support normal hormonal function, provide cushion for organs, act as a long-term energy storage, and aid in the absorption of certain nutrients. The current AMDR for dietary fat intake is 20–35% of total calories per day.<sup>1,9</sup> Elevated estrogen levels during the luteal phase (days 16-28) promote lipolysis, or the breakdown of stored fat to generate energy. During this phase of the menstrual cycle, emphasis should be placed on both adequate daily fat consumption, and adequate fat consumption post-exercise. A lack of enough dietary fat can compromise the restoration of lipid stores following an endurance exercise event, which can negatively affect future, subsequent athletic performance.<sup>1</sup> Adequate dietary fat intake is particularly important during the luteal phase to account for the increased reliance on fat breakdown and utilization for energy, as well as to maintain overall health (i.e. nutrient absorption, hormonal regulation).<sup>1,6</sup>

**Protein** intake is a regulator of skeletal muscle mass and supplies the body with the raw materials needed to build new proteins, including new muscle, antibodies, and enzymes. The current AMDR for dietary protein is 10-35% of total calories, with additional recommendations of 1.2-2.0 grams of protein per kilogram of body weight for athletes, depending on level of physical activity.<sup>1,8</sup> The body constantly breaks down old proteins through oxidation. To build new muscle, the rate of protein synthesis must be greater than the rate of breakdown. Protein oxidation is increased at rest during the mid-luteal phase, (days 16-28) of the menstrual cycle.<sup>1</sup> Further, during this phase, the body directs amino acids to support the production of proteins within the endometrial lining, which decreases plasma levels and thus the availability of amino acids for other functions, such as muscle synthesis.<sup>1</sup> Increasing protein intake during the luteal phase of the menstrual cycle may offset the natural decrease in blood levels and help to restore amino acid plasma levels. This may prevent decreases in muscle mass by increasing amino acid availability for skeletal muscle repair.

**Water** intake is important for maintaining optimal fluid and electrolyte levels in the body. The concentration of electrolytes and the amount of water in the body is tightly controlled, and small variations in electrolytes are part of what triggers the sensation of thirst. In the luteal phase (days 16-28), average core body temperatures are higher, which is correlated with an increased sweat rate.<sup>1, 10</sup> This produces a greater cardiovascular strain during submaximal steady-state exercise, and a heightened threshold for the onset of sweating.<sup>1, 10</sup> Increasing fluid intake during the luteal phase will be important to maintain the body's ability to cool adequately to prevent further increases in body temperature that may negatively impact performance.

**Figure 2: Summary of Nutrition Recommendations by Menstrual Cycle Phase**

	<i>Follicular Phase</i>	<i>Luteal Phase</i>
<i>Caloric Needs</i>		Increase intake to support higher resting energy expenditures (EER).
<i>Carbohydrates</i>	<p>Prioritize adequate carbohydrate intake in the pre- and post- exercise window.</p> <p>Extended amounts of aerobic activity warrant the consumption of 30-60g/hr. of a 6% carbohydrate solution.</p>	<p>Extended amounts of aerobic activity warrant the consumption of 30-60g/hr. of a 6% carbohydrate solution.</p>
<i>Protein</i>		Increase intake to ensure amino acid availability for muscle protein synthesis.
<i>Fat</i>		Increase intake to support reliance on fat as fuel source.
<i>Fluid</i>		Increase intake to maintain body's ability to cool adequately.

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