SPORTS BEVERAGES

Jacklyn Maurer, MS, RD

LEARNING OBJECTIVES

- Identify the role of fluid in sports nutritional beverages.
- Identify the role of carbohydrate in sports nutritional beverages.
- Identify the role of protein in sports nutritional beverages.
- Identify the role of caffeine in sports nutritional beverages.
- Make recommendations using different types of sports nutritional beverages in relation to exercise.

With so many sports nutritional beverages available, it's hard to find an active person who doesn't use at least one of them. This online quick course reviews the role of sports beverages as fuel for exercise, offers information on the science behind these beverages, and provides practical guidelines for the use of sports beverages in relation to exercise. Understanding the science and being familiar the current research regarding the ingredients in sports beverages will help you to better evaluate sports beverage products, answer questions from your clients, and make recommendations about the appropriate use of sports beverages.

THE SCIENCE BEHIND SPORTS BEVERAGES

Not all sports beverages are the same. Some simply replace carbohydrates and electrolytes; others provide added protein, specific amino acids, and even fat, while still others provide herbs, vitamins, and caffeine. Table 1 outlines the different categories of sports beverages.
(See Table 1. "Review of Sports Beverages," page 8.)

Sports beverages are formulated, some based on scientific research, others based on speculation, to contain nutrients (carbohydrate, protein, fat, vitamin, minerals, amino acids, water) and other substances (herbs, caffeine) in proportions that are intended to optimize energy levels, hydration, recovery, muscle growth/repair, and, ultimately, performance. Let's take a look at some of the different ingredients in sports beverages and the science behind them.

Fluid

Fluid replacement is critical to exercise performance due to the role of fluid in body heat regulation (a limiting factor in exercise) and maintenance of adequate hydration levels (ACSM, ADA, and DC, 2000; Murray, 2000). Just slight degrees of dehydration, ~2% of body water levels, can adversely affect exercise performance (Murray, 2000). Greater degrees of dehydration can lead to medical emergencies such as heat exhaustion. Adequate hydration translates into lower heart rate, lower core body temperature, lower rating of perceived exertion, higher stroke volume, higher cardiac output, higher skin blood flow, and, ultimately, better performance (Powers and Howley, 2004). Plain water is usually sufficient for fluid replacement for exercise bouts shorter than 1 hour. However, the benefit of sports beverages with carbohydrates and electrolytes (namely sodium) in addition to water for fluid replacement is that carbohydrate and sodium help promote water uptake in the small intestine and improve fluid absorption (Maughan, 2000). Appropriate fluid intake guidelines in relation to exercise are provided in the "Joint Position Statement: Nutrition and Athletic Performance" published by the American College of

Sports Medicine (ACSM), the American Dietetic Association (ADA) and the Dietitians of Canada (ACSM, ADA, and DC, 2000).

Carbohydrate

Studies on exercise physiology in relation to nutrient metabolism show that carbohydrate is the preferred fuel for both short-duration, high-intensity bouts of exercise, (e.g., fast break for the ball on the basketball court) and longer duration, higher intensity (>70% VO2max) exercise (e.g., 5k race) (Powers and Howley, 2004). In addition, research has demonstrated that depletion of muscle glycogen (stored carbohydrate) and blood glucose limit exercise duration and performance. Several studies have demonstrated the benefit of carbohydrate replacement during exercise that lasts longer than 1 hour (Jacobs and Sherman, 1999; Maughan, 2000; Sugiura and Kobayashi, 1998; Coleman, 2000) and cite that maximum benefit is achieved from a beverage containing 4 to 8% carbohydrate (ACSM, ADA, and DC, 2000; Manore and Thompson, 2000). This concentration should be comprised of glucose, sucrose, or glucose polymers rather than fructose, as the former have faster intestinal absorption rates and have been shown to enhance performance better than fructose (Coleman, 2000). Another factor to consider in carbohydrate-containing sports beverages is osmolality (the concentration of dissolved substances that contributes to a solution being isotonic, hypotonic, or hypertonic) (Maughan, 2000). Carbohydrate increases the osmolality of a solution, slows gastric emptying rates, and increases water flux into the intestine (Maughan, 2000). Most commercial carbohydrate/electrolyte replacement beverages are formulated to have osmolality close to human body fluids and, therefore, won't adversely affect gastric emptying and intestinal fluid flux.

Electrolytes

Sports beverages were developed to provide electrolytes to help replace essential minerals lost through sweating. Electrolytes are minerals, and sweat contains electrolytes in varying quantities. Sodium and chloride are the main electrolytes lost in sweat (Bergeron, 2000). Electrolytes commonly found in sports beverages, like sodium, chloride, and potassium, play key roles in preventing muscle cramps. Further, sodium replacement is critical in the prevention of hyponatremia, a condition of dangerously low blood sodium levels, resulting from both overhydration from fluids devoid of electrolytes (plain water) and excessive loss of sodium through sweat in the absence of sodium replacement (Bergeron, 2000; Manore and Thompson, 2000). Women and recreational athletes who compete in long-duration exercise (e.g., marathons) are at increased risk of hyponatremia due to habitually higher water intake and plain fluid replacement in excess of need. Active people who participate in endurance events like marathons or century cycling events need to be careful to replace lost electrolytes.

Protein

Protein is not a significant contributor to energy supply during exercise. Instead, its main role in the body is structural. In sports beverages, protein is added either in the form of whole protein, such as casein, whey, or soy, as individual amino acids like arginine, glutamine, or, more commonly, as branch chain amino acids (BCAA), leucine, isoleucine, and valine. The theory behind including BCAA in a sports beverage is that during prolonged exercise, BCAA are used for energy production (gluconeogenesis) when glycogen and blood glucose levels decline. As the amount of BCAA declines, an increase in the transport of tryptophan occurs across the blood-brain barrier, leading to central fatigue (secondary to increased brain levels of serotonin). Supplementation with BCAA is purported to delay the onset of this central fatigue by decreasing the entry of tryptophan across the blood-brain barrier. Although safe, convincing evidence of

improvement in performance secondary to BCAA supplementation does not exist. Further, ingesting carbohydrate during exercise blunts the fall in BCAA and the concurrent processes involved in the development of central fatigue (Burke, Desbrow, and Minehan, 2000; Skinner, Coleman, and Rosenbloom, 2000). BCAA consumption should be cautioned because large consumption of BCAA can increase plasma ammonia, which is related to brain toxicity and derangements in muscle metabolism, as well as decrease water absorption from the intestine, leading to gastrointestinal distress (Burke, Desbrow, and Minehan, 2000). Other single amino acids such as argigine, orthinine, lysine, and glutamine are also included in some sports beverages, but research does not support the benefit of any of these amino acids for exercise performance or recovery (Skinner, Coleman, and Rosenbloom, 2000). Given the limited evidence of any additional benefit of single amino acids on exercise performance, and the increased risk for diarrhea and cramping associated with ingestion of single amino acids, their inclusion in sports beverages is likely unnecessary for the general exerciser (Burke, Desbrow, and Minehan, 2000).

On the other hand, there is emerging evidence that supports that a small amount of complete protein (containing all essential amino acids (EAA)) during the recovery period following exercise promotes an anabolic environment that fosters improved conditions for protein synthesis and possibly leads to greater gains in muscle mass with training (Gibala, 2002). A study in recreationally active healthy males and healthy females aged 19-25 found that consumption of a drink with ~0.01 grams per kilogram body weight of essential amino acids 1 and 2 hours postexercise increased net protein balance (Borsheim et al., 2002). Given these findings it appears beneficial to have a complete protein in postrecovery, in addition to carbohydrate. It should be noted that this amount of protein is very small and likely to be met by 1/2 to 1 cup of milk (4 to 8 grams of protein) for most average-sized adults, thereby negating the need to spend money on sports beverages that contain large amounts of protein.

Finally, controversy remains regarding the benefit of having protein in addition to carbohydrate in the immediate postrecovery nutrition plan (within 20 to 30 minutes postexercise). Some studies have reported that sports beverages with protein and carbohydrate elicited greater glycogen resynthesis rates than sports beverages with carbohydrate alone. It is important to note that many of these studies are flawed by their design, namely failure to use isocaloric beverages (both beverages have the same amount of calories) in their comparisons (Gibala, 2002). Studies comparing isocaloric beverages have demonstrated no added benefit of adding protein to a carbohydrate-alone sports beverage as long as the amount of carbohydrate is sufficient to meet postexercise needs (Gibala, 2002). A benefit of adding protein to a carbohydrate-alone beverage within 30 minutes postexercise and the previously demonstrated beneficial effects of protein consumption 1 to 2 hours postexercise on protein balance suggest that protein indeed plays an essential role in postexercise nutrition recovery.

Caffeine

The majority of research over the past 30 years supports the enhancing effect of low doses (5-6 mg/kilogram body weight) of caffeine on endurance exercise performance. Caffeine has been shown in some studies of short-duration, high-intensity exercise to be beneficial; however, not all research is supportive of these findings and most of the research was done on highly trained athletes (Burke, Desbrow, and Minehan, 2000). Therefore, the benefit may not translate to the recreational exerciser. In events lasting 30 to 60 minutes, caffeine ingestion has been shown to increase time to exhaustion and reduce the rate of perceived exertion. For exercise sessions lasting longer than 1 hour, research supports the benefit of caffeine increasing time to exhaustion, decreasing rate of perceived exertion, and in some trials, increasing glycogen sparing

(Skinner, Coleman, and Rosenbloom, 2000). The mechanism resulting in these effects is unclear but seems to be related to the effects of caffeine on the central nervous system (Skinner, Coleman, and Rosenbloom, 2000).

Few studies that have looked at the effect of combining caffeine in a sports beverage have shown beneficial results (Kovacs, Stegen, and Brouns, 1998). However, energy drinks such as Red Bull™ contain greater amounts of caffeine than carbohydrate/electrolyte sports drinks, and may also contain other herbs with similar effects as caffeine (Bonci, 2002). A high content of caffeine (often not apparent on the drink's label) and the potential adverse side effects related to some herbal ingredients make these types of energy drinks poor choices for sports nutrition.

GUIDELINES FOR THE USE OF SPORTS BEVERAGES IN RELATION TO EXERCISE

Before Exercise

If the client's goal is exercise performance, it is crucial that he or she eats before exercise. Typically, this pre-exercise meal should be consumed 2-4 hours before exercise (Coleman, 2000). Clients unable to eat solid food more than 2 hours before starting exercise will benefit from a meal replacement sports beverage. Clients who eat within the 2 hours before starting exercise, or not at all, may benefit from consuming a high-carbohydrate sports beverage within the hour before exercise. A carbohydrate/electrolyte beverage without any additional ingredients is the best choice for fuel consumption 1 hour before exercise. Protein or fat can linger in the stomach and leave the exerciser feeling heavy during activity. Further, high-carbohydrate sports beverages are absorbed more quickly than solid food and, therefore, can offset the occurrence of gastrointestinal distress (Coleman, 2000).

Best Sports Beverage Choices

- ***More than 2 hours before exercise, choose a meal replacement beverage.***
- ***Within 1 hour of exercise, choose a carbohydrate/electrolyte beverage.***

During Exercise

The current recommendations of the ACSM, ADA, and DC are to consume 30 to 60 grams of carbohydrate for every hour of exercise following the initial hour (ACSM, ADA, and DC, 2000).

Best Sports Beverage Choices

- ***Exercise lasting less than 1 hour, choose sports water or plain water.***
- ***Exercise lasting more than 1 hour, choose a carbohydrate/electrolyte beverage.***

After Exercise

Substantial research supports the consumption of carbohydrate in the quantity of 1.5 gram/kilogram body weight within 30 minutes following exercise and then again 2 hours later to replenish glycogen stores depleted during exercise lasting longer than 1 hour (Coleman, 2000). Additionally, recent research supports that a small amount of essential amino acids equivalent to 0.01 g/kg body weight consumed 1 and 2 hours postexercise, and possibly in combination with carbohydrate immediately following exercise, may enhance protein synthesis.

Best Sports Beverage Choices

- ***Following exercise lasting longer than 1 hour, choose a carbohydrate/electrolyte beverage or carbohydrate, electrolyte, and protein beverage.***

- ***2 hours following exercise (if no solid food is available) choose a meal replacement beverage.***

THE BOTTOM LINE

Ultimately, there is no "perfect" sports beverage. Each client's needs are different and the usefulness and potential benefits of sports beverages differ based on the intensity and duration of exercise, the environmental conditions, and the individual characteristics of the exerciser. Further, it is essential to realize that the majority of sports nutrition research is conducted on young, typically highly trained, male athletes. Knowing this, the results of sports nutrition research may not apply as perfectly as you would like to a client who is middle-aged and perhaps starting a physical activity program for the first time. In this case, suggest to your client that he or she eat a balanced diet and consume adequate fluids. Water, milk, juice, and food should take priority over sports beverages.

REFERENCES

Ahrendt, Dale. 2001. "Ergogenic aids: Counseling the athlete." *American Family Physician* 63, no.5: 913-922.

American College of Sports Medicine, American Dietetic Association, and Dietitians of Canada. 2000. "Joint position statement: Nutrition and athletic performance." *Medicine & Science in Sports & Exercise* 32: 2130-2145.

Bergeron, Michael. 2000. "Sodium: The forgotten nutrient." *Gatorade Sports Science Exchange* 13, no.3. Chicago: Gatorade Sports Science Institute.

Bonci, Leslie. 2002. "Energy drinks: Help, harm or hype?" *Sports Science Exchange* 15, no.1. Chicago: Gatorade Sports Science Institute.

Borsheim, E., K. D. Tipton, S. E. Wolf, and R. R. Wolfe. 2002. "Essential amino acids and muscle protein recovery from resistance exercise." *American Journal of Physiology and Metabolism.* 283:E648-E657.

Burke, Louise, Ben Desbrow, and Michelle Minehan. 2000. "Dietary supplements and nutritional ergogenic aids." In *Clinical sports nutrition,* 2d ed. L. Burke and V. Deakin, eds. Boston: McGraw-Hill.

Coleman, Ellen. 2000. "Carbohydrate and exercise." In *Sports nutrition: A guide for the professional working with active people.* C. Rosenbloom, ed. Chicago: American Dietetic Association.

Gibala, Martin. 2002. "Dietary protein, amino acid supplements, and recovery from exercise." *Sports Science Exchange* 15, no.4. Chicago: Gatorade Sports Science Institute.

Jacobs, Kevin Allen, and W. Michael Sherman. 1999. "The efficacy of carbohydrate supplementation and chronic high-carbohydrate diets for improving endurance performance." *International Journal of Sport Nutrition* 9:92-117.

Kovacs, Eva M, Jos HCH Stegen, and Fred Brouns. 1998. "Effect of caffeinated drinks on substrate metabolism, caffeine excretion, and performance." *Journal of Applied Physiology* 85, no. 2:709-715.

Manore, Melinda, and Janice Thomson. 2000. "Fluid and electrolyte balance." In *Sports nutrition for health and performance.* M. Manore and J. Thompson, eds. Champaign, IL: Human Kinetics.

Maughan, Ron. 2000. "Fluid and carbohydrate intake during exercise." In *Clinical sports nutrition.* 2d ed. L. Burke and V. Deakin, eds. Boston: McGraw-Hill.

Minehan, Michelle. 2003. "Sports water." Australian Sports Web – Australian Institute of Sport. Available at: http://www.ais.org.au/nutrition/FactSWater.htm.

Murray, Robert. 2000. "Fluid and electrolytes." In *Sports nutrition: A guide for the professional working with active people.* C. Rosenbloom, ed. Chicago: American Dietetic Association.

Powers, Scott, and Edward Howley. 2004. "Nutrition, body composition, and performance." In *Exercise physiology: Theory and application to fitness and performance.* 5th ed. S. Powers and E. Howley, eds. Boston: McGraw-Hill.

Skinner, Rob, Ellen Coleman, and Christine Rosenbloom. 2000. "Ergogenic aids." In *Sports Nutrition: A guide for the professional working with active people.* C. Rosenbloom, ed. Chicago: American Dietetic Association.

Sugiura, Katsumi, and Kando Kobayashi. 1998. "Effect of carbohydrate ingestion on sprint performance following continuous and intermittent exercise." *Medicine & Science in Sports & Exercise* 30, no.11:1624-1630.

Table 1. Review of Sports Beverages.

Category	Basic Components	Rationale & Use	Research to Support Efficacy & Benefit	Cautions	Example Products
CHO, Electrolyte Replacement	Glucose, glucose polymers, sucrose, sodium, potassium, chloride	CHO replacement during exercise lasting >1 hour; replacement of electrolytes lost through sweating; postexercise CHO/electrolyte recovery/replacement	Abundant for use during exercise lasting >1 hour and for postexercise recovery	To enhance absorption and maximize benefit, beverage should contain 4-8% CHO concentration; high fructose concentration may slow intestinal absorption and lead to GI distress	- Gatorade Thirst Quencher - Powerade - AllSport - Cytomax - Enervit G - GU 2 0 - Ulitma - Recharge - PowerBar Perform
CHO, Electrolyte Replacement with Protein	CHO (glucose, sucrose, glucose polymers), protein (whey, casein, amino acids), electrolytes (sodium, potassium chloride)	Protein will elicit higher insulin release postexercise than CHO alone; BCAA provide energy source during long-duration exercise, decrease central fatigue; protein/AA provide substrate for muscle repair and growth, gluconeogenic AA provide substrate for energy source during exercise	Equivocal; emerging research supports benefit of small amount of EAA after exercise for muscle repair and growth; CHO intake reduces decline in BCAA, questioning efficacy of BCAA supplementation when CHO supplementation is safe, effective, and less expensive	Protein intake during exercise may lead to GI distress; large amount of BCAA can lead to increased plasma ammonia levels that can impair muscle metabolism and be toxic to the brain	- Accelerade - Avalance - SoBe Sports System - Endurox R[4]
Meal Supplement	CHO, protein, fat	Liquid meal replacement or supplement; high CHO variety– purported use pre- or postendurance exercise; high protein variety-- purported use for muscle growth and weight gain; portable nutrition during travel	Limited scientific research; useful as compact source of calories for active people on the go or those needing weight gain; high CHO variety is useful as snack before exercise if person is unable to tolerate solid foods	Concentrated source of calories; caution should be used with people who watch calorie intake for weight management; should be used more as a meal replacement than as a supplement	- Gatorade Energy Drink - Slim Fast - Boost - Ensure - Carnation Instant Breakfast - Metabolol Endurance - Shaklee Physique - UltraFuel
Sports Water	CHO, sodium, potassium; some contain vitamins (B, C, E), calcium, magnesium, zinc, and may be artificially sweetened (no CHO)	An alternative to plain water with added features to help promote fluid intake (CHO, sodium); low calorie alternative to traditional sports beverages	No significant direct research; may prove beneficial for increasing fluid intake secondary to appealing flavors over plain water	Contains too little CHO concentration to provide recommended CHO intake during and postexercise; unnecessary and expensive source of additional vitamins	- Propel Fitness Water - Vitamin Water - Hansen's Purified Energy Water

Table 1. Review of Sports Beverages.-- *continued*

Category	Basic Components	Rationale & Use	Research to Support Efficacy & Benefit	Cautions	Example Products
Energy Drinks	CHO, caffeine, some contain herbs, amino acids, protein, MCT, simple sugars, vitamins, minerals	Ingredients serve to hydrate, energize, fuel, restore, and repair the body prior to and following exercise	Very little direct research, may improve readiness potential, cardiac contractility and concentration; unsubstantiated product label claims; due to lack of research evidence supporting enhanced performance, energy drinks are not currently recommended for fueling, replenishing, or rehydrating active people	Many of the ingredients in these beverages (AA, herbs, vitamins, minerals) have no demonstrated beneficial effects on exercise performance, and some may have adverse effects, e.g., Ephedra (and Ephedra-like substances); no long-term safety data; beverages are not formulated to promote rapid fluid absorption during and immediately after exercise and may hinder hydration; too high of a CHO concentration for rapid absorption during exercise; contain caffeine and high intakes can cause dizziness & tremors	- Red Bull - SoBe Adrenaline Rush - Monster Energy Drink - Hansen's Energy Drink

Key: CHO (carbohydrate), BCAA (branch chain amino acids), AA (amino acids), g, (gram), EAA (essential amino acids), kg, (kilogram), BW (body weight), GI (gastrointestinal), MCT (medium chain triglycerides)

References: Coleman, 2000; Skinner, Coleman, and Rosenbloom, 2000; Burke, Desbrow, and Minehan, 2000; Gibala, 2002; Minehan, 2003; Manore and Thompson, 2000; Bonci, 2002; Ahrendt 2001.

ABOUT THE AUTHOR

Jaclyn Maurer, M.S., R.D., (Jackie) completed a bachelor's degree in food science and human nutrition from the University of Maine in 2000. Immediately following graduation she moved to Tucson, Arizona, to start work on a master's degree in nutritional sciences at the University of Arizona. It was at this time that Jackie took over project coordination of the Combined Events Athlete Development project working with elite American USA track and field athletes. Jackie completed her master's degree in 2001 and then completed a dietetic internship at the University Medical Center, in Tucson, in May 2003. Immediately following her internship, Jackie returned to school as a graduate student seeking a doctoral degree in nutritional sciences with a minor in physiology.

In September of 2003, Jackie passed the American Dietetic Association National Registration Exam and became a registered dietitian. During her time in graduate school Jackie worked on research studies looking at the effects of exercise and hormone replacement therapy on bone mineral density in postmenopausal women (the BEST Study) and provided nutrition education to participants in a weight loss study, Healthy Weight 4 Life (HW4L). As mentioned above, Jackie is project coordinator for the Nutritional Assessment Division of the Combined Events Development Project, supported by USA Track and Field. In addition to her work with the combined events athletes, Jackie works with the College of Agriculture, Department of Nutritional Sciences, Cooperative Extension on outreach nutrition education. She also provides volunteer nutrition consulting for athletes at the University of Arizona and community presentations on sports nutrition to local running groups like Team in Training and the Better than Ever training group. She is a member of the American Dietetic Association and the Sports, Cardiovascular Nutritionists and Weight Management Dietetic Practice Groups of the American Dietetic Association. Ms. Maurer was recently selected as one of Arizona's Registered Young Dietitians of the Year for 2004.

On a personal note, Jackie is an avid runner and was a competitive distance runner from junior high school through college. She also has become a hiker since moving to Arizona.

A special thanks to our course reviewers.

Marlyn Black, BS
Personal Trainer, Lifestyles
Lakeland, Florida

Alison DeCaro, MS
Fitness Program Manager, US Air Force
Eglin AFB, Florida

Sarah Emanuel, MS
Assistant Director, Fitness and Wellness Services, University of Nebraska
Lincoln, Nebraska

Ann J. Rochford, MSW
Clinical Exercise Specialist, Columbia Association Athletic Club
Columbia, Maryland

Disclaimer
This learning guide is informational only. The data and information contained herein are based upon information from various published as well as unpublished sources and merely represent general training, exercise and health literature and practices as summarized by the authors and editors. Care has been taken to confirm the accuracy of the information presented and to describe generally accepted practice. However, the author and publisher are not responsible for errors or omissions or for any consequences from application of the information in this workbook. The publisher of this learning guide makes no guarantees or warranties, express or implied, regarding the currentness, completeness, or scientific accuracy of this information, nor does the publisher guarantee or warrant the fitness, marketability, efficacy, or accuracy of this information for any particular purpose. This summary of information from unpublished sources, books, research journals, and articles is not intended to replace the advice or attention of medical or health-care professionals. This summary is also not intended to direct anyone's behavior or replace anyone's independent professional judgment. If you have a problem with your health, before you embark on any health, fitness or sports training program, including the programs herein, please seek advice and clearance from a qualified medical or health-care professional. The publishers have made every effort to trace the copyright holders for borrowed material. If they have inadvertently overlooked any, they will be pleased to make necessary arrangements at the first opportunity.