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Research Article

Betaine Supplementation has No Effect on Running Sprint Performance

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Abstract

Betaine supplementation is purported to positively influence cycling sprint power output, however investigations of transferable improvements in running performance have yet to be determined. This investigation examined the potential ergogenic effects of betaine supplementation over a 7-day period on running sprint speed and blood lactate accumulation in recreationally active men during sprint interval training (SIT). Twelve men (22 ± 1y, 174.9 ± 5.5 cm, 79.7 ± 10.3 kg, 48.11 ± 4.82 mL·kg^{-1}·min^{-1}) completed two 7-day experimental trials consuming either betaine (3 g·day^{-1} mixed into a 591 mL of a 100% carbohydrate-electrolyte beverage) or a placebo (591 mL carbohydrate-electrolyte beverage) separated by a minimum 21-day washout period, in a randomized, double-blind, within-subject crossover design. Participants reported to the laboratory 2-h after consuming the betaine or placebo beverage, to complete four 30-s sprint bouts interspersed with 240-s of recovery. Indices of anaerobic performance were measured during each sprint, and blood lactate concentrations were tracked pre, during, and immediately post-exercise. Betaine had no effects on peak ($p = 0.303$, $\eta_p^2 = 0.096$), average ($p = 0.554$, $\eta_p^2 = 0.014$), and minimum ($p = 0.982$, $\eta_p^2 = 0.000$) speed performance when compared to placebo. Additionally, no ergogenic effects were present on speed reproducibility ($p = 0.599$, $\eta_p^2 = 0.026$) or lactate accumulation across all SIT bouts, although a 9% (~1.5 mmol·L^{-1}) reduction ($p = 0.054$; $\eta_p^2 = 0.296$) following betaine supplementation. Our data revealed that 7 days of betaine supplementation has no effects on anaerobic performance during traditional SIT sessions.

Keywords: *Anaerobic Performance; Ergogenic Aid; Lactate*

Introduction

Betaine, a trimethyl derivative of the amino acid glycine, is consumed regularly in adult (21 - 65y) diets with elevated concentration in wheat, spinach, beets, and shellfish [1,2]. Average daily consumption of betaine is ~0.1 - 0.4 g·day^{-1}, however dosages ≥ 2.5 g·day^{-1} are purported to induce ergogenic effects [2]. Betaine assists cell volume regulation, protecting protein degradation under environmental (heat) and mechanical (exercise) stress, and as a methyl donor in biochemical pathways, notably increasing skeletal muscle phosphocreatine (PCr) synthesis [3,4]. Additionally, betaine supplementation improves exercise performance by increasing skeletal muscle blood flow through nitric oxide mediated vasodilation [5], while attenuating cellular acidosis [6]. Upregulation of the PCr system and anaerobic metabolism improvements could create power adaptations by generating additional ATP which is crucial for exercise performance [2].

Chronic (7 days) betaine supplementation (2.5 g·day^{-1}) previously improved peak (3.4%) and average (3.5%) power following 12-s "all-out" cycling bouts interspersed with 150-s active recovery [7], however contradictory research demonstrates no improvement during

two Wingate cycling efforts interspersed with 5-min recovery [8]. Chronic (10 - 15 days) betaine supplementation (≥2.5 $g \cdot day^{-1}$) also demonstrated acute anaerobic power improvements in bench press (15%) and vertical jump (9%) assessments [9], however other research has not reproduced these ergogenic effects [10-12]. Divergent responses are attributed to methodology differences such as between or within subject designs, participant cohorts (males and females vs. males only) washout period (14 - 28 days), and exercise testing order [7-12]. Unfortunately, these studies lacked ergogenic investigations into the physiological pathways betaine effects such as metabolic by-product (lactate) reductions.

Acute betaine supplementation (5g dissolved in a carbohydrate-rich beverage) coupled with exhaustive dehydrated running increased blood lactate accumulation (~11%) post-exercise compared to placebo suggesting performance maintenance despite increased by-product production, however increases were not reproduced when dissolved in water [13]. Betaine supplementation also demonstrated trending running time to exhaustion increases (32 ± 173s; $p = 0.12$) at ~84% $\dot{V}O_{2max}$, however large variability existed within the small ($n = 10$) sample size [13]. These findings have not been investigated at greater running intensities supporting or opposing betaine-induced performance outcomes when consumed strictly in a carbohydrate beverage.

Previous research demonstrating ergogenic betaine supplementation effects utilized stationary equipment and lacked explorations of exercise-induced mechanisms driving these improvements [7-9]. Running increases mechanical and metabolic stress potentially increasing cellular betaine uptake [14] providing a novel stimulus to elicit betaine's ergogenic effects of stress-induced (lactate) cellular preservation potentially increasing fatigue resistance [3]. Therefore, this study explored effects of betaine supplementation for 1-week on sprint performance during a traditional sprint-interval training (SIT) session. We hypothesized betaine supplementation would improve sprint performance via attenuated blood lactate accumulation.

Methods

Participants

Twelve males (age: 22 ± 1y, body mass index: 26.1 ± 3.3 $kg \cdot m^{-2}$, $\dot{V}O_{2max}$: 48.11 ± 4.82 $mL \cdot kg^{-1} \cdot min^{-1}$) not using dietary supplements, self-reported non-smokers, deemed healthy according to the Physical Activity Readiness Questionnaire, recreationally active (exercised < 3x/week according to Godin's physical activity and leisure time questionnaire), and not engaging in a systematic training program 3 months prior to data collection participated in this study. Informed consent was provided prior to data collection and ethical approval was obtained from the local university Research Ethics Board. Data collection occurred from 2017 - 2018. An effect size of 0.5 was determined prior to the investigation from previous research demonstrating significant differences [9] requiring 12 participants to produce anaerobic improvements.

Study Design

A double-blind, placebo-controlled, within-subject crossover design was employed. Participants reported to the laboratory on three separate occasions: 1) a familiarization session; 2) a betaine supplement experimental session; and 3) a placebo experimental session. A three-week washout period separated experimental sessions to eliminate supplementation carryover effects. Before each visit, participants refrained from strenuous exercise and alcohol consumption for 24h, and caffeine consumption 12h prior. Participants were instructed to record their food intake and replicate their consumption 24h prior to the session. Timing of experimental sessions was matched (± 30 min).

Familiarization

The familiarization session ensured eligibility, measured aerobic fitness, and provided laboratory equipment acclimatization. Participant height and weight were recorded using a mechanical scale (Health-o-meter Professional, Sunbeam Products Inc., IL, USA) before

performing a motorized treadmill (4Front, Woodway, WI, USA) incremental $\dot{V}O_{2max}$ test determining aerobic fitness using a metabolic cart (MAX II, AEI Technologies, PA, USA). Participants rested ~10 min before becoming familiarized (instructed on proper running technique and performed multiple sprints efforts similar to future experimental sessions) with the non-motorized interval training treadmill (Hi-Trainer, Que., Canada).

Supplementation Overview

Upon familiarization completion, participants were provided with their first round of supplements, including 7 bottles of either commercially available carbohydrate-electrolyte beverage (Kirkland Sport; USA; 152 kcals, 38g carbohydrate) or an identical beverage with 3g of betaine (BetaPower™, DuPont Nutrition and Health, NY, USA) added to each bottle. Betaine was verified at > 99% purity by the manufacturer. To ensure drink concealment, all cap ties were broken in condition preparation. Participants consumed half (~296 mL) of each bottle in the morning and late afternoon/evening each day (days 1 - 6) leading up to the experimental session and provided verbal consumption confirmation. On the experimental day (day 7), participants drank a whole bottle 2h prior to arrival. An independent investigator prepared the beverages, subsequently marking A or B blinding the primary investigator until study completion. Participants attempted to indicate which beverage they received during each session.

Experimental Sessions

Participants arrived at the laboratory on the 7th day of supplementation for their performance test. A 5-min warm-up on a motorized treadmill commenced before the SIT session (4 x 30-s sprints on the self-propelled HiTrainer treadmill interspersed with 4-min recovery). For each sprint, peak, average, and minimum speeds were recorded every 0.5-s by treadmill integrated software. For the determination of supplement induced improvements typical error for peak, average, and minimum speed (± 0.22 $m \cdot s^{-1}$, ± 0.16 $m \cdot s^{-1}$, and ± 0.54 $m \cdot s^{-1}$, respectively) were used for determination of supplement-induced improvement and based upon previous work using the same protocol, population, and equipment [15]. Fatigue index was calculated manually. Finger capillary blood lactate measurements were recorded using a hand-held lactate analyzer (Lactate Pro, Nova Biomedical, USA) prior to exercise and immediately following the second and fourth sprints. Exercise sessions finished with a self-selected pace 5-min cool-down on a motorized treadmill. Participants recorded their food intake for 3-days surrounding each experimental session (day prior, day of, and day after).

Statistical Analysis

Statistical analyses were performed using IBM SPSS26 (SPSS Inc., USA). All data are presented as mean ± standard deviation. Two-way repeated measures (RM) ANOVA were conducted comparing the effects of condition (2) x sprint bout (4) for peak, average, and minimum speed, and fatigue index as well as a two-way RM ANOVA comparing the effects of condition (2) x sprint bout (3) on blood lactate concentration. T-tests determined condition differences in peak, average, and minimum speed across each sprint, and for blood lactate across sampling times. Statistical significance was accepted as $p < 0.05$. Effect sizes were reported as partial eta squared (η_p^2) (small 0.01, medium 0.06, large 0.14) for main effects and interactions and Cohen's d (small 0.2, medium 0.5, large 0.8) for post-hoc comparisons [16].

Results

Participants (n = 12) self-reported full compliance with supplementation protocols, exercise avoidance, alcohol consumption, and caffeine guidelines. Additionally, 83% of participants were unable to distinguish between betaine or placebo conditions.

Peak Speed

There was no condition x sprint bout interaction ($p = 0.605$, $\eta_p^2 = 0.054$) and no main effect of condition ($p = 0.303$, $\eta_p^2 = 0.096$). A main effect of sprint bout ($p < 0.001$, $\eta_p^2 = 0.813$) demonstrated a decrease after subsequent sprint bouts ($p < 0.019$, $d > 0.49$) (Figure 1A).

Average Speed

There was no condition x sprint bout interaction ($p = 0.554$, $\eta_p^2 = 0.060$) and no main effect of condition ($p = 0.697$, $\eta_p^2 = 0.014$). A main effect of sprint bout ($p < 0.001$, $\eta_p^2 = 0.815$) demonstrated a decrease after subsequent sprint bouts ($p < 0.002$, $d > 0.60$), except sprints 3 and 4 which were not different ($p = 0.052$, $d = 0.82$) (Figure 1B).

Minimum Speed

There was no condition x sprint bout interaction ($p = 0.705$, $\eta_p^2 = 0.041$) and no main effect of condition ($p = 0.982$, $\eta_p^2 = 0.000$). A main effect of sprint bout ($p < 0.001$, $\eta_p^2 = 0.641$) demonstrated sprints 1 and 2 produced greater minimum speed (Figure 1C) than sprints 3 ($p < 0.003$, $d > 0.49$) and 4 ($p < 0.015$, $d > 0.59$). No differences existed between sprints 1 and 2 ($p = 0.295$, $d = 0.34$) or 3 and 4 ($p = 1.000$, $d = 0.16$).

Fatigue Index

There was no condition x sprint bout interaction ($p = 0.643$, $\eta_p^2 = 0.049$), main effect of condition ($p = 0.599$, $\eta_p^2 = 0.026$), or main effect of sprint bout ($p = 0.153$, $\eta_p^2 = 0.146$; large; Figure 1D).

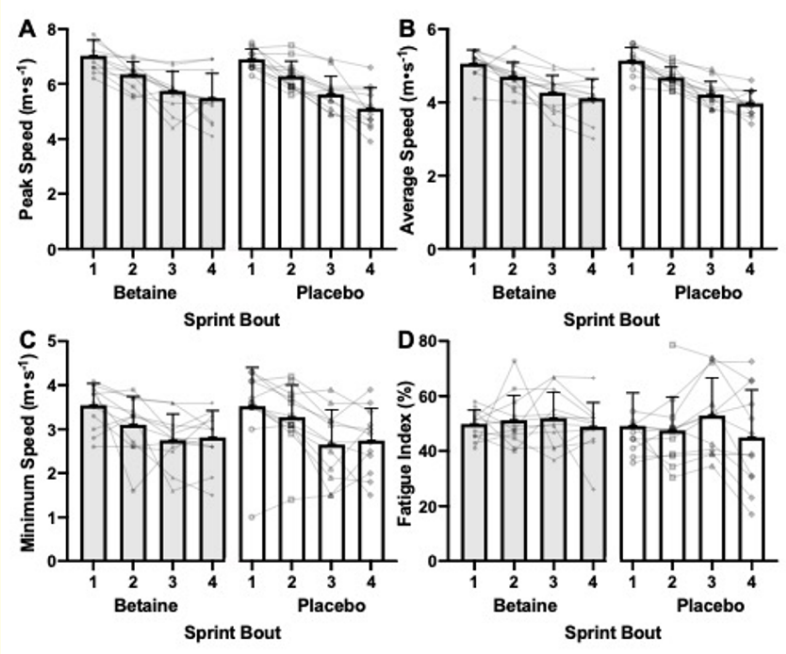

Figure 1: *Mean sprint performance following each bout for (A) peak speed, (B) average speed, (C) minimum speed, and (D) fatigue index is represented by bars, with the grey shapes and lines representing the individual responses at each timepoint. A main effect of time ($p < 0.05$) existed in the betaine supplementation and placebo conditions for peak speed and average speed. Values (bars) are presented as the mean ± the standard deviation.*

Lactate

There was no condition x sprint bout interaction ($p = 0.456$, $\eta_p^2 = 0.069$) and no main effect of condition ($p = 0.054$, $\eta_p^2 = 0.296$). A main effect of sprint bout ($p < 0.001$, $\eta_p^2 = 0.955$; Figure 2) demonstrated lower lactate concentrations pre-exercise versus post-sprint 2 ($p < 0.001$, $d = 0.85$) and post-sprint 4 ($p < 0.001$, $d = 0.79$). No differences existed between post-sprint 2 and 4 ($p = 0.263$, $d = 0.47$).

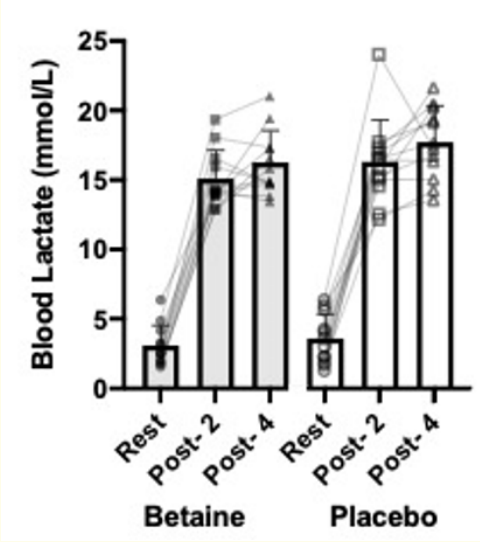

Figure 2: *Mean blood lactate responses prior to, mid-way through, and immediately post-exercise sessions are represented by bars. The grey shapes and lines represent the individual responses at each timepoint. Resting blood lactate concentrations were different ($p < 0.05$) than mid-way and immediately post-exercise blood lactate concentrations in the betaine supplementation and placebo conditions. Values (bars) are presented as the mean ± the standard deviation.*

Discussion

One week of betaine supplementation (3 $g \cdot day^{-1}$) prior to a running-based SIT session failed to produce ergogenic effects on sprint performance or generate reductions in post-exercise lactate accumulation. Although no ergogenic effects were generated, the SIT session itself was strenuous as peak and average sprint speed declined ~0.5 $m \cdot s^{-1}$ and ~0.4 $m \cdot s^{-1}$ respectively across bouts signifying sufficient intensity for generating mechanical and metabolic stress. Overall, these results suggest no ergogenic benefit of chronic betaine supplementation on traditional SIT anaerobic performance.

To our knowledge, no previous research investigated betaine supplementation with running sprint speeds as indices of power. Cycling protocols ingesting similar dosages (2.5 $g \cdot day^{-1}$) demonstrated mixed results [7,8], potentially attributed to collapsed male and female participants in the opposing study [7] as females have lower plasma betaine concentrations attributed to elevated methylation metabolism and betaine catabolism [17]. In our 30-s sprints and previous Wingate efforts [8] absent ergogenic effects suggests betaine ergogenic benefit is solely during brief, explosive efforts (i.e. < 12 s) [7,9]. Although betaine power production improvements are suggested to increase PCr synthesis [1,4], the hypothesized improvements did not translate to running performance in the present study.

Compared to the placebo session, blood lactate accumulation decreased (~9%) following betaine supplementation, however results were insignificant ($p = 0.054$, $\eta_p^2 = 0.296$) and no differences in indices of sprint performance existed suggesting betaine might not improve running performance. In previous running modality studies, betaine supplementation increased blood lactate accumulation by ~1 $mmol \cdot L^{-1}$ relative to placebo, though only generated when betaine was dissolved in a carbohydrate beverage and not water [13] suggesting no direct ergogenic effects of betaine itself. Betaine is purported to decrease lactate accumulation through increased H^+ ion acceptance [6] and/or improved metabolic by-product clearance [5], however suggested glycolytic metabolism improvements have not translated to increased exercise performance.

The present study employed a double-blinded within-subjects study design comparing SIT betaine and placebo treatments, however it is not without limitations. Chronic betaine supplementation periods were shorter (7 days) compared to previous research exhibiting ergogenic effects (14 days) [9] potentially hindering circulating concentrations of betaine [18]. In addition, the inability to confirm betaine accumulation/absorption prevented determinations of supplement ineffectiveness and a lack of muscle tissue sampling prevented explorations of creatine synthase pathway alterations.

Conclusion

One week of betaine supplementation ($3\ g \cdot day^{-1}$) in recreationally active university-aged males did not elicit improvements in anaerobic sprint running performance or lactate accumulation. However, future investigations involving muscle tissue sampling to elucidate betaine's role on biochemical pathways during exercise are warranted.

Practical Application Statement

Our data demonstrate betaine supplementation resulted in no improvement in anaerobic sprint performance and may not be an effective ergogenic aid.

Authors' Contributions

The present study was designed by LWV and TJH; data were collected by LWV, GLM, and GJH; data interpretation and manuscript preparation were undertaken by DPDB. All authors approved the final version of the paper.

Conflicts of Interest

All authors declare no conflicts of interest. The authors declare that the results of the study are presented clearly, honestly, and without fabrication, or inappropriate data manipulation.

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