



The Effects of Pre-Workout Supplementation on Anaerobic Power and Maintenance of Power in College Students

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ABSTRACT

International Journal of Exercise Science 12(2): 355-365, 2019. This study examined the effects of Assault™ pre-workout supplementation on peak power output (PP), mean power output (MP), and percent decline in power output (% decline) during repeated, Wingate anaerobic tests. Thirteen healthy, physically active participants (7 male, 6 female) completed the randomized, double-blind, placebo-controlled crossover design with two conditions, supplement and placebo. The participants visited the laboratory for a total of three visits, 2-7 days apart. During visit 1, the participants completed a 4-minute familiarization warm-up on the Monark cycle ergometer and performed one baseline, 30-second Wingate cycle ergometry test. During visits 2 and 3, the participants consumed either the pre-workout supplement or placebo flavored maltodextrin (randomized by a third party) and waited 20 minutes before beginning the test protocol. Each participant then completed a 4-minute warm-up on the Monark cycle ergometer followed by four, 30-second Wingate tests, with a 5-minute rest between each Wingate. There were no significant two-way condition x Wingate trial interactions for PP (F=0.713, p=0.566), MP (F=0.669, p-value=0.590), or % decline (F=0.398 p=0.540). There was a significant main effect for the Wingate trial for both PP (F=10.632, p=0.002) and MP (F=11.781, p=0.001), but there was no main effect for the Wingate trial for % decline. There were no main effects for condition for any of the variables. The pre-workout supplement examined in this study did not elicit ergogenic effects on anaerobic power output (PP or MP) or the maintenance (% decline) during multiple Wingate tests.

KEY WORDS: High-intensity anaerobic exercise performance, ergogenic aids, caffeine

INTRODUCTION

Pre-workout supplementation has become very popular in recreational and competitive athletes. Athletes ingest pre-workout supplements in an attempt to enhance focus, strength, and power, as well as delay fatigue (24). There are many pre-workout supplements on the market, containing several combinations of active ingredients, but caffeine is the primary active ingredient in most pre-workout supplements. The ingestion of caffeine-containing pre-workout supplements has been shown to increase performance measures when taken 20 minutes prior to a workout (30). Caffeine is suggested to promote strength and power

performance by increasing calcium release from the sarcoplasmic reticulum leading to increased muscle fiber contractility (26, 30). Caffeine has also been shown to delay the perceptions of fatigue by acting as an adenosine receptor antagonist (15). Pre-workout supplements also commonly contain amino acids, beta-alanine, creatine, citrulline-malate, arginine, and B vitamins (B-6, B-12). These additional active ingredients are often combined with caffeine to produce a synergistic effect on anaerobic performance. There is, however, limited research on ergogenic effects of acute supplementation of caffeine in combination with these other active ingredients on anaerobic performance markers, such as repeated, high-intensity cycle ergometry trials.

The combination of ingredients such as caffeine, creatine, and amino acids in pre-workout supplements has been associated with delayed fatigue and enhanced performance during high-intensity anaerobic exercise (29). Pre-workout supplements containing multiple ingredients such as branched-chain amino acids (BCAAs), aspartic acid, and B vitamins may augment the effects of caffeine (5, 6, 18, 31, 34). Branched-chain amino acids, such as leucine, have been shown to enhance cognitive function (34), increase protein synthesis, and decrease protein degradation leading to increased muscle mass (6). Aspartic acid may improve muscular performance by lowering the level of ammonia in the blood (4), while B vitamins, in particular B-6 and B-12, have displayed an important role in metabolic pathways involved in exercise and DNA synthesis, respectively (36). It is currently unknown, however, how the combination of these ingredients may augment the effects of caffeine during short-term, high intensity anaerobic exercise.

The effectiveness of caffeine-containing pre-workout supplements for the enhancement of anaerobic performance remains unclear. Pre-workout supplementation has been shown to increase the total training volume (5, 21) as well as peak and mean power performance during a resistance training protocol (21). In addition, pre-workout supplementation resulted in increased leg press strength, perceived energy, alertness, focus, and reaction time (30). In contrast, pre-workout supplementation prior to a single Wingate anaerobic test was reported to have no significant ergogenic effects on anaerobic power or performance (10,16). Similarly, caffeine supplementation alone had no effect on anaerobic power or capacity from four Wingate anaerobic tests (22). Thus, there are data supporting (5, 21) an ergogenic effect of caffeine containing pre-workout supplements on anaerobic and strength parameters, but the effectiveness of various combinations of ingredients on anaerobic power and capacity from a Wingate test is less clear. No previous studies, however, have examined the effects of the combination of ingredients contained in the Assault™ pre-workout supplement on anaerobic performance during repeated Wingate anaerobic tests. Therefore, the purpose of this study was to examine the effects of Assault™ pre-workout supplement containing caffeine, BCAAs, creatine, beta-alanine, arginine, vitamin B-6, and vitamin B-12 (Assault™, MusclePharm, Inc., Denver, CO, USA) on peak power output (PP), mean power output (MP), and percent decline in power output (% decline) during repeated Wingate anaerobic tests. We hypothesized the pre-workout supplement would result in an increased PP and MP, but no change or a lower % decline for repeated Wingate tests, compared to a placebo.

METHODS

Participants

Fourteen healthy, college-aged students, with experience in high-intensity interval training were recruited for this study. One participant dropped out due to scheduling conflicts. Thus, the analyses included data for thirteen participants. The sample size is based on previous research average values of anaerobic peak power (36) using a medium-to-large effect size of 0.5-0.8, an alpha criterion of 0.05, and a power level of 0.8. The participants consisted of 7 males (25 ± 4 years; 180.1 ± 7.2 cm; 82.2 ± 10.9 kg), and 6 females (24 ± 2 years; 163.3 ± 14.0 cm; 64.6 ± 6.7 kg). Participants were excluded if they consumed more than 200 mg of caffeine (the equivalent caffeine content of 2 cups of coffee) on a regular basis, were pregnant, or had any allergies to the ingredients listed on the supplement label. All participants were between the ages of 18-35, involved in strength training 3-5 times a week for at least one year, and were free from any musculoskeletal or neuromuscular injuries. The investigation was approved by the University of Kentucky Institutional Review Board for the protection of human testing and all participants completed a health history questionnaire and signed informed consent documents before testing.

Protocol

This study was a randomized, double-blind, placebo-controlled crossover design with two conditions, supplement and placebo. The participants visited the Exercise Physiology laboratory for a total of three visits, with each visit scheduled between 2-7 days apart. Participants were instructed to: 1) refrain from eating 2 hours prior to testing; 2) refrain from exercise 12 hours prior to testing; 3) maintain their normal exercise habits and avoid any unaccustomed exercise bouts during their enrollment in the study; and 4) refrain from caffeine 24 hours prior to testing. During visit 1, the participants provided informed consent, completed pre-exercise testing health questionnaires and personal information forms, and performed one baseline 30-second Wingate cycle test. After the Wingate test, the participants were provided a 24-hour food log to complete prior to visits 2 and 3. During visits 2 and 3, the participants consumed either the pre-workout supplement or placebo (randomized by a third party) and waited 20 minutes before beginning the test. Each participant then completed a 4-minute warm-up on the Monark cycle ergometer followed by four 30-second Wingate tests with a 5-minute rest between each Wingate.

Baseline Measurements: During the first visit, the body weight, heart rate, and blood pressure were measured, followed by a baseline Wingate test on a Monark Cycle Ergometer (Monark, model 894E). Prior to the test, the seat height was adjusted so that the participants' legs were near full extension at the bottom of the pedal revolution. Toe cages were used to maintain pedal contact throughout the test. A warm-up was then performed, which consisted of 4-minutes of cycling against 0 kg resistance, with two 5-second sprint intervals at the end of the 2nd and 3rd minutes of the warm-up. The sprints were performed using 7.5% of the participant's body weight as resistance. A 1-minute passive rest followed the warm-up. The Wingate test began with unloaded cycling where the pedaling cadence was increased as high as possible. The resistance (7.5% of the participant's body weight) was automatically applied

when the cadence exceeded 110 rev·min⁻¹ and the participants were instructed to maintain the cadence as high as possible for 30-seconds. The PP was measured as the highest 5-second average power and the MP was measured as the average power during the 30-second test (3). The minimum power was measured as the lowest 5-second power and was used to calculate the percent decline in power output (%decline) using the following equation (3): (peak power - minimum power/ peak power) x 100.

Food log: The participants were instructed to record all food and beverages consumed 24-hours prior to the experimental testing sessions (visits 2 and 3). The participants were asked to consume a similar diet prior to visits 2 and 3. The total energy and macronutrient intake (kcal) were quantified (www.supertracker.usda.gov) for further analysis to determine if there were any differences between visits 2 and 3.

Table 1. Assault™ Pre-workout supplement ingredients

Ingredients	Amount per serving
Calories	10
Total Carbohydrates	2 g
Sugars	2 g
Vitamin C	500 mg
Vitamin E	200 IU
Niacin	25 mg
Vitamin B6	15 mg
Vitamin B12	90 mcg
Calcium	171 mg
Sodium	50 mg
Potassium	40 mg
ATP Amplifier Blend	3,500 mg
Carnosyn Patented Beta Alanine (2,000 mg), L-Tyrosine, L-Aspartic Acid, Red Beet Extract High in Nitrates, (DMG) Dimethylglycine HCl	
Cellular Transport & Insulin Activator	2,952 mg
Dextrose, L-Glycine, Ribose, Cinnulin PF (Cinnamomum Burmannii) Bark Extract	
Athlete Performance Blend	2,000 mg
Creatine Nitrate, L-Arginine Nitrate, BCAA Nitrate 3:1:2 Ratio (L-Leucine, L-Valine, L-Isoleucine)	
Energy and Neuro Igniter	1,750 mg
Choline Bitartrate, Glucuronolactone, PureEnergy Matrix (Caffeine Anhydrous, Pterostilbene), Huperzine A	
Hydration System	1,200 mg
Taurine, Coconut Water Powder, L-Glutamine	

Experimental Trials: Visits 2 and 3 were identical, other than the beverage that was consumed. Upon entering the lab, resting blood pressure and heart rate were measured and a 24-hour food log was collected from each participant. Next, participants consumed either a pre-workout supplement (Table 1) or placebo beverage (randomized by a third party). Participants were given the supplement per label instruction, which resulted in a caffeine dose of 4.2 ± 0.69 mg·kg⁻¹. The placebo was flavored maltodextrin. The participants waited 20 minutes before performing the same 4-minute warm-up as the baseline trials. Following the warm-up, the participants rested for 1 minute. Next, the participants began the first of four, 30-second

Wingate tests with 5-minute rests in between. The Wingate tests followed the same procedures as the baseline trial. During the 5-minute rest, the participants were instructed to stay on the bike for the first minute and get back on the bike for the last minute to help reduce instances of nausea or fainting due to high intensity interval exercise. The other 3 minutes they were free to rest on or off the bike at their preference and drink water ad libitum. After completing the fourth Wingate tests, the participants were instructed to complete a 5 minute cool down at their own pace against 0 kg of resistance.

Statistical Analysis

The reliability of the Wingate test was assessed with intraclass correlation coefficient (ICC) and standard error of the measurement (SEM) for the baseline trial and 1st Wingate of the placebo condition. The peak power, mean power, and % decline values for each test were examined using separate, two-way (2 conditions (SUP and PL) x 4 Wingate trials) repeated measures ANOVAs. Follow up analyses included one-way repeated measures ANOVAs and paired samples t-test. In addition, paired samples t-tests were used to determine if there were differences in total and macronutrient energy intake (kcal) between visit 2 and visit 3. An alpha level of $p \leq 0.05$ was considered statistically significant for all comparisons. All statistical analyses were performed with Statistical Package for the Social Sciences software (SPSS version 24).

RESULTS

The ICC values (SEM) for the peak power, mean power, and % decline were $R=0.981$ (38.4 W), $R=0.980$ (23.4 W), and $R=0.893$ (3.1 W), respectively. There was no significant two-way condition x Wingate trial interaction ($F=0.148$, $p=0.928$) and no main effect for condition ($F=0.160$, $p=0.697$) for peak power (Table 2). There was, however, a main effect ($F=10.632$, $p=0.002$) for the Wingate trial for peak power. The follow-up pairwise comparisons (collapsed across condition) indicated the peak power from trial 1 (909.3 ± 81.3) was significantly greater than trial 2 (826.7 ± 73.6), 3 (743.5 ± 57.8) and 4 (720.3 ± 56.8). In addition, trial 2 mean power was greater than 3 and 4, but 3 and 4 were not different (Figure 2).

Table 2. Mean \pm SD results for four Wingate Trials within each condition, placebo (PL) and supplement (SUP), for peak power (PP), mean power (MP), and percent decline (%decline). Main effects for the within trial findings are presented in text.

	PP		MP		% Decline	
	PL	SUP	PL	SUP	PL	SUP
Trial 1	904.4 \pm 280.9	914.2 \pm 308.7	603.9 \pm 168.4	614.0 \pm 174.4	57.1 \pm 8.8	55.8 \pm 8.5
Trial 2	825.2 \pm 264.6	828.2 \pm 269.5	540.6 \pm 144.3	546.9 \pm 149.0	58.5 \pm 12.5	58.8 \pm 10.6
Trial 3	746.5 \pm 207.2	740.5 \pm 218.2	500.6 \pm 110.3	494.6 \pm 125.2	61.1 \pm 13.7	59.1 \pm 11.8
Trial 4	714.1 \pm 197.0	726.5 \pm 218.7	485.0 \pm 117.1	491.7 \pm 129.7	60.8 \pm 11.8	61.0 \pm 11.3

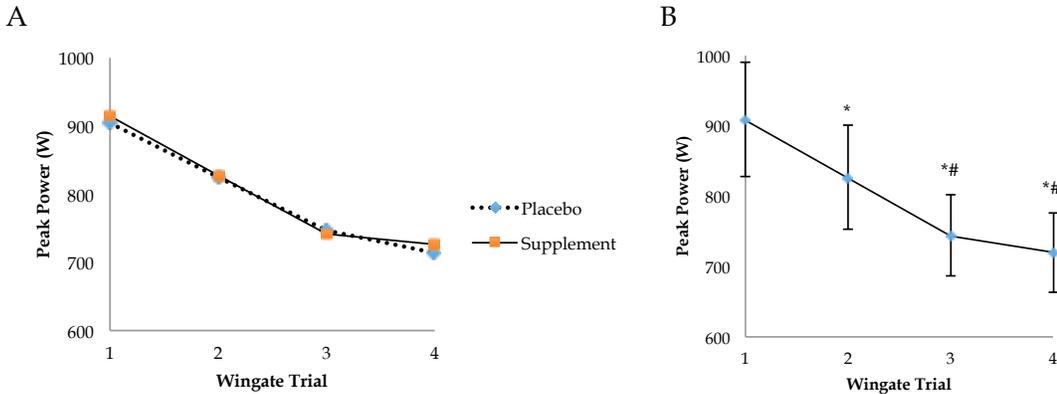


Figure 2. Peak power comparisons between conditions (Placebo and Supplement) for each Wingate trial. A: Displays no difference (no interaction effect) in anaerobic peak power for condition across all Wingate trails. B: Displays the mean comparisons for peak power for each Wingate trial (main effect for trial). *Lower than Trial 1 $p < 0.05$, #Lower than Trial 2 $p < 0.05$

There was no significant two-way condition \times Wingate trial interaction ($F = 0.669$, $p\text{-value} = 0.590$) and no main effect for condition ($F = 0.678$, $p\text{-value} = 0.426$) for mean power. There was, however, a main effect ($F = 11.781$, $p = 0.001$) for the Wingate trial for mean power (Table 2). The follow-up pairwise comparisons (collapsed across condition) indicated the mean power from trial 1 (609.0 ± 47.4) was significantly greater than trial 2 (543.7 ± 40.5), 3 (497.6 ± 32.4) and 4 (488.4 ± 33.9). In addition, trial 2 mean power was greater than 3 and 4, but 3 and 4 were not different (Figure 3).

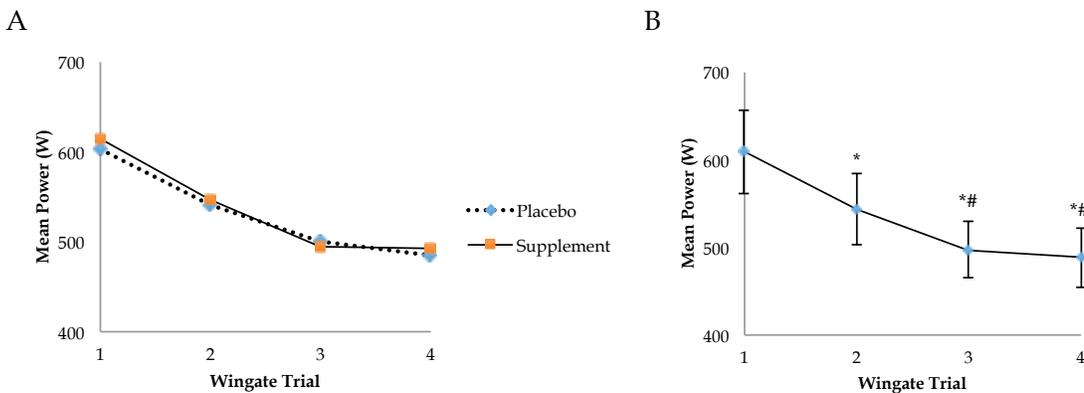


Figure 3. Mean power comparisons between conditions (Placebo and Supplement) for each Wingate trial. A: Displays no differences (no interaction effect) in anaerobic mean power for condition across all Wingate trails. B: Displays the mean comparisons for mean power for each Wingate trial (main effect for trial). *Lower than Trial 1 $p < 0.05$, #Lower than Trial 2 $p < 0.05$

There was no significant two-way condition \times Wingate trial interaction ($F = 0.713$, $p = 0.566$) and no main effect for condition ($F = 0.398$, $p = 0.540$) or Wingate trial ($F = 1.791$, $p = 0.212$) for % decline (Table 2; Figure 4).

A

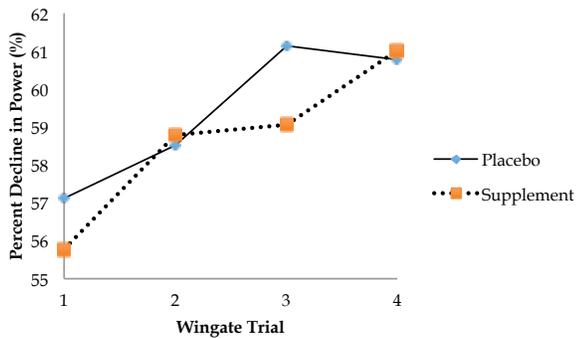


Figure 4. Percent decline comparisons between conditions (Placebo and Supplement) for each Wingate trial. There were no significant differences between the supplement or placebo for percent decline.

Dietary food intake comparing visit 2 and 3 resulted in no significant difference in total kCals ($p=0.226$), PRO ($p=0.352$), CHO ($p=0.794$), or FAT ($p=0.864$).

DISCUSSION

This study examined the effects of the commercially available pre-workout supplement Assault™ on anaerobic power (MP and PP) and maintenance of power (% decline) using repeated 30 second Wingate tests. The results of the current study indicated supplementation with the pre-workout Assault™ had no effect on MP, PP, or %decline. Currently, there is conflicting evidence regarding the effectiveness of pre-workout and/or caffeine supplementation to improve short-duration, high intensity anaerobic power output (9, 10, 13, 17, 19, 21, 22, 23, 27, 35, 36). For example, previous studies showed no effect of $\sim 1\text{-}2\text{mg}\cdot\text{kg}^{-1}$ of caffeine supplementation alone on anaerobic power from a cycle ergometry sprint test in untrained, moderately active males and females (17) or on anaerobic power during a 25-s treadmill sprint test in untrained, recreationally active males (23). Furthermore, a caffeine dose of $\sim 6\text{mg}\cdot\text{kg}^{-1}$ was reported to have no effect on the anaerobic power output from repeated Wingate tests in untrained, moderately active males (22). In contrast, multi-ingredient pre-workout supplementation, containing a relative dose of $3.6\text{mg}\cdot\text{kg}^{-1}$ caffeine resulted in increased peak and mean anaerobic cycling power output during a single 20-s maximal effort test in trained males (27) and caffeine supplementation ($5\text{mg}\cdot\text{kg}^{-1}$) alone improved Wingate peak power in trained male athletes (35). Thus, there is conflicting evidence regarding the effectiveness of caffeine and caffeine containing supplements to improve anaerobic performance. In contrast to previous evidence (27, 35) indicating an ergogenic effect of caffeine containing pre-workout supplementation and caffeine supplementation alone, the current findings supported those of others (17, 22, 23) and indicated no changes in anaerobic performance parameters after supplementation.

It has been suggested that caffeine may improve anaerobic performance through several mechanisms including, increased motor unit firing, calcium ion mobilization from the sarcoplasmic reticulum, and increased nitric oxide (NO) concentration in skeletal muscle (27, 36). These effects, however, may be dependent upon the relative caffeine dosage, subject training level, and muscle fiber type characteristics (17, 22, 23). Specifically, it has been suggested that doses of $4\text{-}6\text{mg}\cdot\text{kg}^{-1}$ may be necessary to facilitate increased anaerobic and

strength measurements in trained athletes (20). Studies have found highly trained athletes demonstrated an increase in anaerobic performance when consuming 4-6mg kg⁻¹ doses of caffeine (19, 35, 36), whereas untrained or non-specifically trained (i.e., not competitive cyclists) individuals demonstrated no improvement in anaerobic performance after similar caffeine doses (11, 13, 22). It is possible the lack of ergogenic effect of the pre-workout examined in this study is due to the low relative caffeine dosage (4.2 ± 0.69 mg kg⁻¹; range = 3.1-5.6 mg kg⁻¹) for physically active, but non-specifically trained participants (i.e., not competitive cyclists) (17, 22, 23). Previous studies (1, 28, 33) have also suggested the muscle fiber type contributions during exercise may be important determinates in the effectiveness of caffeine supplementation. High intensity anaerobic exercise such as Wingate cycle tests, rely heavily on anaerobic energy production through the phosphocreatine (PCr) and glycolytic pathways, which are more developed in fast-twitch glycolytic fibers (FG) (22). Caffeine acts in the central nervous system as an adenosine receptor antagonist (1) and may delay the onset of fatigue during exercise (14). Adenosine receptors are found in greater concentrations in slow oxidative than FG fiber types (1). Therefore, caffeine may not be as effective for improving high intensity cycle ergometry performance, compared with longer duration, aerobic based exercise, due to the reliance on anaerobic energy systems and FG fibers.

The primary active ingredient in this pre-workout supplement was caffeine (30). There were, however, a number of other ingredients (e.g., red beet extract, dimethylglycine HCL, amino acids, L-tyrosine, leucine, and huperzine) that have been reported to have acute effects on exercise performance. For example, red beet extract has been shown to improve vascular control and increase skeletal muscle blood flow during exercise, therefore improving intramuscular pH and resynthesizing creatine phosphate (PCr) (16). There is evidence that dimethylglycine HCL enhances mitochondrial efficiency through vasodilation and increased blood flow to skeletal muscles (27). Previous studies, however, have not demonstrated ergogenic effects on anaerobic power output for red beet extract (8) or dimethylglycine HCL (2) supplementation alone. Other active ingredients such as amino acids, L-tyrosine, leucine, and huperzine A are known to improve cognitive function and slow the onset of fatigue in anaerobic exercise (12, 25, 37). It is believed that these ingredients act synergistically to enhance performance in anaerobic strength and power output (5). The results of this study, however, showed no significant difference between the supplement and placebo conditions in % decline (power maintenance) after consecutive Wingate trials.

The pre-workout supplement examined in this study also contained ingredients that have potential effects on anaerobic energy metabolism after long-term dosing strategies (>4 weeks). For example, beta-alanine and creatine are active ingredients in the pre-workout supplement that independently elicit positive long-term effects on high intensity anaerobic power (27). Beta-alanine has been shown to increase strength and power due to increased carnosine levels and intramuscular buffering capacity after ~4 weeks of supplementation (32). The recommended dose of beta-alanine to elicit increased carnosine levels is 3-6 g · day⁻¹ for 2 to 4 weeks (31). Supplementation with creatine results in increased phosphocreatine stores for high-intensity activities after 1 to 4 week dosing strategies (7, 32). The recommended dose for creatine to elicit effects is 5 g · day⁻¹ for 30 days or 20 g · day⁻¹ for 5-7 days (7). In this study the

pre-workout beta-alanine and creatine dose was 2g and <2g respectively, which may not be great enough to increase the buffering capacity and PCr stores even if taken for at least 4 weeks. Future research should look at the long-term effects of this pre-workout supplement on anaerobic cycle ergometer performance.

In conclusion, the pre-workout supplement examined in this study did not elicit ergogenic effects on anaerobic power (MP and PP) or power maintenance (%decline) following multiple Wingate tests. Further testing is warranted to determine if this pre-workout supplement will produce benefits in highly trained anaerobic athletes at relative doses of approximately 6mg·kg⁻¹ or if long-term supplementation (>4 weeks) would elicit ergogenic effects on anaerobic power.

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