Nutrition Before, During, and After Exercise for the Endurance Athlete

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OBJECTIVES
On the completion of this chapter you will be able to:
1. Understand the consequences of dehydration.
2. Discuss the mechanisms by which the body regulates body temperature and how this affects dehydration.
3. Explain the role of carbohydrate stores in the body and how they affect exercise performance.
4. Understand the relationship between muscle glycogen and exercise performance.
5. Discuss the effects of endurance exercise on muscle damage, soreness, and immune responses.
6. Define the effects of hyperhydration on performance.
7. Talk about the process of glycogen loading and the effects of this practice on performance.
8. Clarify the role of pre-event carbohydrate feedings and outline the basic guidelines for endurance athletes.
9. Discuss the role of fluid, electrolyte, and carbohydrate supplementation during an endurance bout of exercise.
10. Talk about the relationships among cortisol, carbohydrates, and immunosuppression.
11. Appreciate the value of a postexercise fluid and carbohydrate replacement regime.

ABSTRACT
Although it is understood that nutritional supplementation improves performance and enhances training adaptations, it is also vital to grasp how inadequate nutritional practices limit endurance performance. Therefore, in the first section of this chapter, major physiologic factors that result in fatigue during prolonged aerobic exercise are discussed. Adverse consequences of strenuous exercise over time such as muscle damage and immune system suppression are also discussed in this section. In section two, nutritional recommendations in preparation for exercise are presented, whereas nutritional supplementation during exercise is provided in section three. Nutritional strategies for rapid recovery and enhancement of training adaptation are subsequently discussed, whereas the summary section of the chapter consists of practical applications in which nutritional supplementation guidelines are provided to promote endurance performance.

Key Words: aerobic, dehydration, recovery, glycogen, hyperhydration, protein synthesis, nutrient timing
The endurance athlete is generally a very dedicated and compulsive individual willing to train for many hours each day. Although a well-balanced, healthy diet is essential for optimum performance and quality-training sessions day after day, it is also true that endurance athletes have very special nutritional needs that go beyond a well-balanced diet. Numerous studies have documented that endurance athletes can improve their exercise performance during competition and enhance their training sessions with nutritional supplements.

Nutritional supplementation can prevent or slow dehydration, provide additional fuel to drive muscle contraction, reduce muscle damage and inflammation, and speed recovery. However, supplementation is only as effective as the appropriateness of the nutrients provided, as well as the timing of their ingestion. Supplementing with the appropriate nutrients at the appropriate time can have a significant impact on exercise performance and training adaptation.

To understand how nutritional supplementation can improve performance and enhance training adaptation, it is first necessary to understand what limits endurance performance. Therefore, the first section of this review discusses the major physiologic factors that result in fatigue during prolonged, aerobic exercise. Strenuous exercise also can result in physiologic changes that do not initially limit performance, but can have adverse consequences over time. These changes include muscle damage and immune system suppression, and they are discussed in the first section as well. In section two, nutritional recommendations in preparation for exercise are discussed. This is followed in section three with a discussion of nutritional supplementation during exercise. In section four, nutrition for rapid recovery and enhancement of training adaptation is discussed. Section five is the chapter summary, and the last section consists of practical applications in which nutritional supplementation guidelines are provided.

CAUSES OF FATIGUE DURING AEROBIC EXERCISE

The causes of fatigue during prolonged, aerobic exercise will vary according to the type of exercise and the environmental conditions in which the exercise is performed. However, fatigue will typically result from either thermal stress caused by dehydration, muscle glycogen depletion, or limited blood glucose availability caused by a decline in liver glucose output.

Dehydration

The most critical physiologic change that occurs during prolonged exercise is fluid loss. For optimal exercise performance, body temperature must be tightly controlled. There are several mechanisms that the body can use to maintain a stable temperature. For example, during running or cycling, excess body heat can be dissipated by convection, which occurs when cool air moves over the surface of the body. During swimming, excess body heat can be dissipated by the transfer of heat to the water by conduction. However, direct transfer to the environment is generally not an efficient means of dissipating heat, particularly when environmental conditions are hot and humid. During exercise, the primary means of heat dissipation is by sweat evaporation. Evaporation accounts for about 80% of the total heat loss during physical activity. For each liter of water that evaporates, 580 kcal of heat are dissipated from the body and transferred to the environment.

During exercise, heat is generated in relation to exercise intensity. To rapidly dissipate this heat, it is transferred to the blood vessels surrounding the muscles and carried by the blood to vessels just below the surface of the skin. Sweat glands are activated resulting in perspiration, which then evaporates, cooling both the skin and the blood just below the skin. The cooled blood can then be returned to the muscles to help dissipate additional heat. The need to move blood from the muscles to the skin to dissipate heat, however, can put a strain on the heart and cardiovascular system because of the requirement to pump blood to the skin as well as the working muscles. The warmer and more