



AIS SPORTS SUPPLEMENT PROGRAM WEBSITE FACT SHEET

Bicarbonate

Supplement Overview

- Bicarbonate is an extracellular anion with an important role in maintaining pH and electrolyte gradients between intra and extracellular environments.
- Even though bicarbonate already represents the most important extracellular buffer, consumption of large amounts of dietary bicarbonate (“bicarbonate loading”) can temporarily increase blood bicarbonate concentrations and pH, enhancing the buffering capacity of the extracellular space and, indirectly, the active muscle.
- High rates of anaerobic glycolysis in the muscle can produce hydrogen ions in excess of intracellular buffering capacity; however, increasing the extracellular pH and bicarbonate pool can enhance the efflux of the accumulating H⁺ in the muscle into the extracellular space for disposal. This tactic has been used as an ergogenic strategy for sporting events which are dependent on the generation of energy via anaerobic glycolysis.
- A simplistic view of events involving high rates of energy generation from anaerobic glycolysis is that they are limited by the body’s capacity to manage the progressive increase in the acidity of the intracellular environment. Although the direct role of hydrogen ion accumulation in muscle fatigue is unclear, there is evidence dating back to the 1930s that dietary strategies that decrease blood pH (e.g. intake of acid salts) impair capacity high-intensity exercise, while strategies that increase alkalosis such as the intake of bicarbonate improve such performance.
- The most common way to bicarbonate load is to ingest an acute dose of sodium bicarbonate in the hours before the targeted exercise session. Ideally, enough bicarbonate is consumed at the optimal time to sufficiently elevate blood bicarbonate levels to create a meaningful increase in blood buffering capacity
- Citrate loading has also been used as an alternative to bicarbonate loading due to the perception that it may create fewer side effects. However, there is good evidence from studies involving direct comparisons (van Montfoort et al. 2004) and meta-analyses (Carr et al. 2011a) that citrate is significantly less effective in enhancing performance.
- A serial supplementation protocol in which repeated doses of bicarbonate over several days has been shown to increase blood buffering capacity with effects lasting for at least 24 h following the last dose (McNaughton and Thompson 2001). This warrants further investigation although there is only preliminary evidence of performance benefits

Products and protocols

- The most commonly available and cheap source of sodium bicarbonate is the household/baking product, bicarb soda. However, most athletes find bicarb mixed in water to be unpalatably salty
- Alternative and more palatable forms of sodium bicarbonate are found in urinary alkalanisers developed to treat the symptoms of urinary tract infections. These are found both as both
 - capsules (Sodibic: 0.84 g per capsule)
 - flavoured effervescent powder (Ural: 1.76 g per sachet, plus additional amounts of sodium citrate).



Situations for Use in Sport

- There is good evidence for use by athletes competing in high-intensity competition events lasting 1-7 minutes – for example, swimming, rowing and middle distance running events. A recent meta-analysis that bicarbonate supplementation provides a moderate (1.7%) enhancement of the performance of high intensity events lasting ~ 1 min in male athletes, with
 - a smaller effect with an increase in event duration to 10 min+, in female athletes and untrained athletes
 - a larger effect in events with additional repeated sprints or with an increase in the dose above 300 mg/kg/d
- Some newer studies show that bicarbonate supplementation may have benefits for
 - high-intensity events of up to an hour which are conducted at workrates just below the so-called anaerobic/lactate threshold. Additional buffering capacity may support the athlete's ability to increase their pace/output for strategic periods (e.g. surges, sprint to the finish)
 - sports involving repeated sprints or intermittent high intensity activities such as team and racquet sports, and combat sports in which additional buffering can reduce the decline in performance associated with repetitive sprints.
- There is also preliminary evidence of superior adaptations to a block of training when acute bicarbonate supplementation is undertaken prior to a series of interval training sessions (Edge et al. 2006). Chronic support of such workouts may allow the athlete to train harder but cause less damage to the muscle. This needs to be validated within an athletic population.

Concerns Associated with Supplement Use

- The major side effect associated with bicarbonate loading is gastrointestinal distress, with symptoms including nausea, stomach pain, diarrhoea and vomiting. This is a serious practical consideration for athletes in a competition setting, and in some studies has been shown to counteract the potential performance benefits from enhanced buffering. A variety of options to reduce this risk is suggested but need to be better studied and subjected to individual experimentation.
 - It is generally advised that ingesting bicarbonate capsules or dissolvable powder with sufficient fluid to decrease the risk of hyperosmotic diarrhea.
 - Additional research undertaken at the AIS systematically studied a series of bicarbonate supplementation protocols, varying the time taken to consume the load (spreading it over 30-60 mins), the form of the bicarbonate (flavoured powder or capsules) and the consumption of various amounts of fluid or food with the bicarbonate (Carr et al. 2011b). Of the protocols tested, the best strategy to optimise blood bicarbonate and to reduce the occurrence of gastro-intestinal symptoms was to consume bicarbonate capsules in a spread-out protocol, commencing 120-150 min before the start of exercise and, if practical, at the same time as consuming a meal composed of carbohydrate-rich food choices and some fluid.
 - Alternatively, the "serial" protocol can be used in which divided loads of bicarbonate are taken for 3-5 days and then stopped 12-24 hours prior to the event. Ideally, the benefits of the bicarbonate loading will persist but will remove/reduce the risk of



gut problems by removing the need to take a dose immediately prior to competition.

- Repeated use of acute loading protocols (e.g. heats and finals in a single or multi-day competition) may exacerbate the risk of side-effects. This may be reduced if the athlete uses lower doses on subsequent occasions to compensate for bicarbonate remaining in the body, or uses the serial protocol.
- Changes in the pH of urine are expected following bicarbonate supplementation. If an athlete is selected for a drug test, they may need to wait several hours before urinary pH returns to the levels that are acceptable to drug testing authorities. This may cause some disruption to the athlete's routine.
- Interaction with other supplements may need to be considered (e.g. caffeine, [creatine](#), [β-alanine](#)).

Further reading

Carr AJ, Hopkins WG, Gore CJ. Effects of acute alkalosis and acidosis on performance: a meta-analysis. *Sports Med.* 2011a; 41(10):801-14

Carr AJ, Slater GJ, Gore CJ, Dawson B, Burke LM. Effect of sodium bicarbonate on [HCO₃⁻], pH, and gastrointestinal symptoms. *Int J Sport Nutr Exerc Metab.* 2011b 21(3):189-94.

Edge, J, Bishop D, Goodman C. Effects of chronic NaHCO₃ ingestion during interval training on changes to muscle buffer capacity, metabolism and short-term endurance performance. *J Appl Physiol.* 2006;101:918-925.

Matson LG, Tran ZT. Effects of sodium bicarbonate ingestion on anaerobic performance: a meta-analytic review. *Int J Sport Nutr* 1993;3:2–28.

McNaughton L, Thompson D. Acute versus chronic sodium bicarbonate ingestion and anaerobic work and power output. *J Sports Med Phys Fitness* 2001;41:456–62.

Montfoort MCE, Van Dieren L, Hopkins WG, Shearman JP. Effects of ingestion of bicarbonate, citrate, lactate, and chloride on sprint running. *Med Sci Sports Exerc* 2004;36:1239–43.

Please refer to [summary table](#) on research conducted on sodium bicarbonate and citrate loading.

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This Fact Sheet was prepared by AIS Sports Nutrition as part of the AIS Sports Supplement Program (<http://www.ausport.gov.au/ais/nutrition/supplements>). Note that a Fact Sheet with additional information on this topic is available for Members of the AIS Sports Supplement Program at this site.

The AIS Sports Supplement Program has been designed for the specific needs of AIS athletes and all attempts are made to stay abreast of scientific knowledge and of WADA issues related to anti-doping. It is recommended that other athletes and groups should seek independent advice before using any supplement, and that all athletes consult the WADA List of Prohibited Substances and Methods before making decisions about the use of supplement products. © Australian Sports Commission 2012