International Journal of EXERCISE SCIENCE

Original Research

Commercially Available Capsaicin Supplement Fails to Enhance Time-to-Exhaustion During Cycling

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ABSTRACT

International Journal of Exercise Science 13(2): 225-233, 2020. This study examined whether a commercially available low-dose (1.2 mg), chewable capsaicin supplement could enhance endurance cycling performance. Thirteen young (8M/5F), recreationally active individuals (age = 24.2 ± 2.9 yrs, body fat = 21.2 ± 6.1%) participated in the study. The study consisted of three visits, beginning with an initial evaluation of cardiorespiratory fitness (37.1 ± 5.5 ml/kg/min). During the second and third study visits, participants completed time-to-exhaustion (TTE) tests on a cycle ergometer at a workload eliciting ~90% VO2max, 45 minutes after ingesting either a 139 kcal capsaicin fruit gummy, or eucaloric placebo. Heart rate and rating of perceived exertion (RPE) were recorded every two minutes throughout the TTE sessions. Time-to-exhaustion was not significantly different ($p > 0.05$; $d = 0.13$) between placebo (487.8 ± 187.7 sec) and capsaicin (517.5 ± 258.4 sec) trials. Furthermore, heart rate responses and ratings of perceived exertion were similar ($p > 0.05$) between trials. These findings suggest that pre-exercise ingestion of a commercially available low-dose (1.2 mg), chewable capsaicin supplement fails to provide ergogenic benefits for time-to-exhaustion during cycling exercise. Higher doses may be necessary to elicit the performance-enhancing benefits observed during alternative exercise modalities (i.e., running) of comparable intensity.

KEY WORDS: Aerobic exercise, nutrition, cardiovascular, muscle

INTRODUCTION

Capsaicin (8-methyl-N-vanillyl-trans-6-nonenamide) is a naturally occurring substance found primarily in chili peppers that agonizes transient receptor potential vanilloid receptor-1 (TRPV1) ion channels throughout the body leading to the sensation of heat (25). Oral ingestion of capsaicin is purported to elicit a host of physiological effects including activation of the sympathetic nervous system, increased lipid oxidation and energy metabolism (14, 19), thermogenesis (16, 18), and activation of anti-inflammatory pathways (15). In skeletal muscle, capsaicin interaction with TRPV1 on the sarcoplasmic reticulum is suggested to potentiate intracellular calcium release via ryanodine receptor 1 regulation (17), which may have

implications for contractile function and thus athletic performance (e.g., increased power output during cycling via the quadriceps muscle group).

In mice, acute capsaicin ingestion is demonstrated to improve time-to-exhaustion with running and swimming (19, 21, 22) and grip strength (12) in an apparent dose-dependent manner (21). It is important to keep in mind that performance-enhancing capsaicin doses in animal models (up to 1000 mg/kg body weight) are substantially greater than what may be safely tolerated by humans. To date, we were only able to identify four human studies seeking to evaluate the performance-enhancing potential of ingested capsaicin (5-7, 23), three of which from the same investigative team (5-7). In 2012, Opheim and Rankin demonstrated 7-day capsaicin supplementation (25.8 mg/day) provided no appreciable benefits for repeated sprint performance, but evoked significant gastrointestinal distress in nearly a quarter of the subjects (23). Using a lower capsaicin dose (12 mg 45-min prior to exercise), de Freitas and colleagues demonstrated participants were able to perform more repetitions over the course of four squat sets to failure (6), improve 1500-m run time (7) and extend time-to-exhaustion during high-intensity intermittent exercise (i.e., 15-sec sprints:15-sec rest) (5). Given these promising findings, examination of the ability for acute capsaicin supplementation to improve exercise performance in other domains is enticing.

As capsaicin supplementation to enhance sports performance has only recently entered scientific debate, the minimum effective dose that is least likely to elicit gastrointestinal distress has yet to be determined. Therefore, the purpose of this study was to investigate the effect of a commercially available low-dose capsaicin supplement (1.2 mg) on time to exhaustion during cycling, an exercise modality dependent on both cardiovascular and musculoskeletal systems. This was the first exercise-related study in which human subjects ingested a chewable form of capsaicin, rather than a pill. A central mechanism for increased endurance performance has been proposed with carbohydrate mouth rinsing (3), thus, it would be interesting to determine if capsaicin-mediated TRPV1 activation in the oropharynx (1) may yield similar performance benefits (8). With this in mind, we hypothesized that acute low-dose capsaicin supplementation would extend time-to-exhaustion during cycling exercise.

METHODS

Participants

Based on previous observations (7) of capsaicin-mediated improvements in 1500-m run time (d = 1.2), a minimum of ten individuals were required to achieve 80% statistical power at an alpha-level of 0.05. Thus, we recruited thirteen recreationally active (≥ 30-min self-reported moderate-vigorous physical activity per day ≥ 3-d per week) college-age (18-30 yrs) males and females. Participants with orthopedic or neurologic conditions, or those reporting allergies to any of the supplement or placebo ingredients were excluded. This study was approved by the Georgia Southern University Institutional Review Board and all subjects provided written consent to participate. The study was a single blind, randomized crossover design consisting of three visits, as depicted in Figure 1 and described in greater detail below. This research was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science (20).

Table 1. Participant characteristics (Means ± SD)

	Age (yrs)	Height (cm)	Weight (kg)	BMI (kg/m²)	Body Fat (%)	VO_2max (ml/kg/min)
Males (*n* = 8)	25.3 ± 3.1	179.9 ± 3.6	86.5 ± 9.7	27.0 ± 2.6	17.0 ± 3.7	38.4 ± 3.7
Females (*n* = 5)	22.3 ± 2.1	162.8 ± 9.0	68.0 ± 8.5	26.2 ± 1.0	27.0 ± 2.7	34.4 ± 6.3

Protocol

During visit one anthropometrics were obtained and body fat was assessed via bioelectrical impedance analysis using an Omron HBF-306CN portable device (Omron Healthcare, Osaka, Japan). Maximal oxygen consumption (i.e., VO_2max) testing followed a standardized testing protocol proven to elicit volitional exhaustion between 8-12 minutes in duration in a similar population (9). Criteria for attainment of VO_2max included satisfying two of the following: RER > 1.1, rating of perceived exertion (RPE) > 17, or achievement of 90% age-predicted maximal heart rate (2). All testing was performed on a calibrated cycle ergometer (Monark LC6 Novo, Vansbro, Sweden) and seat and handlebar position were adjusted to each participant and positions were recorded for standardization among sessions. A minimum of 48 hours was required between VO_2max and the second study visit.

On the second and third study visits, participants reported to the laboratory where they consumed either a 1) spicy fruit gummy (139 kcals) containing 1.2 mg capsaicin (Bollox Ltd, Admiralty, Hong Kong) or 2) eucaloric fruit gummy, the order of which was randomized. Capsaicin is shown to reach peak plasma concentrations 45 minutes following ingestion (4). Thus, prior to TTE testing subjects were given a 45 minute waiting period during which they remained in the testing facility and sat quietly. TTE sessions began with a 5-min warm-up using 50 W for females and 100 W for males after which the load was increased to the pre-determined wattage eliciting ~90% of individual VO_2max (10). Heart rate was recorded every two minutes and participants were asked to pedal until volitional exhaustion or until they were unable to sustain a cadence of greater than 60 RPM. RPE was recorded two minutes into the testing session but then stopped so as not to interfere with the subject. At the completion of the session, RPE was once again queried. Prior to visit departure, subjects were provided with a gastrointestinal (GI) distress form, where they were asked to document any GI complaints occurring over the next 48 hours. TTE sessions were separated by a minimum of seven days and performed at the same time of day to ensure chronobiologic control. During the 24-h period prior to each visit, subjects were asked to follow the same diet and avoid spicy food as well as refrain from vigorous activity. Subjects were asked to refrain from caffeine the day of exercise testing.

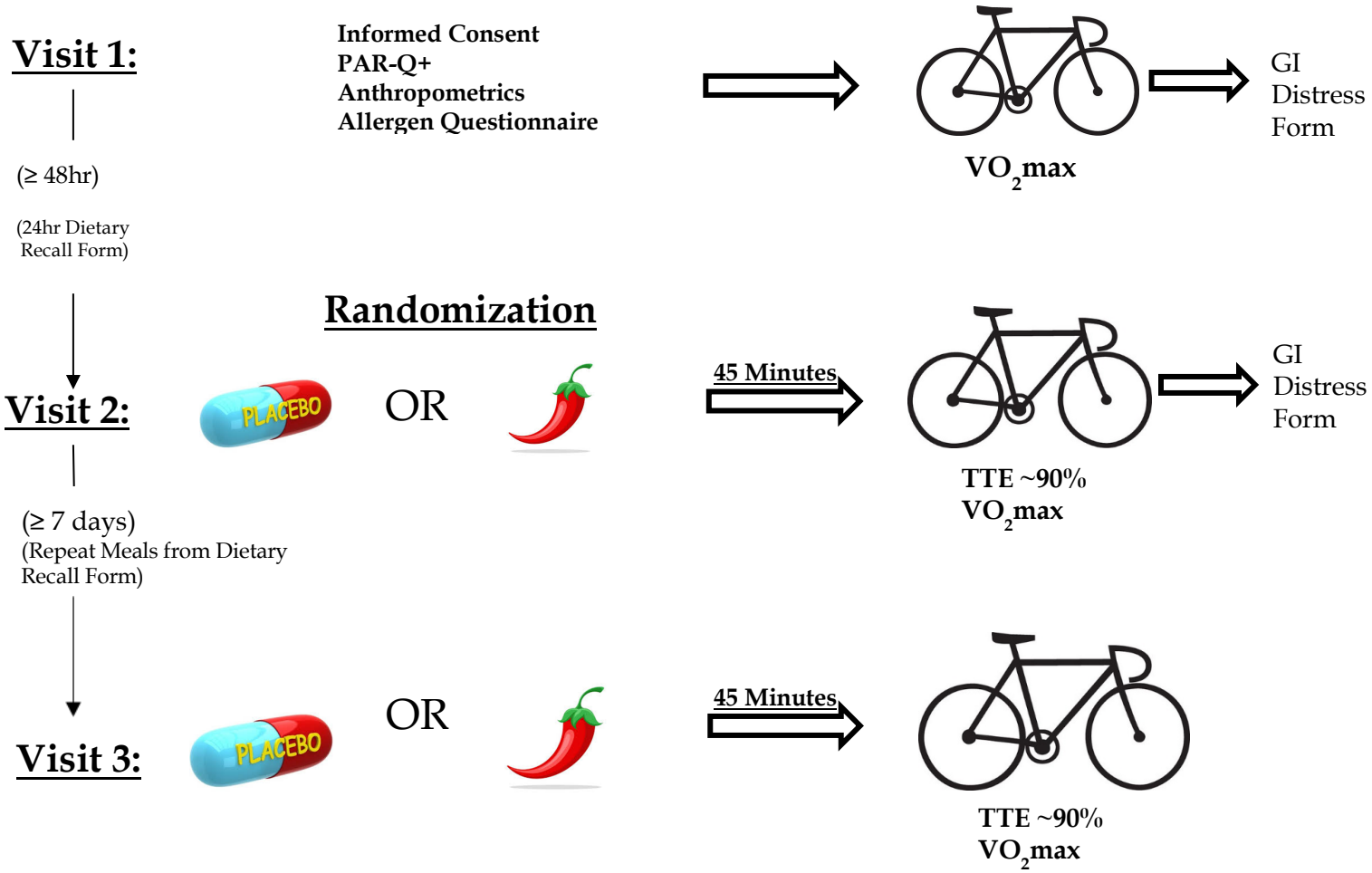

Figure 1. Schematic of study design.

Statistical Analysis

Data was analyzed with the Statistical Package for the Social Sciences (SPSS, Inc., Chicago, IL, USA). Independent variables included the capsaicin or placebo conditions, while dependent variables were TTE, RPE, and heart rate. Normality of data was confirmed using the Shapiro-Wilk test, with the exception of heart rate max during capsaicin trials and RPE at test termination of placebo trials. Paired *t*-tests and corresponding effect sizes (Cohen's d) were run to compare time to exhaustion, heart rate response (average and maximum), and RPE values between trials. Additionally, paired *t*-tests with appropriate Bonferroni adjustment were used to evaluate potential differences in heart rates between trials at 2, 4, 6, 8 and 10 minutes. Wilcoxon Signed-Rank tests were used for data that were not normally distributed (heart rate max and RPE at test termination). Alpha level was set at <0.05.

RESULTS

Participant Characteristics: Participant characteristics are provided in Table 1 as means ± SD. The capsaicin supplement was well-tolerated by all participants, without a single complaint of gastrointestinal distress. Cardiorespiratory fitness (i.e., VO_2max) values were ~50th percentile

for both male and female subjects (2), which confirmed their recreationally active status. Peak power outputs achieved during the VO_2max test were 240 ± 24 and 172 ± 21 watts for males and females, respectively.

Time to Exhaustion: In all trials, average time to exhaustion was 502.62 sec. Time to exhaustion at a workload eliciting ~90% VO_2max was not significantly different (p = 0.52; d = 0.13) between placebo (487.8 ± 187.7 sec) and capsaicin (517.5 ± 258.4 sec) trials (Figure 2). Average cadence was not significantly different (p > 0.05) between placebo (69.2 ± 5.6) and capsaicin (68.9 ± 4.8) trials. Similar TTE (519.0 ± 240.6 sec vs. 499.8 ± 196.8 sec) and cadence (68.7 ± 4.0 vs. 69.3 ± 5.6) values between trials 1 and 2, respectively, confirmed a lack of learning effect.

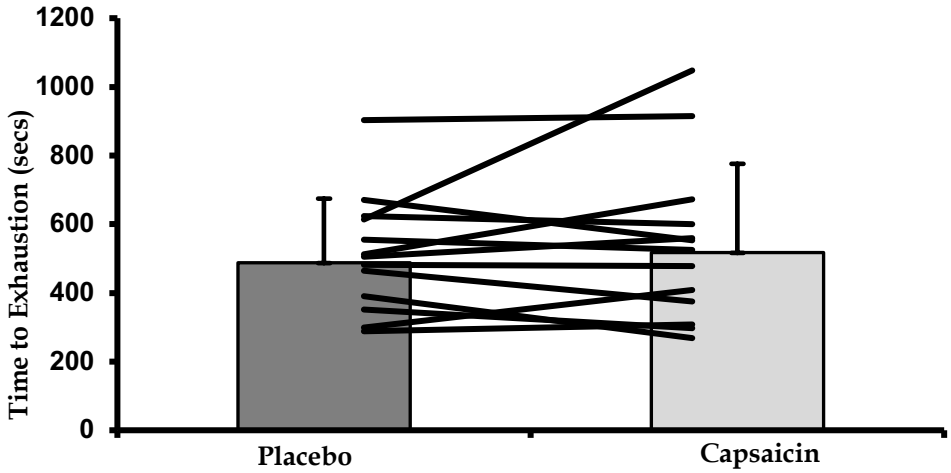

Figure 2. Means ± SD (bars) and individual data points (lines) for placebo and capsaicin time-to-exhaustion trials.

Heart rate and Rating of Perceived Exertion Measures: Pre-exercise resting heart rate was not significantly different (p > 0.05; d = 0.18) 45-min after ingesting either the capsaicin (71.3 ± 8.5 bpm) or placebo (73.7 ± 16.7 bpm) supplement. Average heart rate did not differ (p = 0.78; d = 0.13) between placebo (148.3 ± 11.8 bpm) and capsaicin (146.2 ± 8.1 bpm) TTE trials. Furthermore, maximal heart rate was also similar (p = 0.90; d = 0.05) between placebo (182.1 ± 8.7 bpm) and capsaicin (182.5 ± 7.2 bpm) trials. Average heart rate values throughout the time to exhaustion sessions in placebo and capsaicin trails were also similar (p > 0.05) at all time points (i.e., 2, 4, 6, 8, and 10 min; Figure 3). Participant ratings of perceived exertion (RPE) did not differ (p > 0.05) during the warm-up (9.8 ± 1.6 vs. 8.8 ± 1.4; d = 0.65), two minutes into the trial (13.4 ± 2.4 vs. 13.3 ± 2.0; d = 0.03), and at session termination (18.6 ± 1.1 vs. 18.6 ± 1.3; d = 0.0) between placebo and capsaicin trials, respectively.

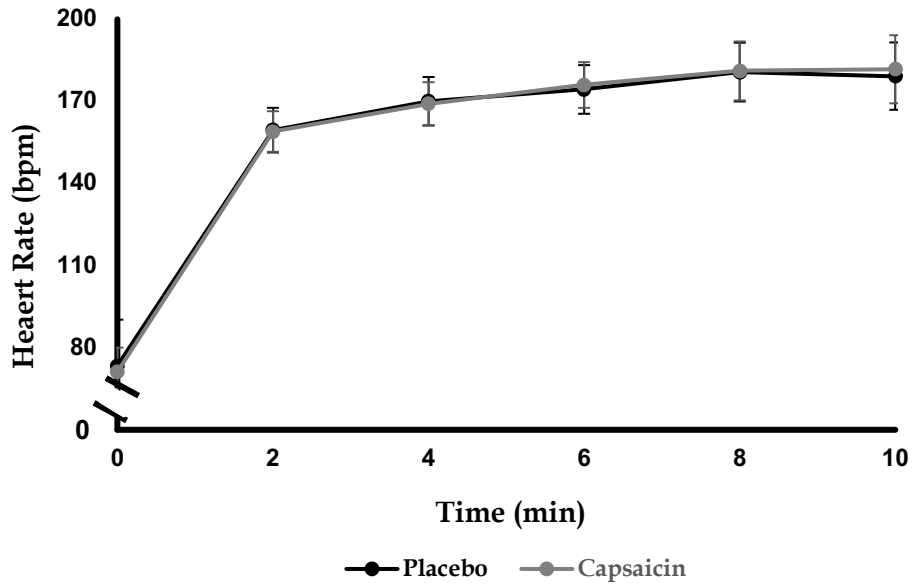

Figure 3. Average heart rate values for placebo (black) and capsaicin (gray) trials at 0 (rest), 2, 4, 6, 8, and 10 minutes during time to exhaustion trials (Means ± SD).

DISCUSSION

Contrary to our hypothesis, a commercially available low-dose (1.2 mg), chewable capsaicin supplement failed to extend time-to-exhaustion during cycling exercise. The ineffectiveness of the administered supplement to influence exercise performance was supported by its inability to alter related physiological parameters (i.e., heart rate and/or perceived exertion). This finding is in contrast to previous investigations showing improvements in both aerobic (7) and anaerobic (5, 6) exercise performance following acute ingestion of a larger-dose (12 mg) capsaicin pill, which appeared to moderate subjective strain (i.e., RPE).

To maximize ergogenic potential while minimizing unwanted side-effects, a minimum effective dose for pre-exercise capsaicin ingestion should be determined. Gastrointestinal complaints have been reported in previous performance-related human studies issuing doses of ~0.3 mg/kg body weight (23). However, substantially lower capsaicin doses (0.03 mg/kg body weight) ingested with a meal have proven to enhance fat oxidation and energy expenditure in resting human subjects (13). The present study utilized a similar capsaicin dose (~0.02 mg/kg body weight) in chewable form, based on the postulate that stimulation of oral TRPV1 receptors may amplify the physiological response, but no ergogenic effects were observed. Taken together, these findings suggest that although lower capsaicin doses may be sufficient to influence resting physiology, higher doses may be necessary to significantly alter physiological function and influence high-intensity exercise performance. Future studies are encouraged to explore the potential for cumulative low-dose capsaicin supplementation as a means to overcome undesirable gastrointestinal side effects while maximizing performance benefits.

Contrary to the notion that low-dose capsaicin supplementation may acutely influence resting systems physiology, resting heart rate was not affected 45-min after capsaicin ingestion.

Furthermore, similar heart rate values between TTE trials (Figure 3) provide continued support for a lack of capsaicin-mediated chronotropic influence. Moreover, similar RPE scores at various time points in the present study insinuates that the orally administered low capsaicin dose was inadequate to alter subjective strain. This finding is in contrast to previous research that used a larger capsaicin dose (12 mg) where reduced perceived exertion and improved 1500-m run performance were observed (7), portending to a possible sympathetic-mediated increase in pain threshold. These conflicting findings bring to light the probable mechanism by which greater capsaicin doses may improve exercise performance (i.e., increased tolerance to exertion).

Findings from the present study should be interpreted in the context of a few considerations. First, it should be acknowledged that subjects may have been able to differentiate between the placebo and capsaicin-containing fruit gummies (both 139 kcals), although we avoided asking about this matter in an attempt to mitigate participant performance bias. If an understanding of whether capsaicin-mediated activation of oral receptors (2, 24) plays a role in mediating the physiological response to capsaicin ingestion is desired, this obstacle is difficult to overcome. It is also possible that any performance-enhancing benefits of capsaicin may have been masked by the well-known benefits of pre-exercise carbohydrate intake (11). This study was also the first to examine the ergogenic potential of capsaicin in a mixed-gender sample, and although no gender differences were observed, this could be due to our relatively modest sample size. Finally, it should be kept in mind that although participants in our study were recreationally active, most were not accustomed to cycling exercise, and thus upstream neuromuscular competencies may have limited time-to-exhaustion performance before the intramuscular benefits of capsaicin could be realized.

In summary, acute capsaicin ingestion using a commercially available low-dose (1.2 mg), chewable supplement did not affect time to exhaustion, heart rate response, or perceived exertion during high-intensity cycling exercise. Higher capsaicin doses may be necessary to improve cycling performance in recreationally active individuals. However, the effects of this low capsaicin dose on metabolic function and/or performance in more familiar exercise modes is unknown and deserving of further inquiry.

ACKNOWLEDGEMENTS

The authors have no conflicts of interest to declare and no funding was received for this study. We would like to thank our participants for their time and efforts that made this study possible.

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