The Time Course for Changes in Plasma [H+] After Sodium Bicarbonate Ingestion

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Numerous studies have demonstrated that induced alkalosis through ingestion of a sodium bicarbonate (NaHCO₃) solution can enhance performance during maximal-intensity exercise of varying durations, as well as maintain performance during high-intensity intermittent exercise.¹-³ Several studies have investigated the effect of dose ingested on subsequent exercise performance. For example, Horswill et al⁴ demonstrated that doses of less than 0.2 g/kg were ineffective in improving performance during 2 minutes of maximal cycle exercise, whereas Wilkes et al⁵ improved run performance of similar duration using a dose of 0.3 g/kg. Most studies have used a dose of 0.3 g/kg, and this seems to be the largest that can safely be consumed without an unacceptable risk of side effects of gastrointestinal distress. Although there is some consensus with regard to the optimal dose of NaHCO₃ that should be ingested, the timing of ingestion in relation to the start of exercise seems to vary from study to study. Matson and Tran⁶ conducted a meta-analysis and found that studies that produced a large effect size in terms of improved exercise performance were associated with larger doses (0.278 ± 0.60 g/kg) and produced greater decreases in preexercise plasma [H⁺] and greater increases in [H⁺] after exercise than in studies that used lower doses (0.236 ± 0.70 g/kg). Because it appears that the magnitude of the induced change in plasma [H⁺] determines the success or lack thereof of NaHCO₃ as an ergogenic aid, it is necessary to establish the time course for changes in plasma [H⁺] after ingestion of the most commonly reported dose. This will allow identification of the optimal time of ingestion in relation to the subsequent maximum change in plasma [H⁺] and thus the timing of the commencement of exercise.

Methodology

Ten healthy participants (7 male, 3 female, age 28 ± 1.6 years) agreed to perform the experimental procedures. All provided informed consent, and all procedures used were approved by the institutional ethics committee.

The participants reported to the laboratory at 10 AM after an overnight fast on 2 separate occasions separated by a minimum of 7 days. Capillary blood for determination of plasma [H⁺] was taken immediately on arrival at the laboratory, and all analyses were performed using a Compact 3 blood-gas analyzer (AVL...
Medical Instruments, Stone UK). Blood was sampled using glass capillary tubes containing 6 IU Na-heparin and 9 IU Li-heparin per 100-µL tube volume (AVL Medical Instruments). Several studies have demonstrated that arterIALIZED capillary blood gives a true picture of acid-base status. To ensure that the peripheral capillary beds were arterialized, each participant’s hand was immersed in a water bath at ~50°C for approximately 1 minute before sampling. The first drop of blood was wiped away, and one end of the tube was held flush with the wound so that the blood traveled directly from the tissue to the capillary. This procedure was repeated before all subsequent sampling.

Over the course of the next 30 minutes participants consumed a solution of 0.3 g/kg NaHCO$_3$ or CaCO$_3$ in 400 mL of plain water in 3 equal doses taken at 0, 15, and 30 minutes. Subjects were encouraged to drink ad libitum during this period and throughout the rest of the experiment. Prior pilot work had revealed that spreading the dose in this manner appeared to result in fewer incidents of gastrointestinal disturbance than giving the dose in a single bolus. The treatments were administered in a double-blind fashion, and the order was randomized. After the treatment solution had been consumed, a further blood sample was taken and then repeated at 30-minute intervals for the next 180 minutes.

Differences in plasma [H$^+$] in the period after NaHCO$_3$ and CaCO$_3$ ingestion were identified using a 2-way repeated-measures analysis of variance (ANOVA) followed by the Bonferroni post hoc test. All statistical analyses were performed using Graphpad Prism Version 4, and statistical significance was set at the $P < .05$ level.

Results

Plasma [H$^+$] was lower after NaHCO$_3$ than CaCO$_3$ at all points after ingestion (see Figure 1). This difference reached statistical significance ($P < .05$) at 30, 60, 90, and 120 minutes. The size of the difference between the 2 conditions increased

Figure 1 — Changes in plasma [H$^+$] during 180 minutes after ingestion of NaHCO$_3$ or CaCO$_3$. *$P < .05$. 