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Role of nutrition in performance enhancement and post exercise recovery

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Abstract

A number of factors contribute to success in sport, and diet is a key component. An athlete's dietary requirements depend on several aspects, including the sport, the athlete's goals, the environment, and practical issues. The importance of individualized dietary advice has been increasingly recognized, including day-to-day dietary advice and specific advice before, during, and after training and/or competition. Athletes use a range of dietary strategies to improve performance, with maximizing glycogen stores a key strategy for many. Carbohydrate intake during exercise maintains high levels of carbohydrate oxidation, prevents hypoglycemia, and has a positive effect on the central nervous system. Recent research has focused on athletes training with low carbohydrate availability to enhance metabolic adaptations, but whether this leads to an improvement in performance is unclear. The benefits of protein intake throughout the day following exercise are now well recognized. Athletes should aim to maintain adequate levels of hydration, and they should minimize fluid losses during exercise to no more than 2% of their body weight. Supplement use is widespread in athletes, with recent interest in the beneficial effects of nitrate, beta-alanine, and vitamin D on performance. However, an unregulated supplement industry and inadvertent contamination of supplements with banned substances increases the risk of a positive doping result. Although the availability of nutrition information for athletes varies, athletes will benefit from the advice of a registered dietician or nutritionist.

Keywords: nutrition, diet, sport, athlete, supplements, hydration

Introduction

Carbohydrate loading aims to maximize an athlete's muscle glycogen stores prior to endurance exercise lasting longer than 90 minutes. Benefits include delayed onset of fatigue (approximately 20%) and improvement in performance of 2%–3%. Initial protocols involved a depletion phase (3 days of intense training and low carbohydrate intake) followed by a loading phase (3 days of reduced training and high carbohydrate intake). Further research showed muscle glycogen concentrations could be enhanced to a similar level without the glycogen-depletion phase and more recently, that 24 hours may be sufficient to maximize glycogen stores. Current recommendations suggest that for sustained or intermittent exercise longer than 90 minutes, athletes should consume 10–12 g of carbohydrate per kg of body mass (BM) per day in the 36–48 hours prior to exercise.

There appears to be no advantage to increasing pre-exercise muscle glycogen content for moderate-intensity cycling or running of 60–90 minutes, as significant levels of glycogen remain in the muscle following exercise. For exercise shorter than 90 minutes, 7–12 g of carbohydrate/kg of BM should be consumed during the 24 hours preceding. Some but not all studies have shown enhanced performance of intermittent high-intensity exercise of 60–90 minutes with carbohydrate loading.

Carbohydrate eaten in the hours prior to exercise (compared with an overnight fast) has been shown to increase muscle glycogen stores and carbohydrate oxidation, extend cycle time to exhaustion, and improve exercise performance. Specific recommendations for exercise of longer than 60 minutes include 1–4 g of carbohydrate/kg of BM in the 1–4 hours prior. Most studies have not found improvements in performance from consuming low glycemic index (GI) foods prior to exercise. Any metabolic or performance effects from low GI foods appear to be attenuated when carbohydrate is consumed during exercise.

Carbohydrate intake during the event

Carbohydrate ingestion has been shown to improve performance in events lasting approximately 1 hour. A growing body of evidence also demonstrates beneficial effects of a carbohydrate mouth rinse on performance. It is thought that receptors in the oral cavity signal to the central nervous system to positively modify motor output.

In longer events, carbohydrate improves performance primarily by preventing hypoglycemia and maintaining high levels of carbohydrate oxidation. The rate of exogenous carbohydrate oxidation is limited by the small intestine's ability to absorb carbohydrate. Glucose is absorbed by the sodium-dependent transporter (SGLT1), which becomes saturated with an intake of approximately 1 g/minute. The simultaneous ingestion of fructose (absorbed via glucose transporter [GLUT5]), enables oxidation rates of approximately 1.3 g/minute, with performance benefits apparent in the third hour of exercise. Recommendations reflect this, with 90 g of carbohydrate from multiple sources recommended for events longer than 2.5 hours, and 60 g of carbohydrate from either single or multiple sources recommended for exercise of 2–3 hours' duration (Table 1). For slower athletes exercising at a lower intensity, carbohydrate requirements will be less due to lower carbohydrate oxidation. Daily training with high carbohydrate availability has been shown to increase exogenous carbohydrate oxidation rates.

Table 1: Carbohydrate recommendations for well-trained athletes during exercise

Exercise duration	Example	Recommended carbohydrate intake per hour
30–75 minutes	Sprint triathlon (750 m swim, 20 km cycle, 5 km run) Netball (4× 15-minute quarters)	Small amounts or mouth rinse[a]
1–2 hours	Soccer/football – 2× 45-minute halves	30 g[a]
2–3 hours	Marathon run (42.2 km run)	60 g[a]
>2.5 hours	Half ironman triathlon (1.9 km swim, 90 km cycle, 21.1 km run)	90 g[b]

Notes:

[a] Single (eg, sports drinks containing glucose) or multiple (eg, sports drink containing glucose and fructose) transportable carbohydrates;

[b] multiple transportable carbohydrates only. Adapted from Jeukendrup A. A step towards personalized sports nutrition: carbohydrate intake during exercise. *Sports Med*. 2014;44 Suppl1:S25–S33.

The "train-low, compete-high" approach

The "train-low, compete-high" concept is training with low carbohydrate availability to promote adaptations such as enhanced activation of cell-signaling pathways, increased mitochondrial enzyme content and activity, enhanced lipid oxidation rates, and hence improved exercise capacity. However, there is no clear evidence that performance is improved with this approach. For example, when highly trained cyclists were separated into once-daily (train-high) or twice-daily (train-low) training sessions, increases in resting muscle glycogen content were seen in the low-carbohydrate-availability group, along with other selected training adaptations. However, performance in a 1-hour time trial after 3 weeks of training was no different between groups. Other research has produced similar results. Different strategies have been suggested (eg, training after an overnight fast, training twice per day, restricting carbohydrate during recovery), but further research is needed to establish optimal dietary periodization plans.

Fat as a fuel during endurance exercise

There has been a recent resurgence of interest in fat as a fuel, particularly for ultraendurance exercise. A high-carbohydrate strategy inhibits fat utilization during exercise, which may not be beneficial due to the abundance of energy stored in the body as fat. Creating an environment that optimizes fat oxidation potentially occurs when dietary carbohydrate is reduced to a level that promotes ketosis. However, this strategy may impair performance of high-intensity activity, by contributing to a reduction in pyruvate dehydrogenase activity and glycogenolysis. The lack of performance benefits seen in studies investigating "high-fat" diets may be attributed to inadequate carbohydrate restriction and time for adaptation. Research into the performance effects of high fat diets continues.

Protein

While protein consumption prior to and during endurance and resistance exercise has been shown to enhance rates of muscle protein synthesis (MPS), a recent review found protein ingestion alongside carbohydrate during exercise does not improve time–trial performance when compared with the ingestion of adequate amounts of carbohydrate alone.

Fluid and electrolytes

The purpose of fluid consumption during exercise is primarily to maintain hydration and thermoregulation, thereby benefiting performance. Evidence is emerging on increased risk of oxidative stress with dehydration. Fluid consumption prior to exercise is recommended to ensure that the athlete is well-hydrated prior to commencing exercise. In addition, carefully planned hyperhydration (fluid overloading) prior to an event may reset fluid balance and increase fluid retention, and consequently improve heat tolerance. However, fluid overloading may increase the risk of hyponatremia and impact negatively on performance due to feelings of fullness and the need to urinate.

Hydration requirements are closely linked to sweat loss, which is highly variable (0.5–2.0 L/hour) and dependent on type and duration of exercise, ambient temperature, and athletes' individual characteristics. Sodium losses linked to high temperature can be substantial, and in events of long duration or in hot temperatures, sodium must be replaced along with fluid to reduce risk of hyponatremia.

It has long been suggested that fluid losses greater than 2% of BM can impair performance, but there is controversy over the recommendation that athletes maintain BM by fluid ingestion throughout an event. Well-trained athletes who "drink to thirst" have been found to lose as much as 3.1% of BM with no impairment of performance in ultraendurance events. Ambient temperature is important, and a review illustrated that exercise performance was preserved if loss was restricted to 1.8% and 3.2% of BM in hot and temperate conditions, respectively.

Dietary supplementation: nitrates, beta-alanine, and vitamin D

Performance supplements shown to enhance performance include caffeine, beetroot juice, beta-alanine (BA), creatine, and bicarbonate.Comprehensive reviews on other supplements including caffeine, creatine, and bicarbonate can be found elsewhere. In recent years, research has focused on the role of nitrate, BA, and vitamin D and performance. Nitrate is most commonly provided as sodium nitrate or beetroot juice. Dietary nitrates are reduced (in mouth and stomach) to nitrites, and then to nitric oxide. During exercise, nitric oxide potentially influences skeletal muscle function through regulation of blood flow and glucose homeostasis, as well as mitochondrial respiration. During endurance exercise, nitrate supplementation has been shown to increase exercise efficiency (4%–5% reduction in VO_2 at a steady state; 0.9% improvement in time trials), reduce fatigue, and attenuate oxidative stress. Similarly, a 4.2% improvement in performance was shown in a test designed to simulate a football game.

BA is a precursor of carnosine, which is thought to have a number of performance-enhancing functions including the reduction of acidosis, regulation of calcium, and antioxidant properties. Supplementation with BA has been shown to augment intracellular carnosine concentration. A systematic review concluded that BA may increase power output and working capacity and decrease feelings of fatigue, but that there are still questions about safety. The authors suggest caution in the use of BA as an ergogenic aid.

Vitamin D is essential for the maintenance of bone health and control of calcium homeostasis, but is also important for muscle strength, regulation of the immune system, and cardiovascular health. Thus inadequate vitamin D status has potential implications for the overall health of athletes and performance. A recent review found that the vitamin D status of most athletes reflects that of the population in their locality, with lower levels in winter, and athletes who train predominantly indoors are at greater risk of deficiency. There are no dietary vitamin D recommendations for athletes; however, for muscle function, bone health, and avoidance of respiratory infections, current evidence supports maintenance of serum 25-hydroxyvitamin D (circulating form) concentrations of 80–100 nmol/L.

Diets Specific for Post Exercise

Recovery from a bout of exercise is integral to the athlete’s training regimen. Without adequate recovery of carbohydrate, protein, fluids, and electrolytes, beneficial adaptations and performance may be hampered.

Muscle glycogen synthesis

Consuming carbohydrates immediately postexercise to coincide with the initial rapid phase of glycogen synthesis has been used as a strategy to maximize rates of muscle glycogen synthesis. An early study found delaying feeding by 2 hours after glycogen-depleting cycling exercise reduced glycogen synthesis rates. However the importance of this early enhanced rate of glycogen synthesis has been questioned in the context of extended recovery periods with sufficient carbohydrate consumption. Enhancing the rate of glycogen synthesis with immediate carbohydrate consumption after exercise appears most relevant when the next exercise session is within 8 hours of the first. Feeding frequency is also irrelevant with extended recovery; by 24 hours postexercise, consumption of carbohydrate as four large meals or 16 small snacks had comparable effects on muscle glycogen storage.

With less than 8 hours between exercise sessions, it is recommended that for maximal glycogen synthesis, 1.0–1.2 g/kg/hour is consumed for the first 4 hours, followed by resumption of daily carbohydrate requirements. Additional protein has been shown to enhance glycogen synthesis rates when carbohydrate intake is suboptimal. The consumption of moderate to high GI foods postexercise is recommended; however, when either a high-GI or low-GI meal was consumed after glycogen-depleting exercise, no performance differences were seen in a 5 km cycling time trial 3 hours later.

Muscle protein synthesis

An acute bout of intense endurance or resistance exercise can induce a transient increase in protein turnover, and, until feeding, protein balance remains negative. Protein consumption after exercise enhances MPS and net protein balance, predominantly by increasing mitochondrial protein fraction with endurance training, and myofibrillar protein fraction with resistance training.

Only a few studies have investigated the effect of timing of protein intake postexercise. No significant difference in MPS was observed over 4 hours postexercise when a mixture of essential amino acids and sucrose was fed 1 hour versus 3 hours after resistance exercise. Conversely, when a protein and carbohydrate supplement was provided immediately versus 3 hours after cycling exercise, leg protein synthesis increased threefold over 3 hours. A meta-analysis found timed postexercise protein intake becomes less important with longer recovery periods and adequate protein intake, at least for resistance training.

Dose–response studies suggest approximately 20 g of high-quality protein is sufficient to maximize MPS at rest, following resistance, and after high-intensity aerobic exercise. Rate of MPS has been found to approximately triple 45–90 minutes after protein consumption at rest, and then return to baseline levels, even with continued availability of circulating essential amino acids (termed the “muscle full” effect). Since exercise-induced protein synthesis is elevated for 24–48 hours following resistance exercise and 24–28 hours following high-intensity aerobic exercise, and feeding protein postexercise has an additive effect, then multiple feedings over the day postexercise might maximize muscle growth. In fact, feeding 20 g of whey protein every 3 hours was subsequently found to maximally stimulate muscle myofibrillar protein synthesis following resistance exercise.

In resistance training, where postexercise intake of protein was balanced by protein intake later in the day, increased adaptation of muscle hypertrophy resulted in equivocal strength performance effects. Most studies have not found a subsequent benefit to aerobic performance with postexercise protein consumption. However, in two well-controlled studies in which postexercise protein intake was balanced by protein intake later in the day, improvements were seen in cycling time to exhaustion and in cycling sprint performance.

Fluids and electrolyte balance

Fluid and electrolyte replacement after exercise can be achieved through resuming normal hydration practices. However, when euhydration is needed within 24 hours or substantial body weight has been lost (>5% of BM), a more structured response may be warranted to replace fluids and electrolytes.

Risk of Contravening the Doping Regulations

Supplement use is widespread in athletes. It is difficult to compare studies due to differences in the criteria used to define dietary supplements, variations in assessing supplement intake, and disparities in the populations studied.

Athletes take supplements for many reasons, including for proposed performance benefits, for prevention or treatment of a nutrient deficiency, for convenience, or due to fear of "missing out" by not taking a particular supplement.

The potential benefits (eg, improved performance) of taking a dietary supplement must outweigh the risks. There are few permitted dietary supplements available that have an ergogenic effect Dietary supplementation cannot compensate for poor food choices. Other concerns include lack of efficacy, safety issues (toxicity, medical concerns), negative nutrient interactions, unpleasant side effects, ethical issues, financial expense, and lack of quality control. Of major concern, is the consumption of prohibited substances by the World Anti-Doping Agency (WADA).

Inadequate regulation in the supplement industry (compounded by widespread Internet sales) makes it difficult for athletes to choose supplements wisely. In 2000–2001, a study of 634 different supplements from 13 countries found that 94 (14.8%) contained undeclared steroids, banned by WADA. Many contaminated supplements were routinely used by athletes (eg, vitamin and mineral supplements). Several studies have confirmed these findings.

A positive drug test in an athlete can occur with even a minute quantity of a banned substance. WADA maintains a "strict liability" policy, whereby every athlete is responsible for any substance found in their body regardless of how it got there. The World Anti-Doping Code (January 1, 2015) does recognize the issue of contaminated supplements. Whereas the code upholds the principle of strict liability, athletes may receive a lesser ban if they can show "no significant fault" to demonstrate they did not intend to cheat. The updated code imposes longer bans on those who cheat intentionally, includes athlete support personnel (eg, coaches, medical staff), and has an increased focus on antidoping education.

In an effort to educate athletes about sports-supplement use, the Australian Institute of Sport's sports-supplement program categorizes supplements according to evidence of efficacy in performance and risk of doping outcome. Category A supplements have sound evidence for use and include sports foods, medical supplements, and performance supplements. Category D supplements should not be used by athletes, as they are banned or are at high risk for contamination. These include stimulants, prohormones and hormone boosters, growth hormone releasers, peptides, glycerol, and colostrum.

Conclusion

Athletes are always looking for an edge to improve their performance, and there are a range of dietary strategies available. Nonetheless, dietary recommendations should be individualized for each athlete and their sport and provided by an appropriately qualified professional to ensure optimal performance. Dietary supplements should be used with caution and as part of an overall nutrition and performance plan.

References

1. Burke LM, Meyer NL, Pearce J. National nutritional programs for the 2012 London Olympic Games: A systematic approach by three different countries. In: van Loon LJC, Meeusen R, editors. Limits of Human Endurance. Vol. 76. Vevey, Switzerland: Nestec Ltd; 2013. pp. 103–120. (Nestle Nutrition Institute Workshop Series).
2. Jeukendrup AE, Martin J. Improving cycling performance: how should we spend our time and money. Sports Med. 2001; 31(7):559-569.
3. Wright DA, Sherman WM, Dernbach AR. Carbohydrate feedings before, during, or in combination improve cycling endurance performance. J Appl Physiol (1985). 1991; 71(3):1082-1088.
4. Karlsson J, Saltin B. Diet, muscle glycogen, and endurance performance. J Appl Physiol. 1971; 31(2):203-206.
5. Sherman WM, Costill DL, Fink WJ, Miller JM. Effect of exercise-diet manipulation on muscle glycogen and its subsequent utilization during performance. Int J Sports Med. 1981; 2(2):114-118.
6. Raman A, Macdermid PW, Mündel T, Mann M, Stannard SR. The effects of carbohydrate loading 48 hours before a simulated squash match. Int J Sport Nutr Exerc Metab. 2014; 24(2):157-165.
7. Balsom PD, Wood K, Olsson P, Ekblom B. Carbohydrate intake and multiple sprint sports: with special reference to football (soccer) Int J Sports Med. 1999; 20(1):48-52.
8. Abt G, Zhou S, Weatherby R. The effect of a high-carbohydrate diet on the skill performance of midfield soccer players after intermittent treadmill exercise. J Sci Med Sport. 1998; 1(4):203-212.
9. Burke LM, Claassen A, Hawley JA, Noakes TD. Carbohydrate intake during prolonged cycling minimizes effect of glycemic index of pre-exercise meal. J ApplPhysiol (1985). 1998; 85(6):2220-2226.
10. Gant N, Stinear CM, Byblow WD. Carbohydrate in the mouth immediately facilitates motor output. Brain Res. 2010; 1350:151-158.
11. Sawka MN, Burke LM, Eichner ER, Maughan RJ, Montain SJ, Stachenfeld NS. American College of Sports Medicine American College of Sports Medicine position stand. Exercise and fluid replacement. Med Sci Sports Exerc. 2007; 39(2):377-390.
12. Australian Institute of Sport. ABCD Classification System [webpage on the Internet] Bruce, Australian Capital Territory: Australian Sports Commission; 2015. [Accessed March 24, 2015]. Available from: http://www.ausport.gov.au/ais/nutrition/supplements/classification.
13. Wylie LJ, Mohr M, Krustrup P, *et al.* Dietary nitrate supplementation improves team sport-specific intense intermittent exercise performance. Eur J Appl Physiol. 2013; 113(7):1673-1684.
14. Blancquaert L, Everaert I, Derave W. Beta-alanine supplementation, muscle carnosine and exercise performance. Curr Opin Clin Nutr Metab Care. 2015; 18(1):63-70.
15. Schoenfeld BJ, Aragon AA, Krieger JW. The effect of protein timing on muscle strength and hypertrophy: a meta-analysis. J IntSoc Sports Nutr. 2013; 10(1):53.

16. Hoffman JR, Ratamess NA, Tranchina CP, Rashti SL, Kang J, Faigenbaum AD. Effect of protein-supplement timing on strength, power, and body-composition changes in resistance-trained men. Int J Sport NutrExercMetab. 2009; 19(2):172-185.
17. Rowlands DS, Wadsworth DP. Effect of high-protein feeding on performance and nitrogen balance in female cyclists. Med Sci Sports Exerc. 2011; 43(1):44-53.
18. Nelson AR, Phillips SM, Stellingwerff T, *et al.* A protein–leucine supplement increases branched-chain amino acid and nitrogen turnover but not performance. Med Sci Sports Exerc. 2012; 44(1):57-68.
19. World Anti-Doping Agency. World Anti-Doping Code 2015. Montreal, Quebec: World Anti-Doping Agency, 2015.
20. Aljaloud SO, Ibrahim SA. Use of dietary supplements among professional athletes in Saudi Arabia. J NutrMetab. 2013; 245349.
21. Kim J, Lee N, Lee J, Jung SS, Kang SK, Yoon JD. Dietary supplementation of high-performance Korean and Japanese judoists. Int J Sport NutrExercMetab. 2013; 23(2):119-127.