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ORIGINAL RESEARCH

Sodium Bicarbonate Supplementation Does Not Improve Running Anaerobic Sprint Test Performance in Semiprofessional Adolescent Soccer Players

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Ergogenic strategies have been studied to alleviate muscle fatigue and improve sports performance. Sodium bicarbonate ($NaHCO_3$) has improved repeated sprint performance in adult team-sports players, but the effect for adolescents is unknown. The aim of the present study was to evaluate the effect of $NaHCO_3$ supplementation on repeated sprint performance in semiprofessional adolescent soccer players. In a double-blind, placebo-controlled, crossover trial, 15 male semiprofessional adolescent soccer players (15 ± 1 years; body fat $10.7 \pm 1.3\%$) ingested $NaHCO_3$ or a placebo (sodium chloride) 90 min before performing the running anaerobic sprint test (RAST). A countermovement jump was performed before and after the RAST, and ratings of perceived exertion, blood parameters (potential hydrogen and bicarbonate concentration), and fatigue index were also evaluated. Supplementation with $NaHCO_3$ promoted alkalosis, as demonstrated by the increase from the baseline to preexercise, compared with the placebo (potential hydrogen: $+0.07 \pm 0.01$ vs. -0.00 ± 0.01, $p < .001$ and bicarbonate: $+3.44 \pm 0.38$ vs. -1.45 ± 0.31 mmol/L, $p < .001$); however, this change did not translate into an improvement in RAST total time (32.12 ± 0.30 vs. 33.31 ± 0.41 s, $p = .553$); fatigue index (5.44 ± 0.64 vs. 6.28 ± 0.64 W/s, $p = .263$); ratings of perceived exertion (7.60 ± 0.33 vs. 7.80 ± 0.10 units, $p = .525$); countermovement jump pre-RAST (32.21 ± 3.35 vs. 32.05 ± 3.51 cm, $p = .383$); or countermovement jump post-RAST (31.70 ± 0.78 vs. 32.74 ± 1.11 cm, $p = .696$). Acute $NaHCO_3$ supplementation did not reduce muscle fatigue or improve RAST performance in semiprofessional adolescent soccer players. More work assessing supplementation in this age group is required to increase understanding in the area.

Keywords: buffers, fatigue, sprint interval training

Soccer is an intermittent sport consisting of several short and explosive actions performed at high intensities, such as sprints, dribbles, kicks, headers, and changes-of-direction, with random acceleration and deceleration sequences all interspersed by periods of recovery during the game (Di Salvo et al., 2017). The ability to perform repeated sprints is considered one of the fundamental attributes for a soccer player to be able to perform all physical, technical, and tactical actions required in the game. Nevertheless, it is important to consider the maturation level of adolescent players (Pereira da Silva et al., 2007; Selmi et al., 2017) and the influence this may have on their exercise capacity (Buchheit et al., 2010).

The ability to maintain high-powered actions (e.g., jumps, headers, and changes of direction) decreases during a competitive game due to fatigue (Bradley et al., 2010). The intermittent nature and prolonged duration of soccer require players to perform exercise with contributions from both aerobic and anaerobic energy systems (Bangsbo, 1994). Considering that the development of fatigue occurs through distinct actions during the game, the underlying mechanism behind this reduction in performance is undoubtedly multifactorial and can include phosphorylcreatine depletion, glycogen depletion, dehydration, and metabolic acidosis due to metabolite accumulation (i.e., increased hydrogen cations [H^+]). In order to delay fatigue caused by high-intensity exercise, studies have sought to reduce the impact of metabolic acidosis (Bishop et al., 2004; Jones et al., 2016), increasing extracellular H^+ buffering and increasing muscles' potential hydrogen (pH) through sodium bicarbonate ($NaHCO_3$) supplementation (Krustrup et al., 2015).

An increased repeated sprint ability has been associated with a greater H^+ buffering capacity in team-sports players (Bishop et al., 2004). Therefore, it appears logical to speculate that performance during this type of activity might be improved with $NaHCO_3$ supplementation. Indeed, $NaHCO_3$ has been shown to improve repeated sprint performance in team-sport athletes (Bishop & Claudius, 2005; Miller et al., 2016). However, it is currently not known whether $NaHCO_3$ supplementation could attenuate fatigue during repeated sprint activity in adolescent team-sport players,

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since no studies currently exist within this age group. Therefore, determination of the effect of $NaHCO_3$ supplementation on a repeated sprint test in adolescent soccer players may provide insight as to whether this may be an effective strategy to improve youth team-sports performance. This is a critical period in relation to growth and development, and the need for adequate nutritional intake in adolescence is paramount. Certainly, data supporting the use of dietary supplements among adolescents are limited and require more evidence. The aim of the current investigation was to evaluate the effect of $NaHCO_3$ supplementation on the performance of semiprofessional adolescent soccer players during a repeated sprint test. It was hypothesized that $NaHCO_3$ supplementation would improve performance and reduce fatigue and perceptual measures of the semiprofessional athletes.

Methods

Study Design

This was an acute, double-blind, randomized, crossover, placebo-controlled trial. The athletes were allocated to ingest either $NaHCO_3$ or a placebo (sodium chloride [NaCl]), with 7 days of washout between sessions (Durkalec-Michalski et al., 2018). The placebo, NaCl, was chosen because of its similarity in taste and its lack of ergogenic effect for performance, as shown in other studies (Freis et al., 2017). The order of the interventions was randomized using random-number-generating software. The laboratory that supplied the supplements was responsible for the blinding procedures. The $NaHCO_3$ and placebo were provided in sachets with the athlete's name; these sachets were similar in appearance and without any indication of its content. Both the $NaHCO_3$ and placebo were lemon flavored in order to mask any differences in taste. The codes were only revealed after all the analyses were performed.

Population and Sample

The inclusion criteria were adolescent males aged between 14 and 15 years, playing for a professional soccer club and undertaking systematized training (performed 6 days/week). The exclusion criteria were the use of any type of nutritional supplements, any injury in the last 3 months, the regular use of medication, and any report of muscle discomfort related to weekly workloads.

To calculate the sample size, the G*Power® software (version 3.1.9.2; Universität Kiel, Kiel, Germany) was used, taking into consideration the study by Deb et al. (2018), which was based on total sprint time. The values found as reference showed that, with a level of significance of 5% and statistical power of 80% (power $[1 - \beta] = 0.80$), a total of 10 individuals was required. The required sample size was then rescaled for 15, considering a dropout rate of 50%.

A total of 35 players were screened, 20 of whom were excluded according to the inclusion and exclusion criteria, leaving 15 adolescents from an under-15 semiprofessional championship category who participated in the study. The players trained for approximately 15 hr/week and had a mean age of 15 ± 1 years, body fat percentage of 10.7 ± 1.3%, and a peak height velocity (PHV) of 13.7 ± 0.5 years. The project was approved by the research ethics committee of the Federal University of Goiás (CAAE: 2.759.986/2018) and registered at ensaiosclinicos.gov.br (RBR-45QCKT). Written consent was obtained from all of the participants included in the study and by their legal guardians, as required.

Procedures for Data Collection

The data collection occurred throughout the month of August of 2018. The first visit was used for anthropometric data collection and anamneses, while the final two visits were used for the main interventions, with a 1-week interval between the main sessions. On intervention meeting days, the athletes arrived at the club at 7 a.m., after a 12-hr overnight fast and having refrained from intense exercise within 24 hr before the procedures.

On test days, the participants received an opaque sports bottle that did not allow visual identification regarding the contents therein. The bottle contained a previously sealed sachet with the athlete's name and contained either 0.3 g/kg body mass (BM) $NaHCO_3$ or 0.2 g/kg BM NaCl, which was mixed with 500 ml of water by our team nutritionist present at the location. The different amounts of $NaHCO_3$ (0.3 g/kg BM) and NaCl (0.2 g/kg BM) allowed for more similarity in flavor and had no impact on the blinding. The supplements were ingested within 5 min, 90 min before the start of exercise testing, to coincide with the mean peak bicarbonate (HCO_3^-) concentrations (Gough et al., 2017).

Assessment of Food Intake and Side Effects

The study participants were advised to maintain their regular eating habits. The athletes underwent nutritional anamnesis within 7 days, including 3 nonconsecutive days of a self-reported food record with the prospective collection, making sure to include one weekday, a weekend day, and the food record of the day before the protocol. This was performed the week before both sessions. Dietary information was analyzed by the AVANUTRI® software (Avanutri & Nutrição Serviços e Informática Ltda, Rio de Janeiro, Brazil). Energy and macronutrients were estimated in absolute values.

To evaluate any side effects associated with supplementation used in the study, an adapted questionnaire was applied at 0, 10, 40, 60, 80, 100, 110, and 130 min after supplementation (Jeukendrup et al., 2000). The questionnaire investigated the presence of symptoms that may arise from the use of $NaHCO_3$ supplementation, including stomachache and stomach discomfort, nausea, dizziness, headache, flatulence, the urge to urinate and evacuate, eructation/belching, heartburn, bloating sensation, intestinal pain, the urge to vomit, vomiting, diarrhea, and abdominal distention. The athletes were asked about symptoms and were required to rate their intensity from 0 to 10; descriptors were used at 0 (*no effect*), 3 (*mild*), 6 (*moderate*), 9 (*intense*), and 10 (*very intense*).

Anthropometric Measurements

Anthropometric measurements were taken according to the International Society for the Advancement of Kinanthropometry's manual. Measurements were taken at 7 a.m., while the participants were still in a fasted state.

Height and BM were evaluated by means of an anthropometric mechanical scale accurate to 100 g (Filizola model 160/300; Técnica Industrial Oswaldo Filizola Ltda, Brás, Brazil) and a stadiometer accurate to 0.1 cm, according to standard protocol (Lohman et al., 1988). To obtain skinfold measurements, a 0.1-mm resolution plicometer (Cescorf®, Cescorf Equipamentos para Esporte Ltda, Brazil) was used at four anatomical points (triceps, abdomen, supra iliac, and subscapularis), following Faulkner's protocol (Faulkner, 1968). All measurements were performed on the right side of the body following unified standards, in a closed environment, and by the same evaluator, with the subjects wearing light clothes and without shoes.

Maturation Level

Biological maturation was assessed using PHV, which is an indirect measure to calculate the maturation stage. Age of PHV is the most commonly used indicator in longitudinal studies considering adolescent somatic maturation (Malina et al., 2015). The calculation of PHV was performed using interactions between leg length and trunk-head height, age and leg length, age and trunk-head height, as well as weight-to-height ratio (Mirwald et al., 2002).

Repeated Sprint Protocol

The RAST was chosen because of its relevance to actions commonly performed by soccer players and because it has been validated as a tool for anaerobic evaluation and predictor of anaerobic power (Zagatto et al., 2009). The participants performed an individualized warm-up that ranged from 5 to 10 min, which consisted of walking, jogging, sprinting, and dynamic stretching.

The protocol consisted of performing six maximal 35-m sprints, with a passive 10-s interval between runs. The players were positioned behind a line marked by cones, and times were recorded precisely to the nearest 0.01 s by a BROWER photocell Timing System® (Brower Timing Systems, Draper, UT) (De Andrade et al., 2016), located at the start and end points. Performance variables (power and fatigue index) were calculated using the sprint time data and are reported as the mean, *SD*, and range (minimum and maximum values; Arazi et al., 2017).

Individual responses were calculated according to total sprint time using the spreadsheet of Swinton et al. (2018), using 50% confidence intervals, a typical error (0.7634 s) calculated from RAST reproducibility data (Zagatto et al., 2009), and a smallest worthwhile change of 0.2 × the *SD* of the placebo session.

Countermovement Jump Protocol

To determine lower limb neuromuscular fatigue, the athletes performed a countermovement jump (CMJ) before and after the RAST (Bosco, 1999). The participants performed three consecutive jumps, with a 30-s interval between attempts. The jumps were performed on a Chronojump-Bosco system® (Bosco System, Barcelona, Spain) Jump platform and evaluated by a microcontroller (De Blas et al., 2012). Jump height was measured as an indicator of lower limb muscle power levels, considering the mean value of the three attempts (Claudino et al., 2016).

Subjective Effort Perception Assessment

Ratings of perceived exertion (RPE) were used to quantify the generated sensation of exertion using an 11-point scale (CR-10) applied to the whole body (Borg, 1998). The RPE scale was applied 30 min after the end of the exercise session (Foster et al., 2001).

Biochemical Analysis

Blood was drawn (10 ml) from the antecubital vein by a trained phlebotomist, while the participants remained seated. Samples were collected in the morning after a 12-hr overnight fast, before, and immediately after the repeated sprint protocol and analyzed for pH and base excess (BE) using a blood gas analyzer (COBAS B 121 Roche®; Roche Diagnostics, Mannheim, Germany). As provided by the manufacturer, the coefficient of variance for pH, partial pressure of oxygen, and partial pressure of carbon dioxide were 0.1%, 2.7%, and 2.4%, respectively. Blood HCO_3^- concentration was calculated according to the Henderson–Hasselbalch equation (Corey, 2003). Blood lactate (BL) measurements were taken twice from the fingertip, immediately before and after the RAST, using a portable lactate monitor (Accutrend® Plus; Roche Diagnostics, Basel, Switzerland). The coefficient of variation provided by the manufacturer for BL ranged between 1.8% and 3.3%.

Statistical Analysis

The values are expressed as mean ± standard error of mean and minimum and maximum values (for performance measures during the repeated anaerobic sprint test). The data were analyzed using R and R Studio software (R Studio, Inc., Boston, MA). Residual normality analysis was performed by the Lilliefors test for the study variables. The carryover effect was analyzed according to Rosner (2010), without significant values (RAST, total time: 0.57, fatigue index: 0.06, mean power: 0.20, max power: 0.63; RPE: 0.80; CMJ: 0.61; pH: 0.13; HCO_3^-: 0.93; BE: 0.49; BL: 0.75; CHO: 0.49; LIP: 0.25; protein: 0.18; and kcal: 0.60). The food intake analysis was adjusted for energy intake (Willett et al., 1997). To account for the potential influence of a learning and treatment order effect, all variables were analyzed using a factorial analysis of variance plus Tukey's differentiation test to analyze the difference between periods and sequence effects, and treatments and time. The periods refer to Weeks 1 and 2 of the intervention, and the sequence effects refer to which sequence the participant underwent (placebo/$NaHCO_3$ or $NaHCO_3$/placebo). Treatment refers to the supplement intervention (two levels = $NaHCO_3$ and NaCl), while time refers to the collection moment for blood pH, HCO_3^-, and BE (three levels = baseline, preexercise, and postexercise); BL and CMJ (two levels = preexercise and postexercise); assessment moment for each side effect (eight levels = 0, 10, 40, 60, 80, 100, 110, and 130). Food intake, RAST performance (total time, fatigue index, mean power, and maximum power), and RPE were analyzed according to periods, sequence effects, and treatments.

Results

A significant Treatment × Time interaction ($p < .001$) was found for blood pH, HCO_3^-, BE, and BL. Post hoc comparisons showed that supplementation with $NaHCO_3$ promoted alkalosis from the baseline to preexercise when compared with the placebo (pH: +0.07 ± 0.01 vs. −0.00 ± 0.01, $p < .001$ and HCO_3^-: +3.44 ± 0.38 vs. −1.45 ± 0.31 mmol/L, $p < .001$), and BE (+4.41 ± 0.36 vs. −1.82 ± 0.26 mmol/L, $p < .001$) in the $NaHCO_3$ compared with placebo group, respectively (Table 1). Blood pH, HCO_3^-, and BE decreased significantly from pre- to postexercise in $NaHCO_3$ and placebo (all *p*s <.05), with no differences between treatments (Table 1). BL increased significantly after the exercise protocol ($NaHCO_3$: +9.58 ± 1.21 and placebo: +7.50 ± 1.21 mmol/L, $p < .001$ in both treatments), however, without a difference between treatments ($p = .630$; Table 1).

Supplementation with $NaHCO_3$ did not improve total RAST time, fatigue index, mean and maximum power, RPE, or CMJ (all *p*s > .05; Table 2). Individual analysis revealed that $NaHCO_3$ supplementation improved the overall RAST performance in two athletes and worsened the performance in another two athletes (Figure 1); performance was unchanged in the remaining 11 athletes.

Treatment × Time interactions ($p < .05$) were found for side-effect symptoms of stomachache, with a difference between

Table 1 Effect of $NaHCO_3$ on Biochemical Parameters

Blood variables	Placebo	$NaHCO_3$	*p* treatment
pH baseline	7.31 ± 0.00	7.30 ± 0.01	.256
pH preexercise	7.31 ± 0.00	7.37 ± 0.01*	**<.001**
pH postexercise	7.14 ± 0.02*·**	7.21 ± 0.01*·**	**<.001**
HCO_3^- baseline (mmol/L)	26.70 ± 0.29	26.57 ± 0.31	.682
HCO_3^- preexercise (mmol/L)	25.25 ± 0.27*	30.01 ± 0.35*	**<.001**
HCO_3^- postexercise (mmol/L)	15.30 ± 0.46*·**	17.90 ± 0.40*·**	**<.001**
BE baseline (mmol/L)	–0.26 ± 0.29	–0.71 ± 0.34	.164
BE preexercise (mmol/L)	–1.56 ± 0.24	3.70 ± 0.39*	**<.001**
BE postexercise (mmol/L)	–13.30 ± 2.50*·**	–9.91 ± 1.66*·**	**<.001**
BL preexercise (mmol/L)	3.02 ± 0.29	4.09 ± 0.85	.160
BL postexercise (mmol/L)	12.60 ± 1.29**	11.59 ± 0.84**	.630

Note. Data are presented as mean ± *SE*. pH = potential hydrogen; $NaHCO_3$ = sodium bicarbonate; HCO_3^- = blood bicarbonate; BE = base excess; BL = blood lactate. The *p* value was obtained by factorial analysis of variance. Bold values are statistically significant.
*$p < .05$ versus baseline. **$p < .05$ versus preexercise.

Table 2 Effect of $NaHCO_3$ Supplementation on Various Performance Measures During the Repeated Anaerobic Sprint Test in Semiprofessional Adolescent Soccer Players

Performance variables	Placebo	$NaHCO_3$	*p* treatment
RAST total time (s)	33.31 ± 0.41 (29.82–36.32)	33.12 ± 0.30 (30.70–34.89)	.533
RAST fatigue index (W/s)	6.28 ± 0.64 (4.00–11.90)	5.44 ± 0.64 (2.60–11.50)	.263
RAST Mean power (W)	8.86 ± 0.17 (8.00–11.50)	8.70 ± 0.26 (7.10–11.80)	.608
RAST Maximum power (W)	7.38 ± 0.26 (5.90–10.10)	7.44 ± 0.21 (6.30–9.40)	.710
RPE (points)	7.80 ± 0.10 (7.00–8.00)	7.60 ± 0.33 (5.00–9.00)	.525
CMJ pre (cm)	32.05 ± 3.51 (22.75–50.14)	32.21 ± 3.35 (24.07–46.99)	.383
CMJ post (cm)	32.74 ± 1.11 (26.13–50.14)	31.70 ± 0.78 (27.78–48.99)	.696

Note. Data are presented as mean ± *SE* (minimum–maximum values). $NaHCO_3$ = sodium bicarbonate; RAST = running anaerobic sprint test; RPE = ratings of perceived exertion; CMJ = countermovement jump. The *p* value was obtained from the factorial analysis of variance.

sessions at 10 min ($NaHCO_3$: 1.60 ± 0.55 points and placebo: 0.20 ± 0.19 points, $p = .040$; Supplementary Figure 1 [available online], item K), and abdominal distention, with a difference between sessions at 80 min ($NaHCO_3$: 1.20 ± 0.38 points and placebo: 0.40 ± 0.26 points, $p = .029$; Supplementary Figure 1 [available online], item J). Time interactions (Supplementary Figure 1 [available online]) were observed for eructation ($p < .001$, item H), flatulence ($p = .025$, item E), and the urge to urinate ($p < .001$, item F). No time and treatment interactions were observed regarding nausea, dizziness, headache, the urge to evacuate, bloating sensation, intestinal pain, the urge to vomit, vomiting, and diarrhea (Supplementary Figure 1 [available online]). Calorie (1,849 ± 105 vs. 1,913 ± 131 kcal, $p = .496$), carbohydrate (233 ± 18 vs. 217 ± 20 g, $p = .390$), and lipid (57 ± 3 vs. 63 ± 5 g, $p = .147$) intake prior to the main sessions (placebo vs. $NaHCO_3$) were not different. Protein intake was higher prior to the placebo trial (106 ± 6 vs. 93 ± 4 g, $p = .008$).

Discussion

To our knowledge, this is the first double-blind, placebo-controlled, crossover study to evaluate the effects of $NaHCO_3$ supplementation on repeated sprint performance in semiprofessional adolescent soccer players. It was found that $NaHCO_3$ supplementation promoted alkalosis; however, this did not result in improved performance, power, fatigue, or loss of muscle strength after a high-intensity intermittent exercise protocol. These data suggest that $NaHCO_3$ supplementation is not ergogenic during this football-specific running performance test in adolescent football players.

Supplementation with $NaHCO_3$ has conflicting results regarding its ergogenic effects, and in many cases, it is noted that genetic aspects, performance protocols, administration form, side effects, and dose are likely factors associated with contrasting evidence (Heibel et al., 2018). Our findings corroborate other studies that also showed no changes in the performance of repeated sprint protocols using $NaHCO_3$ (Bishop et al., 2004; Saunders et al., 2014a), although there are studies that have found positive results (Ducker et al., 2013; Miller et al., 2016). The lack of an effect in this study may be due to the length of the exercise protocol employed; it has been suggested that increased buffering capacity does not improve repeated sprints of short duration, such as those performed during the RAST protocol (Brisola et al., 2015). However, protocols of longer duration, such as the Yo-Yo intermittent recovery test, may be more susceptible to improvements with $NaHCO_3$. Indeed, Krustrup et al. (2015) showed improved Yo-Yo intermittent recovery test level 2 performance in trained male athletes following 0.4 g/kg BM $NaHCO_3$.

According to previous studies, the dose of $NaHCO_3$ used in this study should have been sufficient to increase blood HCO_3^-

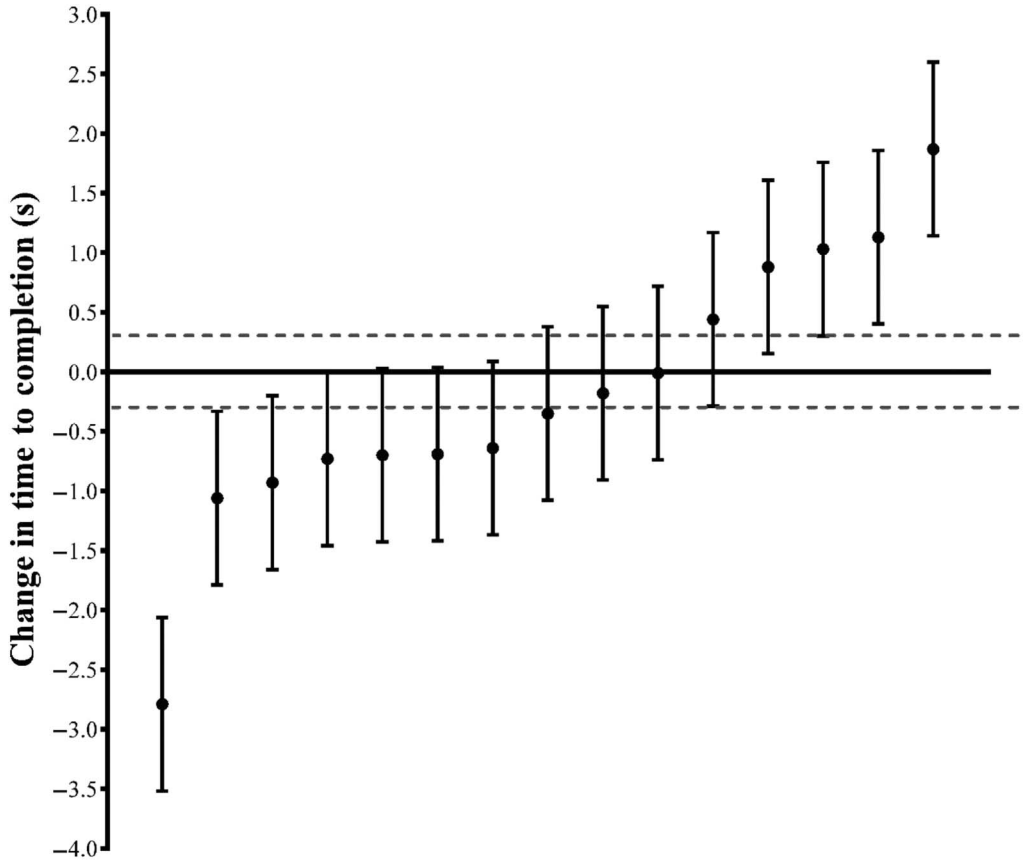

Figure 1 — Individual responses in the running anaerobic sprint test performance after sodium bicarbonate supplementation compared with placebo. Data are individual change in time to completion ± 50% confidence intervals. The dotted gray lines indicate the smallest worthwhile change in performance.

concentration by 5–6 mmol/L. However, blood HCO_3^- concentration only increased by +3.4 ± 0.4 mmol/L, which is far below the increases commonly shown in the literature (Carr, Hopkins, & Gore, 2011). It is important to note that we provided a relative dose of $NaHCO_3$, based upon previous work, but this likely led to lower absolute doses of $NaHCO_3$ because of the difference in body weight between adults and adolescents. Further work is required to determine the most appropriate and minimum dose necessary to increase blood HCO_3^- concentration independent of body weight for adolescent or lightweight individuals.

Authors have suggested that a 5- to 6-mmol/L increase is necessary to elicit an ergogenic effect, which could explain the lack of a performance effect shown here. Interestingly, only one individual showed increases >5 mmol/L; however, it did not improve the participant's performance. It is currently unclear why the absolute changes in blood HCO_3^- were so low, but it might be related to the physical maturational level of the participants since adolescents display differences from adults in gastrointestinal physiology (e.g., low caecal pH; Bai et al., 2016) or distal gut microbiota (Agans et al., 2011). It is speculated that responses to supplementation could be more effective in more physically mature individuals (Selmi et al., 2017), while multiple factors are associated with individual variability in maturational aspects, such as the time practicing a sport, genetics, and nutritional and social aspects (Silva & Marins, 2014). Nonetheless, more research is needed as to whether maturational aspects influence the responses to ergogenic resources such as $NaHCO_3$.

Individual response to $NaHCO_3$ is also a topic much discussed by researchers (Heibel et al., 2018; Jones et al., 2016; Saunders et al., 2014b). Among strategies for the use of supplementation, prior testing in game situations and training seems to be critical, as possible side effects may occur and categorizing individuals into responders and nonresponders seems to be an important measure (De Araujo Dias et al., 2015; Saunders et al., 2014b). The categorization of players according to response and nonresponse showed two players who were considered responders and two nonresponders to $NaHCO_3$ supplementation. These data perfectly fit in a normal distribution curve, suggesting that there was no effect of supplementation on exercise performance in the current study.

The influence of $NaHCO_3$ supplementation on CMJ is contrasting, with no effect in male professional and elite cyclists following three consecutive Wingates (Zabala et al., 2011; Zabala et al., 2008), while CMJ was improved during a modified basketball simulation protocol in female university basketball players (Delextrat et al., 2018). In the current study, $NaHCO_3$ supplementation did not affect CMJ performance in semiprofessional adolescent soccer players undergoing a high-intensity intermittent exercise protocol. The nonuniform results between studies may be due to differing supplementation protocols, different athlete populations, and the timing or isolation of the CMJ in relation to other exercise tasks performed. For example, herein, it was shown that CMJ was unchanged before or after the exercise task, while Delextrat et al. (2018) showed improved CMJ performance throughout the exercise protocol. Improved CMJ performance

throughout an intermittent exercise protocol would likely be more beneficial for team-sport performance. Therefore, further work should confirm whether CMJ performance throughout games play performance can be improved with $NaHCO_3$ supplementation.

The incidence of side effects in this study was low, although the symptoms were highest at 80-min postsupplementation, which was close to the time that exercise was performed. The incidence of associated side effects can be ergolytic to exercise performance (De Araujo Dias et al., 2015; Saunders et al., 2014b), although not all studies have shown this (Price & Simons, 2010). Thus, it is possible that the side effects here may have contributed to the lack of a performance effect, although absolute symptom scores were low. The use of gastro-resistant capsules has been shown to reduce side effects (Hilton et al., 2019), which might consequently avoid any ergolytic effects associated with $NaHCO_3$ and improve performance. Another factor to consider would be genetic polymorphisms in the monocarboxylate transporters, which are associated with different BL and H^+ cotransport kinetics (Cupeiro et al., 2012). However, in this study, the genetic polymorphisms of the players were not evaluated, which could be considered a limitation.

In conclusion, supplementation of 0.3 g/kg BM $NaHCO_3$ did not improve repeated sprint performance or reduce subsequent muscle fatigue in adolescent soccer players. This may have been due to the modest increases in serum HCO_3^- concentration, although our data may also suggest that RAST performance of semiprofessional adolescent soccer players is not limited by muscle acidosis. Future studies should be directed toward optimizing the dose of $NaHCO_3$ for this population, considering the time to peak of this particular supplement, and also regarding different ways to administer the supplement to avoid side effects, all of which may modify the findings.

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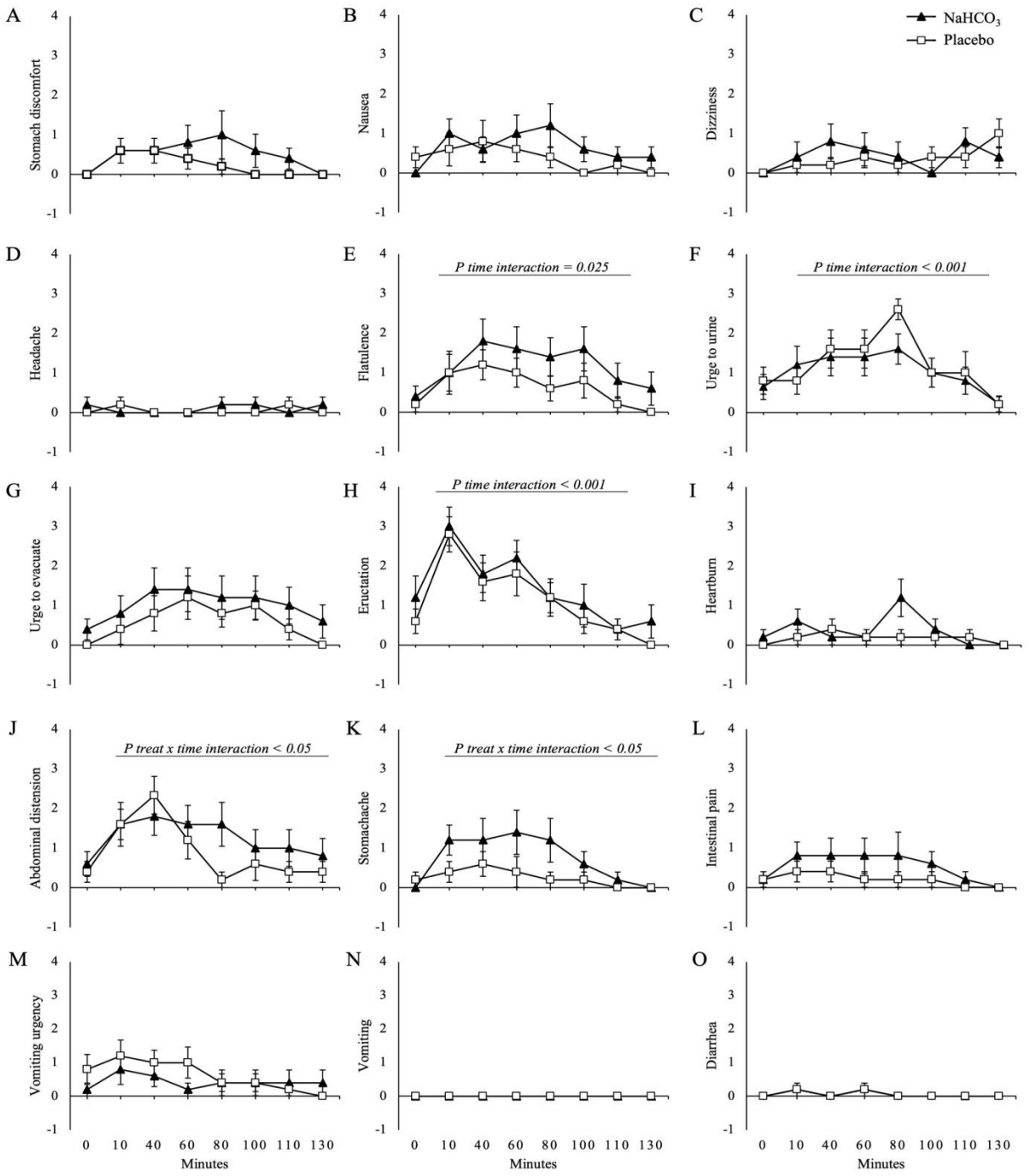

Supplementary Figure 1S. Side-effects reported by semi-professional adolescent soccer players after sodium bicarbonate ($NaHCO_3$) or placebo supplementation.