GATORADE SPORTS SCIENCE INSTITUTE

PRACTICAL SPORTS NUTRITION: MAINTAINING HYDRATION AND PROPER FUELING

FUELING ATHLETIC PERFORMANCE

THE IMPORTANCE OF MAINTAINING HYDRATION AND PROPER FUELING FOR ATHLETES

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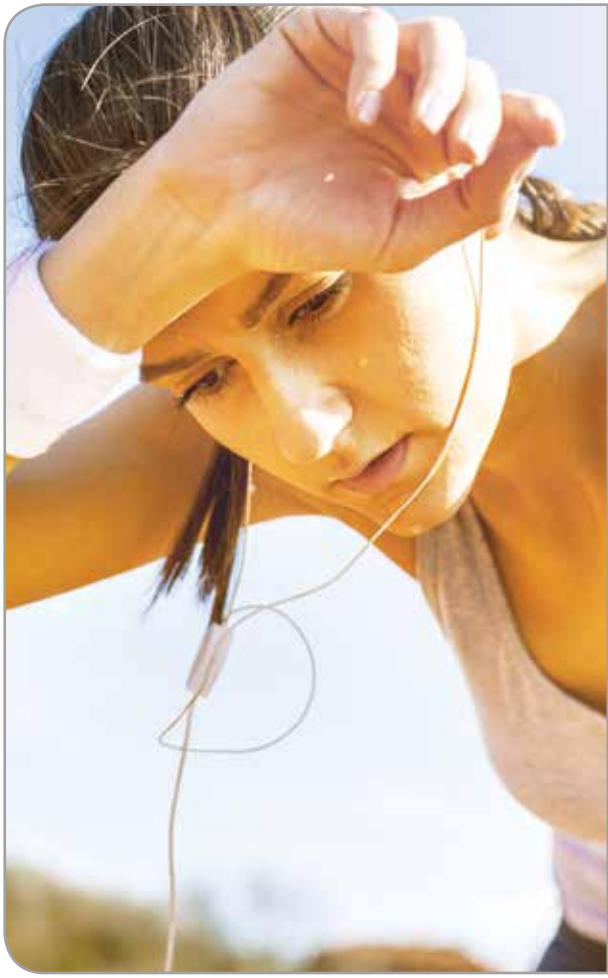
FLUIDS AND HYDRATION

Physiology of Hydration

Hydration is an essential component of a diet to attain optimal performance in training/competition. We sweat during exercise to dissipate heat and keep cool, and to limit the increase in our core body temperature. If an athlete does not replace the lost sweat, they can become mildly dehydrated (~2% of body mass lost through sweat). They will experience a drop in blood volume and a reduction in blood flow to the skin. Maintaining blood flow to the skin during high intensity exercise is important as that is how we transfer the heat generated in the body to the periphery, where it can be lost through sweating.[1] Mild dehydration has been shown to impair the ability to compete at a high level in athletes by decreasing muscle function and the ability of the brain to stay alert and focused.[2,3,4]



Some important points about hydration:

- Sweat is mostly water and salt (electrolytes). The more one sweats during activity, the more fluid and salt that must be replaced.
- Thirst may not be a good indicator of dehydration. Consume fluids before you feel thirsty.
- Consume water and preferably sport drinks (as they provide fluid, electrolytes and energy) before, during and after exercise.

Remember, sweat rate is unique so there are no generic recommendations for all athletes.

Why is a sports drink useful during intense exercise?

A sports drink during exercise is best suited to give the body what it needs. It replaces the fluid and some of the salt that is lost through sweating. It also has some carbohydrate in the form of sugar to fuel the muscles and the brain during physical activity, as carbohydrate is the fuel of choice for stop-and-go sports and most high-intensity activities that athletes engage in. Finally, sports drinks also taste good when athletes are hot, sweaty and thirsty. The salt in sports drinks also has the proper electrolyte profile to maintain the physiological drive to drink. Many athletes rely on thirst alone to stimulate drinking, but thirst may be an inaccurate gauge of fluid needs when we're physically active. Thirst is driven by two key physiological changes: a rise in the concentration of sodium level and a drop in blood volume. Whenever we sweat, part of that sweat comes from our blood. Since we lose more water molecules from the blood than we do electrolytes, the plasma-sodium concentration (the saltiness of the blood) rises, which stimulates thirst. However, if sweat is replaced by plain water, the plasma sodium concentration falls, which reduces thirst.[1]

Practical Applications

- A good way to determine if athletes are staying hydrated is to weigh them in minimal clothing, such as shorts and t-shirt, before and after practices and competitions. If an athlete loses more than 1.5-2% of their body mass, it is likely that their performance may suffer.

For example, a 70 kg person should not lose more than 1.05 -1.4 kg through sweating (equivalent to 1.05 - 1.4 litres of sweat). A smaller person or child weighing 50 kg should not lose more than 0.75 - 1.0 kg of body mass during practices and competitions. Ideally, little or no weight loss during activities is desired (especially if activity will occur again later in the day).

- Adults and children generally underestimate their fluid needs during exercise lasting more than 30 minutes. As children respond to dehydration with a larger increase in their core body temperatures, every effort should be made to prevent exercise-induced dehydration in child athletes.

- One should make certain that children and adults arrive fully hydrated for practice sessions and competitions. This can be achieved by drinking ~400 mL of fluid in the 60-90 minutes before activity for children and ~500-700 mL for adults. Support personnel need to enforce drink pauses every 15-20 min during practices, even when the athletes do not feel thirsty. Some sports games give ample opportunities to drink as the shifts of the game allow constant access to drinks (hockey), while others do not (soccer).

- In tournament situations, it is important to make sure athletes drink enough during or after each game to maintain their body mass. This will ensure they are properly hydrated for the following games, as they may be required to play 2-3 games per day. In some situations athletes are not allowed to leave the athletic venue until their body mass is the same as when they arrived.

- Cooling a drink to refrigerator temperature and, in particular, adding flavour to the drink will increase its taste. Athletes will voluntarily drink more when the drink is tasty. Therefore, beverages flavoured to satisfy each athlete's taste preference should be readily available for the athlete to drink before, during, and after training sessions and competitions.

THE IMPORTANCE OF CARBOHYDRATE FOR ATHLETES

Carbohydrate (in the form of sugar) is the dominant fuel for the contracting muscles and brains of athletes during stop and go sports. Carbohydrate provides the fuel for the high intensity "aerobic" aspect of exercise and also for the "anaerobic" sprints or bursts that characterize many sports. It is estimated that more than 75% of the fuel used by athletes during practices and games comes from carbohydrate.[5] Fat will provide much of the remaining energy (~20%) and protein is not a significant fuel source (~5%) in well-fed athletes.

Storing Carbohydrate in the body

Athletes store carbohydrate in their muscles as glycogen. Carbohydrate is also stored in the liver as glycogen. When an athlete is exercising at a high intensity, muscle glycogen is used to provide energy for the contracting muscles, while the liver releases carbohydrate from glycogen into the blood as glucose. The blood glucose is taken up and used by the muscles as well as by the brain, as glucose is the preferred fuel of the brain. The liver must release enough glucose into the blood to balance that used by the muscles and brain so athletes do not experience low blood sugar and fatigue. A proper carbohydrate-rich diet in the days and hours before practices and games ensures that the player's muscle and liver glycogen stores are full.

Fuel during exercise

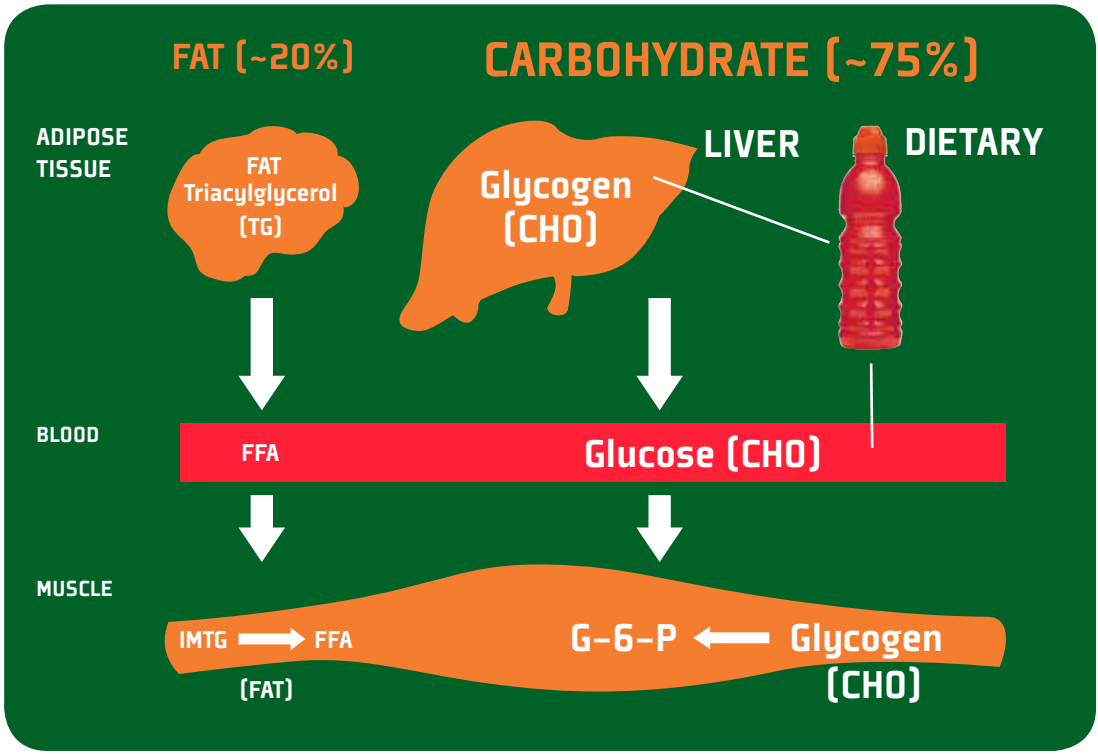
Athletes can help the liver preserve its glycogen by consuming carbohydrate during exercise. For instance, a well-formulated sports drink contains water and salt but also low levels of carbohydrate (6% or 6 grams sugar/100 mL of fluid). The carbohydrate is rapidly absorbed into the blood as glucose (or fructose which is converted to glucose in the liver) and used by the muscles and brain. When glucose is provided in this manner it reduces the need for muscle glycogen and also for liver glycogen, and allows the athlete to work harder and longer before their carbohydrate stores are depleted.[6] Consuming a sports drink with carbohydrate simply provides a third source of carbohydrate that augments what is stored in the muscle and liver.

Many studies in a variety of stop-and-go team sports have shown how important carbohydrate is as a fuel, and how ingesting low levels of carbohydrate (up to ~ 6 g/100 mL) during intermittent, high intensity exercise helps maintain maximum physical and mental performance. [2,3,4,6,7,8,9,10,11]

Signals to the Brain

Carbohydrate in a sports drink has one other very powerful effect. When it is ingested, the sugar in the drink is sensed by sugar receptors in the mouth. These sensors send signals to important areas in the brain that reduce the feeling of fatigue, maintain the ability to focus and stay alert, and ultimately improve performance as exercise is prolonged.[12]

FUEL SOURCES DURING EXERCISE



REFERENCES

1. Sawka MN, Burke LM, Eichner ER, et al. American College of Sports Medicine position stand. Exercise and fluid replacement. Med Sci Sports Exerc. 2007;39:377-90.

2. Davis, JM, DA Jackson, MS Broadwell, JL, Queary and CL Lambert, C.L. Carbohydrate drinks delay fatigue during intermittent, high-intensity cycling in active men and women. Int J Sport Nutr 7: 261–273, 1997.

3. Dougherty, KA, LB Baker, M Chow and WL Kenney. Two percent dehydration impairs and six percent carbohydrate drink improves boys' basketball skills. Med Sci Sports Exerc 38: 1650–1658, 2006.

4. Nicholas, CW, K Tsintzas, L Boobis, and C Williams. Carbohydrate-electrolyte ingestion during intermittent high intensity running. Med Sci Sports Exerc. 31: 1280–1286, 1999.

5. Green, HJ. Glycogen depletion patterns during continuous and intermittent ice skating. Med Sci Sports Exerc 10: 183-187, 1978.

6. Foskett, A, C Williams, L Boobis, and K Tsintzas. Carbohydrate availability and muscle energy metabolism during intermittent running. Med Sci Sports Exerc 40: 96–103, 2008.

7. Below, PR, R Mora-Rodriguez, J Gonzalez-Alonso, and EF Coyle. Fluid and carbohydrate ingestion independently improve performance during 1 h of intense exercise. Med Sci Sports Exerc 27: 200–210, 1995.

8. Currell, K, S Conway, and AE Jeukendrup. Carbohydrate ingestion improves performance of a new reliable test of soccer performance. Int J Sports Nutr Exerc Metab 19:34-46, 2009.

9. Linseman, ME, MS Palmer, HM Logan-Sprenger, and LL Spriet. Mild dehydration impairs thermoregulation and performance during an ice hockey scrimmage. Appl Physiol Nutr Metab 39:1214-1221, 2014.

10. Nicholas, CW, C Williams, HK Lakomy, G Phillips, and A Nowitz. Influence of ingesting a carbohydrate-electrolyte solution on endurance capacity during intermittent, high-intensity shuttle running. J Sports Sci 13: 283–290, 1995.

11. Welsh, RS, JM David, JR Burke, and HG Williams. Carbohydrates and physical/mental performance during intermittent exercise to fatigue. Med Sci Sports Exerc 34: 723-731, 2002.

12. Chambers ES, MW Bridge DA Jones. Carbohydrate sensing in the human mouth: effects on exercise performance and brain activity. J Physiol 587:1779-94, 2009.

EATING AROUND EXERCISE: FOOD IDEAS

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What we eat and drink around exercise provides fuel for performance and helps our body recover.[1] Finding the right foods to eat around exercise can be challenging. Common mistakes include eating too much fat and protein before exercise and not consuming enough carbohydrate during and after exercise.

Carbohydrate is our main fuel for exercise

It is important to consume carbohydrates at regular intervals during the day (every 2-4 hours)[2], along with smaller amounts of protein and fats. In the hour before exercise, limit fat and protein. Fat and protein are slower to digest leaving your stomach feeling heavy and full.

Don't forget protein for a speedy recovery

For fast recovery from exercise - choose a snack with at least 1.0 g/kg carbohydrate and 0.25 g/kg protein. For an 80 kg (175 lb) athlete - 80 g of carbohydrate and 20 g of protein.[3,4,5] A snack in the 30 minutes after exercise can help to increase your speed of recovery. If you have at least one full day to recover before your next intense workout, an immediate snack is not necessary as long as you eat carbohydrate rich foods at regular intervals throughout your day.[6]

Proper hydration is critical

Remember to hydrate before, during and after exercise. A handy strategy is to weigh yourself before and after exercise. Even sweat losses of less than 2% of your body weight can hurt your performance.[7] Consume at least 500 mL of fluid in the few hours before exercise, drink enough during exercise to prevent weight loss and after exercise replenish any weight lost at a rate of 1 - 1.5 L per kilogram of sweat lost.[8]

Practice your fueling during your regular workouts and begin to develop a list of foods and drinks that work for you

Refer to the list on the following page for some ideas to get you started. Remember to always try the suggestions before using them in a competition situation. Everyone is different – find out what works best for you!

REFERENCES

1. Nutrition and Athletic Performance, Joint Position Paper, Dietitians of Canada, American College of Sports Medicine. American Dietetic Association. 2008.

2. Schabort EJ, Bosch AN, Weltan SM, Noakes TD. The effect of a preexercise meal on time to fatigue during prolonged cycling exercise. Med Sci Sports Exerc. 1999;31:464-471.

3. Witard, O. C., Jackman, S. R., Breen, L., Smith, K., Selby, A., & Tipton, K. D. (2014). Myofibrillar muscle protein synthesis rates subsequent to a meal in response to increasing doses of whey protein at rest and after resistance exercise. The American Journal of Clinical Nutrition, 99(1), 86–95.

4. Witard et al, The Sport and Exercise Scientist, Issue 41, Autumn 2014 n www.bases.org.uk.

5. Moore, D.R. et al. (2014). Protein Ingestion to Stimulate Myofibrillar Protein Synthesis Requires Greater Relative Protein Intakes in Healthy Older Versus Younger Men. Journal of Gerontology Biological Sciences & Medical Sciences, In press.

6. Burke LM, Collier GR, Davis PG, Fricker PA, Sanigorski AJ, Hargreaves M. Muscle glycogen storage after prolonged exercise: effect of the frequency of carbohydrate feedings. Am J Clin Nutr. 1996;64:115-119.

7. Ryan et al, JAP, 1998

8. Sawka MN, Burke LM, Eichner ER, Maughan RJ, Montain SJ,Stachenfeld NS. American College of Sports Medicine position stand. Exercise and fluid replacement. Med Sci Sports Exerc. 2007;39:377-390.

9. Ivy JL, Katz AL, Cutler CL, Sherman WM, Coyle EF. Muscle glycogen synthesis after exercise: effect of time of carbohydrate ingestion. J Appl Physiol. 1988;64:1480-1485.

10. Burke LM, Collier GR, Hargreaves M. Muscle glycogen storage after prolonged exercise: effect of the glycemic index of carbohydrate feedings. J Appl Physiol. 1993;75:1019-1023.

	Options Prepared at Home	Options on the Road
Light Breakfasts Could be eaten 1-2 hrs before exercise. <10g of fat to aid digestion. Drink 2-4 cups (0.5-1 L) fluid. (Any combination of fluids: water, juice, milk, sport drink, coffee, tea etc.)	• Cereal and milk • Toast and peanut/almond butter • Egg whites and toast • Smoothie – fruit and yogourt • Homemade muffin and milk • Hot cereal: oats, instant oatmeal, cream of wheat • Bagel and light cream cheese or nut butter	• Bagel and light cream cheese or peanut/almond butter • Bars: granola, fruit or nut bars (Avoid bars with >15 g of protein this close to exercise) • Instant oatmeal or drive-thru oatmeal Try to avoid heavy, high fat foods 1-2 hours before exercise. Experiment and see what works for you.
Full Breakfasts Could be eaten 2-4 hours before exercise.[1] Drink 2-4 cups (0.5-1 L) fluid. (Any combination of fluids: water, juice, milk, sport drink, coffee, tea etc.)	• Eggs and toast, could include ham if you have at least 3 hrs pre-exercise • Whole grain cereal and milk • Peanut/almond butter and toast • Yogourt, fruit and nuts • Whole grain pancakes, crepes or French toast, cottage cheese + fresh fruit • Oatmeal with egg whites stirred in at the last few minutes of cooking	• Sport bars – most bars are fine if you have 3 hours to digest • If ordering eggs – request egg whites to lower fat content, whole grain toast, fruit instead of home fries, ham instead of bacon or sausage • Breakfast sandwich – ask to hold the butter if you are getting cheese or meat on the sandwich • Oatmeal, fruit and nuts • Pancakes, waffles and French toast at restaurants are high in carbohydrate, however can sometimes be very high in fat. Be aware of portion size and try to include whole grains and fruit.
Pre-exercise Meals (Lunch or Dinner) at least 2-4 hours before exercise.[1] Drink 2-4 cups fluid minimum.	• Any combination of protein, starch and vegetables: i.e.: fish, rice and vegetables • Chicken, pasta and salad • Homemade burger with extra-lean meat • Shepherd's pie with extra-lean meat • Grilled cheese (using light cheese) • Soup, salad and whole grain bread • Homemade lasagna with extra-lean meat and light cheese • Soft tacos or quesadillas made with lean meat, light cheese, vegetables and whole grain wraps	• Grilled meat/fish + rice/pasta + vegetables • Sub sandwich (check online for <20 g of fat incl. toppings) • Pasta with red sauce and salad (avoid commercial cream sauce due to high fat content) • Club sandwich – made with light mayo or butter (not both) • Chicken Caesar salad. Consider asking for the dressing on the side so you can limit to 2 Tbsp • Grilled chicken sandwich with salad or baked potato • Whole grain pizza with light toppings such as vegetables and chicken • Stop at a grocery store with a food counter and get salads, grilled meat, fruit, whole grain buns, etc. Try to avoid carbonated beverages, spicy foods and fried foods.
Recovery Snacks For fastest recovery (ie: tournament situation) consume a carb-protein snack within 30 min of exercise and refuel again every 2 hours.[9] Aim to take in .25 g/kg body weight of protein[1,2,3] and 1-1.5 g of carbs per kg of body weight.[9] Sugars are needed during and immediately after exercise since we want fast delivery of those carbs to the muscle.[10] Replace sweat lost by drinking 1 - 1.5 L of fluid for every kg of body weight lost during exercise.[8]	• Chocolate milk • Trail mix • Sandwich and juice • Yogourt and fruit • Smoothies • Bagel and cream cheese/peanut butter • Homemade muffin and milk • Cheese/crackers and juice • Cereal and milk • Cottage cheese and fruit • Applesauce and nuts • Cookies and milk • Any homemade meal or snack with a source of protein and a good source of carbohydrate ie: tuna pasta salad, eggs, toast and juice, cottage cheese and fruit, baked beans and toast, feta cheese and watermelon, sardines and toast, teriyaki stir fry with meat and rice etc.	• Commercial recovery shakes • Chocolate milk • Sport bars • Granola bars, nuts and juice • Smoothies/shakes • Sub sandwich and drink • Whole grain pizza with light topping • Any meal that contains source of protein and a good source of carbohydrate. Don't be afraid of sugars after exercise! They aid in fast delivery of nutrients to the muscle.[5]

Make a List of Your Favorite Pre-Game Meals and Snacks:

Home Prepared	On the Road

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