FUELING FOR FITNESS: FOOD AND FLUID RECOMMENDATIONS FOR BEFORE, DURING, AND AFTER EXERCISE

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LEARNING OBJECTIVE

- The purpose of this article is to provide an update on food and fluid recommendations before, during and after exercise to improve the health and performance of fitness and recreational sports enthusiasts.

Key words:
Nutrition, Food, Hydration, Sport, Recreation

INTRODUCTION

Some of the most frequently asked questions from fitness professionals and their clients deal with food and fluid consumption before, during, and after exercise. People often are confused about what they should eat or drink to optimize performance and fitness and achieve body weight goals. Recently, the American Dietetic Association, Dietitians of Canada, and the American College of Sports Medicine published a joint position statement regarding nutrition and athletic performance that included recommendations about food and fluid consumption before, during, and after exercise (19). The guidelines provided here were developed from this position statement and updated with current research to provide practical recommendations for fitness professionals and their clients when preparing for and recovering from exercise. Although it is appropriate for health and fitness professionals to advise their clients regarding the importance of nutrition and hydration relative to exercise, the sports dietitian with the credential Registered Dietitian (RD) and/or Board Certified Specialist in Sports Dietetics (CSSD) is the professional that can provide specific recommendations tailored to the client's energy and nutrient needs, weight management and fitness goals, and address potential barriers, such as traveling or time constraints, or clinical issues. Creating this collaboration between exercise and nutrition professionals optimally supports the client's intervention, which ultimately meets the code of ethics of all health professionals.

Nutrition recommendations for individuals that exercise are primarily based on a person's overall energy needs and body weight goals. Furthermore, clients are interested in improving their fitness status, and fitness professionals want to promote better health. Appropriate fueling before, during, and after exercise can assist in supporting all of the following: energy balance, weight management,

health, and fitness. Factors, such as exercise frequency, intensity, duration, eating patterns throughout the day, health issues, and work schedules, play a role when making decisions about the quantity, quality, and timing of food and fluid intake relative to exercise.

This paper will provide general nutrition and hydration recommendations for fitness professionals and their clients. However, it is important to understand that no one approach fits everyone. The case studies at the end of this paper provide examples of unique situations that dictate tailored approaches to nutrition and hydration recommendations before, during, or after exercise.

FUELING FOR FITNESS: BEFORE EXERCISE

It has long been known that preexercise meals and/or beverages rich in carbohydrate (CHO) improve endurance capacity (22). However, depending on the physiological demand and the goal of the exercise session, a typical high-CHO intake is not always necessary. Therefore, meals ingested before exercise should be individualized for differences in daily energy requirement, weight and fitness goals, and personal preferences. Optimal timing of food intake relative to exercise also is not always feasible because of busy work schedules, time constraints, and social commitments. Individuals should experiment with food intake and the timing before exercise to minimize gastrointestinal upset and to maximize energy levels to enhance performance and promote health.

Preexercise Meals

In general, preexercise meals should be consumed 3 to 4 hours before exercise. Meals should contain between 1 to 4 g CHO/kg or 0.5 to 2 g CHO/lb of body mass (19) (*e.g.*, whole grains, cereals, pasta, rice, potatoes, vegetables, fruit), moderate protein (*e.g.*, chicken, tofu, fish, low fat dairy, eggs), and some fat (*e.g.*, olive oil, nuts) (see Table 1 for CHO content in common foods and fluids). To meet weight loss goals, half of the plate should be from vegetables and fruit, one fourth of the plate from lean protein, and the rest from whole grains or legumes (*e.g.*, beans, lentils). This approach offers a balanced, nutrient-dense meal that is relatively low in calories but satisfies the appetite; a strategy also easily visualized using the USDA myplate (see www.choosemyplate.gov) as a means to highlight the concept of energy density (see review by Rolls [20]).

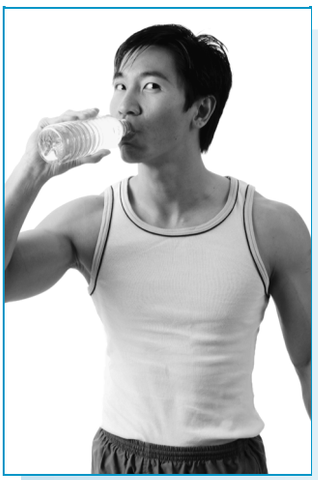
If exercise duration and/or intensity is high for clients or professionals who exercise multiple times per day, the preexercise plate may mimic more like that for fitness or performance (see Figure). This plate would have a gradual focus on starchier CHO such as pasta, rice, potatoes, breads, cereals, and fruit, with one fourth of the plate coming from protein and one fourth from quickly digesting vegetables such as steamed carrots, butternut squash, or vegetable soup. Thus, more processed, easily digestible CHO, including starchy vegetables, are appropriate for prolonged exercise, high-intensity or intermittent-type physical demands because these foods can be absorbed quicker than less processed starches, and if consumed in higher amounts and sufficiently before the onset of exercise, they contribute to stored energy (*e.g.*, liver and muscle glycogen) for the exercise session (6).

TABLE 1: **Carbohydrate Content of Common Foods and Fluids**

Food	CHO (g)	Sport Foods/Drinks	CHO (g)
1 medium Bagel	50	Sport drink (8 oz)	15
1/2 cup rice, cooked	25	Sport bar	25 to 45
1/2 cup pasta, cooked	15	Energy gel	25
1 cup vegetables, cooked	10	3 Energy blocks/chews	25
1 cup starchy vegetables	20	Chocolate milk (8 oz)	20
1 whole fruit	25	1 Serve recovery mix	30 to 50
1 cup plain yogurt	12	Low-fat milk smoothie (6 to 10 oz)	25 to 40
1 cup fruit yogurt	15 to 25	Fruit juice (8 oz)	25 to 30

1 Fluid ounce (oz) = 29.6 mL or approximately 30 mL.

Figure. Ideas for a healthy, fitness, and performance plate. Figure courtesy of Nanna Meyer, Ph.D, R.D., CSSD and Katie Frushour, R.D.



The closer to the start of exercise, the smaller the meal should be. Individuals may benefit from consuming CHO such as fresh fruit or fruit compote; half a bagel with a little almond or peanut butter and jam; cereal with milk and fruit; a CHO sports bar; or 8 oz of a sport drink (≤1 hour before exercise). Although consuming CHO in the hour before exercise can result in hyperglycemia (*e.g.*, high blood glucose), often followed by a rapid decrease in blood glucose concentration (also called rebound hypoglycemia) at the onset of exercise, these metabolic challenges show no negative performance impact (10). Additionally, research has shown that consuming a small snack or drinking a sport drink before the exercise session may be a good approach to aid with glucose delivery to both muscle and the brain, especially if the last meal was consumed more than 3 to 4 hours before exercise or if clients are hungry or tired.

Fluids

Four hours before a workout, individuals are advised to drink 5 to 7 mL of water or sport drink/kg body mass (~1.5 to 2 cups) (21). This will optimize hydration and allow time for excretion of any excess fluid. To meet weight loss goals, individuals may prefer flavored water, diluted apple juice (a European tradition), or a low calorie sport drink over other beverages. A good way to monitor hydration status before exercise is to check one's urine color. It should be lightly yellow (*e.g.*, like lemonade), which indicates adequate hydration. Clients/fitness professionals should not begin exercise being thirsty. An additional 3 to 5 mL/kg body mass (~1 to 1.5 cups) of fluid should be consumed if urine is dark yellow (21).

FUELING DURING EXERCISE

CHO intake during exercise has been shown to maintain energy levels and improve exercise capacity and performance of endurance and intermittent type sports (for reviews, see Karelis *et al.* (11), Phillips *et al*. (18), and Temesi *et al*. (24)). CHO supplementation during prolonged exercise serves to reduce mental fatigue and maintains CHO oxidation rates (*e.g.,* the ability of the muscle to burn CHO), especially late during exercise. These two issues are critical to prevent the famous "bonking" or "hitting the wall," and therefore, CHO supplementation helps to maintain blood glucose concentration and exercise intensity and, thus, delays the onset of fatigue. Therefore, CHO supplementation during exercise may make the overall physical task more enjoyable and do so with less strain to both body and mind. However, CHO supplementation during exercise may not be suitable for everyone. In fact, there is little benefit to using CHO for a low intensity, 45- to 60-minute exercise bout, such as a cardio session in the gym, especially if incorporated for weight management. For activities exceeding 1 hour, CHO supplementation may be recommended.

How much CHO is necessary to provide a performance benefit depends on the duration and intensity of exercise, the goal of the session, and other factors; however, amounts between 30 and 60 g/h typically are recommended (19). If exercise is shorter than 60 minutes, the individual has eaten within 3 to 4 hours of exercise, and the goal is weight loss, then the intake of water is sufficient. However, if clients have neglected to eat, then they might try consuming some CHO (*e.g.*, sport drink, CHO-containing bar or gel) during exercise to maintain exercise intensity and focus. This also could be accomplished by drinking a lower calorie sport drink with electrolytes. The recommended CHO amount for moderately intense exercise sessions, lasting between 1 and 2 hours, is 30 g/h. If exercise exceeds 2 hours, includes multiple workouts, or is intense, the intake of a sport drink, CHO-containing bar, gel, real food, or a combination aiming at approximately 60 g of CHO/h (9) (see Table 1 for CHO content), taken in 15- to 20-minute intervals, is recommended.

The CHO ingested during exercise is absorbed via multiple transporters in the small intestine (5). There is a transporter for glucose and a transporter for fructose. Once absorbed, the CHO is transported to muscle and converted to energy through oxidation. Recently, it has been shown that oxidation rates can be maximized if enough CHO is ingested and that the gastrointestinal transport mechanism is likely the rate-limiting factor relative to how much ingested CHO is ultimately oxidized in muscle (8). Thus, products with multiple sugars (*e.g.*, glucose and fructose) use two transport systems, which move CHO across the intestinal wall for absorption into the blood stream more efficiently than a single transporter (8). This is important especially if the rate of CHO ingestion exceed 60 g/h (7), as the glucose transporter seems to be saturated at approximately 1 g/min. Rarely are such high ingestion rates recommended in recreational exercisers, but they are recommended for intense events exceeding 3 hours (3,9) and have recently been shown to enhance endurance performance over more conservative intakes (4,25).

The form of CHO ingested (*e.g.*, sport drink versus bar) does not seem to alter the gut's ability to absorb the CHO or the muscle's capacity to oxidize CHO. Thus, as long as the amount and type of sugar (at high ingestion rate) are selected carefully and the exerciser has habituated to the intakes, the CHO form does not seem to play a role (16,17).

Regardless, clients or fitness professionals should test fueling strategies during exercise for preference, tolerance, and ultimately, efficacy. Gastrointestinal problems often arise because people are afraid of "hitting the wall" and think "more food and drink is better." However, keeping things simple and using what's been proven, such as a sport drink and an extra energy source (*e.g.*, bar, gel, or food) on an hourly basis for prolonged and high-intensity exercise is the best approach to optimize fueling.

Fluid

Fluid replacement during exercise should occur according to sweat rate, which can vary with environmental factors such as heat and humidity, exercise intensity, sport, age, and sex (21). Sweat rate can be estimated from preweight and postweight measures and fluid intake (Table 2).

Although replacing too little fluid, or becoming dehydrated, is probably more likely in exercisers, health and fitness professionals also should alert their clients that drinking too much may be just as dangerous. Hyponatremia, or the dilution of plasma sodium level, commonly referred to as water intoxication, can be fatal and is common in prolonged activities such as the marathon. Data show that slow marathon times, smaller body size, and weight gain from excessive fluid intake during the marathon are risk factors of hyponatremia (2).

FUELING AFTER EXERCISE

Recovery nutrition has gained great attention in both the fitness industry and in elite sports. The aim of recovery nutrition is to replace what is lost during exercise (*e.g.*, fluid, glycogen) and to support an optimal hormonal and metabolic environment to promote muscle building and repair, ultimately resulting in training adaptations. Therefore, the initial strategy for recovery nutrition should include fluid, electrolytes (*e.g.*, sodium), CHO, and protein. Whether recovery nutrition shortly after exercise is necessary depends on the amount of recovery time between exercise sessions and when the next eating occasion may occur. For the occasional exerciser, drinking chocolate milk and eating a big meal right after exercise is probably too much of a good thing. However, for daily gym goers, or clients with serious fitness, muscle mass, and performance goals, immediate recovery nutrition strategies should be considered.

Fluids and Electrolytes

One of the most important aspects of recovery is replacing lost fluids and electrolytes. To achieve optimal rehydration after exercise, 1.5 times more fluid should be consumed than what was lost (see Table 1 for rehydration recommendation) (23). Consuming rehydration beverages with electrolytes or consuming water with a snack and continuing to rehydrate with subsequent meals/snacks will optimize fluid and electrolyte replacement (13).

Carbohydrate

The window for optimal recovery of muscle energy (glycogen) stores ranges from 30 minutes to 4 hours after exercise. The earlier CHO is ingested within this window, the faster glycogen (energy) stores are replenished. To fully replenish glycogen stores (*e.g.*, after a marathon, soccer match, or heavy 2-hour lifting protocol), 24 hours are needed generally (3). Thus, immediate CHO intake is important especially for those exercising multiple times per day or engaging in high-intensity or prolonged exercise. These individuals should aim at ingesting approximately 1 to 1.2 g CHO/kg/h (~0.4 to 0.5 g/lb/h; see Table 1 for CHO content). This means that recovery occurs over a period of several hours, starting with initial recovery within the first 30 minutes after exercise and repeatedly for up to 4 hours (3,26). For most recreational exercisers, the timing and amount of CHO intake is not as critical, as long as a meal is consumed within a reasonable time frame after exercise. A great way to initiate the recovery processes is using a sport drink, even if lower in calories or diluted. It assists in quick rehydration because of fluid, sodium, and glucose working together for timely absorption. In addition, CHO promotes glycogen resynthesis. Adding protein in the form of a snack to the sport drink or combining all four components in a recovery beverage can meet easily the initial postexercise needs!

Protein

Adding protein to a postworkout recovery strategy supports muscle repair and growth. Recent research suggests that consuming

TABLE 2: **Sweat Rate Calculation for a Female Exerciser**

Date	Workout Condition	Preexercise Weight	Postexercise Weight	Weight Change	Fluid Loss During Exercise	Fluid Consumed During Exercise	Fluid Loss + Fluid Consumed	Hourly Sweat Rate
July 23, 2011	1 hour indoor spinning	130 lbs (59.1 kg)	129 lbs (58.6 kg)	1 lb (~0.5 kg)	16 oz* (~454 mL)	8 oz	16 + 8 = 24 oz	24 oz
Replacement of fluid during exercise	Drink 16 to 20 oz/hour for spinning indoors or simply avoid a body mass loss greater than 2% in temperate, warm environments. Avoid weight gain from consuming too much fluid.							
Rehydration after exercise	Drink 1.5 × 24 oz (= 36 oz) over the course of several hours to optimize rehydration.							

**1 lb of body mass equals 16 oz of fluid. 1 kg = 2.2 lbs. 1 quart (32 oz) = ~1000 mL or 1 L.*

TABLE 3: **Example of Clients and Recommendations for Fueling Fitness**

Situations	Before	During	After
Normal weight female skips lunch frequently before a 75-minute gym workout, which starts with cardio, followed by lifting and Pilates. She does not like to eat before workouts but reports feeling dizzy during exercise.	She may try to eat lunch 2 to 3 hours before exercise. Lunch example: Sandwich with whole grain bread, mustard, turkey, lettuce, tomato w/ fresh fruit, and glass of regular or soy milk	Although water is appropriate, she may consume a sport drink at 30 g CHO/h, especially if lunch is small or nonexisting. A combination of water, gels, or blocs also may be appropriate.	To optimize protein synthesis and recovery from resistance exercise, she may consider ingesting a recovery mix or sport drink + snack (*e.g.*, yogurt, chocolate milk, or bar containing some protein).
Overweight client is focused on fat and weight loss. He exercises in the pool using a combination of swimming, water walking, and water aerobics. His workout is scheduled from 10 to 11:30 a.m. He wonders about how to optimize weight loss through proper fueling.	He may try to eat breakfast around 7:30 a.m. Breakfast example: Bowl of fresh, seasonal fruit, topped with Greek-style yogurt, granola sprinkles, coffee/tea, and water	Water	He may eat lunch within 1 hour of exercise. Lunch example: Fresh salad bowl topped with grilled tilapia and a fresh fruit, black bean salsa, olive oil, vinegar, cucumber water or water.
A first-time marathoner is getting ready for a marathon in Florida.	She may try to eat a high CHO diet (7 to 10 g CHO/kg per day) 3 days before marathon start. She should get assistance from a sport dietitian for CHO loading. Her last meal (*i.e.,* breakfast) should be consumed 3 to 4 hours before race start. Preevent breakfast example: Bowl of oatmeal with apple sauce, brown sugar, salt 2 scrambled eggs with light wheat toast and diluted juice or sport drink 60 minutes before: 1 cup of sport drink or 1 gel + water	Sport drink according to sweat rate + gels at 20- to 30-min intervals with ~60 g CHO/h of exercise. Attention to dehydration and overhydration, especially in high heat and humidity.	To assist with recovery, she may prioritize sport drink, water, yogurt, smoothie, chocolate milk, or a recovery product immediately after the race, followed by a balanced meal with some salty food and additional fluids.
An older adult is starting out with resistance training. His goal is to increase muscle mass. Training occurs from 7 to 9 a.m., before work.	He may eat a small breakfast before lifting. Breakfast example: Bowl of whole grain cereal with low fat milk and seasonal fruit. Water, coffee, or tea.	Water	To optimize muscle protein building, he may consume chocolate milk, a milk- and/or yogurt-based smoothie or a recovery mix. For continued recovery, an additional snack 1 hour later also may be recommended, followed by lunch. Snack example: Turkey jerky, cucumber slices, whole grain crackers

approximately 15 to 25 g of protein (1), typically found in milk (8 g of protein per cup), a Greek yogurt (15 to 20 g of protein per cup), or commercially available recovery products (*e.g.*, CHO-protein mix, CHO-protein bar), is the maximum needed to stimulate muscle repair and growth after exercise.

Protein should be ingested as part of a recovery snack or beverage as soon as is possible after exercise, especially after resistance exercise (15), after intense endurance exercise (12), and if energy and/or CHO intake is reduced for weight loss, but the training goal is to optimize muscle mass (14,26). Repeated feedings of protein throughout the day in the form of meals and snack can support further muscle protein building (19). For most exercisers, a meal containing protein (4 to 6 oz of meat, poultry, fish, or vegetarian equivalents) ingested within 1 to 2 hours after exercise will be sufficient (Table 3).

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CONDENSED VERSION AND BOTTOM LINE

Adopting nutritional strategies within the joint position statement often will improve exercise tolerance and help fitness professionals and their clients recover rapidly from workouts. An important premise of these general recommendations is that the optimal mixture of nutrients to speed recovery from hard training and competition can be obtained by consuming wholesome foods and beverages, provided correct choices are made regarding quantity, quality, and timing. The primary advantages of properly formulated products marketed for "sports nutrition and recovery" are convenience and good taste.