



AIS SPORTS SUPPLEMENT FRAMEWORK

SODIUM BICARBONATE

What is it?

- > Bicarbonate is an endogenously produced extracellular anion, and an integral component of the body's primary pH buffering system. During high rates of anaerobic glycolysis (inevitable during prolonged periods of intense exercise), the muscle can produce hydrogen ions (H⁺) in excess, which eventuates in metabolic disturbances and ultimately may contribute to fatigue. Extracellular bicarbonate facilitates the removal of these H⁺, and to a point, supports the body's ability to match the high rates of energy demand required to maintain muscle contractile function during such activity.
- > Numerous studies have demonstrated that endogenous bicarbonate levels can be safely and acutely increased after the oral ingestion of between 200 and 300 mg/kg body mass (BM) of sodium bicarbonate.^{1,2} The additional bicarbonate is believed to attenuate the inevitable increase in intramuscular H⁺, synonymous with high-intensity exercise, although the physiologic mechanisms *directly* responsible for performance augmentation in humans are unclear.³
 - Meta-analyses have reported that supplementation at these levels can result in an approximate 2 to 3% improvement across a variety of performance measurements (e.g. power, speed, work capacity, time to failure) during both single and repeated bouts of high-intensity exercise typically lasting 1-10 minutes in duration.^{4,5,6}
 - The 2018 International Olympic Committee Sports Nutrition Consensus Statement recommendations suggest that sodium bicarbonate is one of five dietary supplements that consistently improves performance in the elite athlete.⁷

What does it look like?

- > The most commonly available and economical source of sodium bicarbonate is the household/baking product baking soda. However, most athletes find ingesting sodium bicarbonate mixed in water or even diluted with cordial to be unpalatably salty.
 - Alternative powder forms of sodium bicarbonate are also found in urinary alkalinisers such as *Ural Effervescent Powder* (1.75 g per sachet), which also contain other ingredients (e.g. carbohydrates, citric acid and most notably sodium citrate (630 mg)).
- > A more palatable delivery of sodium bicarbonate can be provided in tablet or capsule form (e.g. *Sodibic*TM at 840 mg per tablet). While less convenient, filling enteric capsules (e.g. *Capsugel*[®]) with either bicarbonate powder or aqueous solution may also be a viable option. This capsule casing is proposed to resist the acidity of the stomach, instead dissolving in the intestine, which may also reduce gastro-intestinal (GI) symptoms of bicarbonate ingestion.⁸
- > Transdermal delivery of sodium bicarbonate is commercially available (*Amp Human*[®]), however more research is needed on the efficacy of this delivery system.⁹

How and when should I use it?

- > Current ingestion recommendations are to consume between 200 to 400 mg/kg BM with a small, carbohydrate dense meal (~1.5 g/kg BM CHO) approximately 120 to 150 min prior to exercise.⁷
 - Broad ingestion recommendations should only serve as a starting point, as several practical issues associated with sodium bicarbonate may influence the efficacy of this supplement such as ingestion timing, individual tolerability and/or susceptibility to GI distress, and the potential co-ingestion of other supplements.^{10,11,12} Where practicable, monitoring of blood bicarbonate concentrations and pH in response to sodium bicarbonate ingestion, warm-up and event are also strongly encouraged. Experience at the AIS has shown that this frequently uncovers issues that can be manipulated to enhance outcomes for the individual athlete.
 - There is some preliminary evidence that timing an individual's ingestion protocol in order to commence competition at their individualized peak blood buffering capacity may improve performance. However, this requires periodically measuring blood bicarbonate changes over multiple testing sequences.¹⁰
 - If individualizing the ingestion strategy is not feasible, ingestion at the higher end of the recommended doses (e.g. 300 to 400 mg/kg BM) 2 to 3 hours pre-competition should significantly elevate blood buffering capacity to levels presumed to be ergogenic (~ 5 – 6 mmol/L increase) with effects lasting for 3 to 4 hours. Co-ingestion with a small high carbohydrate meal supports blood alkalosis while reducing the occurrence of GI symptoms. This method of delivery would allow more time for those athletes susceptible to GI distress (which typically peaks 90 min post-ingestion) to resolve any potential issues before competition.



- > There is good evidence for the use of bicarbonate by athletes competing in high-intensity activity lasting from 1 to 7 minutes – for example, swimming, rowing and middle-distance running events.⁴
 - It should be recognized that in many events of this type, competition may require the athlete to undertake several events within a relatively short timeframe, or to compete later the same day. This competition schedule may require an adjustment of sodium bicarbonate loading protocols to account for repeated events. In this example, “split” strategies of loading may be incorporated around time constraints, or alternatively using a “top-up” approach with smaller amounts (e.g. 100 mg/kg BM) consumed once or twice over the remainder of the competition timeframe.⁷ As there is no published data on the efficacy of split- or top-up approaches, this would need to be trialed in training.
 - Alternatively, a bicarbonate supplementation protocol involving multiple divided doses over several days before competition may be appropriate. This involves a higher daily bicarbonate dose (500mg/kg BM) in several even doses (e.g., 100mg/ kg BM with 3 main meals and 2 snacks) up to 5 days before competition, as well as the day of competition.¹³
- > Over the past decade, there have been a few studies reporting benefits in physical performance improvements in skill-based sports requiring prolonged, repeated high-intensity efforts (e.g. team, racquet and combat sports).
 - Given this evidence, high-intensity events of up to an hour which are conducted at work rates just below an individual's anaerobic/lactate threshold may also be relevant for sodium bicarbonate supplementation. In this instance, the additional buffering capacity may support the athlete's ability to increase their pace/work output for strategic periods (e.g. surges, sprint finishes).
- > There is a growing body of evidence that suggests increases in aerobic adaptability (e.g. increased oxidative and mitochondrial function) are augmented with sodium bicarbonate supplementation during blocks of interval training sessions.^{14,15}
 - There is also evidence supporting fatigue attenuation after acute sodium bicarbonate supplementation in measures of explosive power (e.g. rate of force development).^{16,17}
- > There have been studies investigating the efficacy of co-ingestion with other supplements (e.g. caffeine, creatine, beta-alanine, ketone bodies), however presently the evidence is equivocal (with the exception of sodium bicarbonate appearing to counteract the acidity induced by ketosis).

Are there any concerns or considerations?

- > The major side effect associated with sodium bicarbonate supplementation 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 this may counteract the potential performance benefits from enhanced buffering.
 - Research undertaken at the AIS systematically studied a series of sodium bicarbonate supplementation protocols, varying the time taken to consume the load (spreading it over 30 to 60 mins), the form of the delivery (flavoured powder or capsules) and the consumption of various amounts of fluid or food with the sodium bicarbonate.⁴ Of the protocols tested, the best strategy to optimise blood bicarbonate levels and to reduce the occurrence of GI symptoms was to consume capsules in a spread-out protocol, commencing 120 to 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.
- > It is generally advised to ingest sodium bicarbonate capsules or dissolvable powder with sufficient fluid to decrease the risk of hyperosmotic diarrhea (~ 10ml/kg BM).
 - Given the significant amount of fluid intake recommended to alleviate GI distress, consideration may be given toward the additional weight gain this might induce for weight-dependent sports.
- > Repeated use of acute loading protocols (e.g. heats and finals in a single or multi-day competition) may require individualized attention to 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.
- > Anecdotal feedback from athletes also suggests that those unfamiliar with sodium bicarbonate supplementation may need to experience the supplement on a number of occasions prior to competition, due to the potential for impaired perceptive feedback from the working muscles.
- > Changes in urinary pH 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.

Where can I find more information?

Gatorade Sports Science Institute

www.gssiweb.org/en/sports-science-exchange/Article/sse-124-buffers-and-their-role-in-the-nutritional-preparation-of-athletes

Supplement safety information and batch tested product list

[Supplements in sport | Sport Integrity Australia](#)



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The Australian Institute of Sport (AIS) Supplement Framework is an initiative of the Australian High Performance Sport System. The AIS acknowledges the support of members of the National Institute Network (NIN) and National Sporting Organisations (NSO) and their staff in delivering content expertise. This information is intended to help athletes, coaches and scientists make evidence-based decisions about the use of supplements and sports foods. Before engaging in supplement use, we recommend that each individual refer to the specific supplement policies of their sporting organisation, sports institute or parent body, and seek appropriate professional advice from an accredited sports dietitian (www.sportsdietitians.com.au).

Athletes should be aware that the use of supplements may have doping implications. Athletes are reminded that they are responsible for all substances that enter their body under the 'strict liability' rules of the World Anti-Doping Code. Some supplements are riskier than others. The Sport Integrity Australia (SIA) app is a useful resource to help mitigate the risk of inadvertent doping by helping to identify supplements that have been batch-tested. The SIA App provides a list of more than 11,000 batch-tested products. We recommend that all athletes consult the educational resources of SIA regarding the risks associated with supplements and sports foods. While batch-tested products have the lowest risk of a product containing prohibited substances, they cannot offer you a guarantee that they are not contaminated (www.sportintegrity.gov.au/what-we-do/supplements-sport).

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Last updated March 2021

