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Abstract

The purpose of this study was to investigate the effects of a multi-ingredient pre-workout supplement (MIPS) on mental and physical performance. Seventeen exercise-trained men (n = 7) and women (n=10) completed this randomized, placebo-controlled, double-blind, counterbalanced, crossover trial. Participants consumed either a multi-ingredient pre-workout supplement (MIPS) or a placebo in a randomized, counterbalanced order. Forty-five minutes post-consumption, the following assessments were conducted: psychomotor vigilance test (PVT), Profile of Mood States (POMS), Stroop test, vertical jump test, and a Cold pressor test. There was a one-week washout period between assessments. There were significant differences in the incongruent task for the Stroop test where the treatment group had faster reaction times than the placebo group at the 45-minute post-consumption (reaction time: treatment 862 ± 160 ms, placebo 942 ± 204 ms, $p = 0.0424$). There were no significant differences between groups for the other indices of mood, the PVT, congruent scores of the Stroop test, vertical jump, or the Cold Pressor test. Thus, the acute consumption of a multi-ingredient pre-workout supplement produced a significant improvement in a sustained-attention, reaction-timed task.

Keywords

caffeine, supplement, focus, performance, exercise

Cover Page Footnote

Acknowledgements: MRM Nutrition (Oceanside, CA) provided the multi-ingredient pre-workout supplement as well as the placebo. The Institute of Human Performance (Boca Raton, FL) served as the clinical site for the investigation.

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Keywords

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Introduction

Multi-ingredient pre-workout supplements (MIPS) have been shown to affect exercise performance [1-6]. Endurance trained runners have increased time to fatigue during sustained running at lactate threshold [2]. Consuming caffeine-containing energy drinks have also been shown to improve performance during a 1-hour timed cycling trial [7]. Following a bout of high intensity exercise in active females, the acute ingestion of MIPS improved feelings of focus, anaerobic capacity, and upper body muscular endurance [8]. Caffeine (a main ingredient in the product tested) consumption through energy drinks have shown to improve time to exhaustion during endurance events, improved measures on energy, focus, fatigue, and increased energy expenditure in several studies [5,9]. Caffeine has also be shown to improve inhibitory control in athletic tasks [10].

Nitrous oxide (NO) plays an important role in blood flow and performance [11]. NO related supplements such as those containing beet products enhance sports performance [12]. L-citrulline (a main ingredient in the product tested) is a precursor to L-arginine which is one of the substrates responsible for nitrous oxide synthesis (NOS) [13]. L-citrulline is recycled to L-arginine through the L-citrulline NO cycle and performs an important role in the regulation and metabolism of NO [13]. L-citrulline has been shown to improve cognitive function [14], and improved exercise tolerance [15].

β-alanine (a main ingredient in the product tested) is a precursor that limits the rate of carnosine synthesis in muscle fibers [16]. Carnosine is a cytoplasmic dipeptide that aids in the buffering of hydrogen ion (H^+) that decreases physical performance during intense exercise[17]. Thus, the purpose of this study was to investigate the effects of a multi-ingredient pre-workout supplement (MIPS) on mental performance, mood, pain tolerance, and physical performance.

Materials and Methods

This study was a randomized, placebo-controlled, double blind, counterbalanced, crossover trial. Subjects reported to the lab on two separate occasions with a one-week washout period to participate in testing. They were given the treatment or placebo on the first visit, then consumed the treatment or placebo (depending on what they were given the first visit) on the second visit. The treatment product "Driven" pre-workout (provided by MRM Nutrition 2665 Vista Pacific Dr., Oceanside, CA 92056, USA) contains 155 mg of caffeine from InnovaTea® (tea leaves), 2,00 mg of L-Citrulline, 1,00 mg of CarnoSyn® (β-alanine), and 500 mg of Red Beet Powder as the active ingredients. The placebo was maltodextrin.

Participants

Seventeen exercise-trained men (n = 7) and women (n = 10) volunteered for this clinical trial. Subjects reported to the lab on two separate occasions one week apart to participate in testing. In accordance with the Helsinki Declaration, the Institutional review Board for the university approved all procedures involving human subjects (IRB# IRB000NV21JC103 through Keiser University). A written informed consent was obtained from all participants prior to participation. Exercise history and caffeine consumption were assessed through a questionnaire. Participants estimated their daily caffeine consumption, and exercise history was determined by reporting average weekly resistance training, aerobic training exercise times, other forms of exercise, and how many years they have been training. Participants who exercise at least three days a week on average for the past year and are daily caffeine consumers (the amount did not qualify or disqualify from participation) met the qualifications.

Body Composition

A multi-frequency bioelectrical impedance assessment device (InBody 270) was used to assess body composition (body mass, fat mass, lean body mass, body fat percentage, and total body water in liters). We instructed participants to arrive fasted for at least three hours. The participants stood on the platform of the device with bare feet on the electrodes and are then instructed by the device to grasp the handles (which contains additional electrodes on thumb and fingers) while maintaining straight arms and their arms horizontally adducted approximately 30 degrees. This assessment takes ~1 minute. Only baseline body composition was assessed during this study.

Table 1: Research Participant Characteristics

Age y	22±3
Height cm	174±7
Body mass kg	81.5±21.0
Lean body mass kg	61.1±10.8
Fat mass kg	15.9±8.2

% Body fat	20.2±8.0
Total body water liters	44.7±7.9
Total # of years of training	9.4±6.9
Average hr of aerobic exercise per week	3.8±5.3
Average hr of resistance training per week	7.6±3.2
Other exercise per week	1.1±1.8
Average caffeine consumed daily	185±150

Data are expressed as the mean±SD. n=17 (10 female, 7 male).

Multi-Ingredient Pre-Workout Supplement (MIPS) and Placebo

The MIPS and placebo were donated by MRM Nutrition (2665 Vista Pacific Dr. Oceanside, CA 92056, USA) (Figure 1). InnovaTea® Caffeine from Tea (155 mg per 6.5 g scoop to be mixed with water), along with L-Citrulline (2,000 mg), CarnoSyn® Beta-Alanine (1000 mg), and Red Beet Powder (500 mg) are the primary active ingredient in the MIPS. The placebo was made of maltodextrin. Both placebo and the MIPS were placed in identical bags with different codes. Both powders appeared identical and were mixed with ~8-12 fluid ounces of water for consumption. The placebo was a mix of Trehalose, Acacia Fiber, Red Beet Powder, Natural Flavor, Citric Acid, Silicon Dioxide, and Stevia Extract.

Figure 1: MIPS Nutrition Panel

Supplement Facts

Serving size 1 scoop (6.5 g)

servings per container 20

Amount Per Serving	**% Daily Value**

Calories	10			
Total Carbohydrate	2	g	1	% *
Total Sugars	1	g		†
Includes 1g Added Sugars			2	% *
Vitamin C (as ascorbic acid)	100	mg	110	% *
Niacin	10	mg	60	% *
Vitamin B6 (as pyridoxine hydrochloride)	5	mg	290	% *
Vitamin B12 (as methylcobalamin)	25	mcg	1040	% *
Pantothenic Acid (as calcium pantothenate)	100	mg	2000	% *
L-Citrulline	2,000	mg		†
CarnoSyn® Beta-Alanine	1,000	mg		†
Red Beet Powder	500	mg		†
N-Acetyl-Tyrosine	250	mg		†
InnovaTea® Caffeine from Tea (155mg caffeine)	160	mg		†
Peak ATP®	25	mg		†
* Percent Daily Value are based on a 2,000 calories diet.				

ɨ Daily Value not established

Other Ingredients: Raw cane sugar, natural flavor, stevia leaf extract, citric acid, silicon dioxide, and monk fruit extract.

Profile of Mood State POMS

The Profile of Mood State (POMS) is a 65-word standard validated psychological test to assess transient and distinct mood states[18]. The test listed words such as "angry", "tense", "lively", etc., and next to each word is a drop-down menu with the words "how I have felt" above them. The options in the drop-down menu were "not at all", "a little", "moderately", "quite a bit", and "extremely". This test scores total mood disturbance, anger, depression, fatigue, tension, and vigor.

Stroop Test

The Stroop Test is a commonly used neuropsychological test used to assess the ability of an individual to inhibit cognitive interference when a specific stimulus is processed and impedes the simultaneous processing of a second stimulus [19]. This phenomenon is known as the Stroop effect [19]. This test has multiple congruent and incongruent tests throughout the protocol (roughly 56 trials of congruent and incongruent). An example of a congruent test on the Stroop test would be when you read the word "red", and the word is in the color red. An example of an incongruent test is when you read the word "red", and the word is written in blue.

Vertical Jump

The vertical jump test is a common physical power test used in multiple sports assessments as well as laboratory assessments. We used a Vertex measuring device for our study. The vertex has flags that represent height in inches and feet. The bottom flag is placed at the top of the participants reach when standing and arms are extended. They perform three jumps trying to touch the highest flag possible.

Cold Pressor Test

The cold pressor test is administered by immersing a limb (a hand in our case) into cold water to elicits an emotional/motivational pain experience [20]. It is widely used to evaluate (experimental) pain and is measured by an increase in heart rate (HR) and blood pressure (BP) [20].

Performance Testing Procedures

Participants arrived at the lab on two separate occasions separated by one week between the hours of 1200 and 1300 on both days. The participants' physical characteristics were assessed, then they consumed either the treatment or the placebo. At 45 minutes post consumption they filled out the Profile of Moods State (POMS) questionnaire, performed a Stroop Test protocol, a 3-trial max vertical jump test, and a Cold Pressor Test. The same measures were again repeated at 90-minutes post consumption. After one week the participants reported back and consumed either the treatment or placebo drink (the opposite of the drink they consumed on their first visit), then they repeated the same measures as the previous week at 45-minutes post consumption, and then again at 90-minutes post consumption.

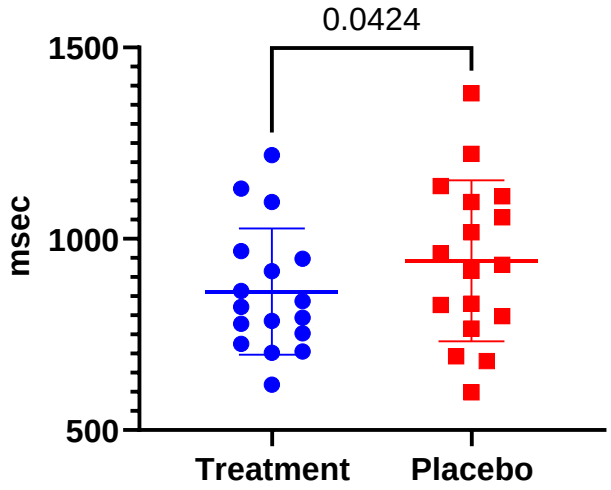
Statistical Analysis

All statistical analysis was per formed on GraphPad (Prism 6) statistical software. All the data for this study is presented as the mean ± SD. A paired t-test was performed to determine whether statistically significant differences ($p < 0.05$) occurred between the treatment and the placebo (i.e., for PVT, Stroop Test, vertical jump, and Cold Pressor Test); a Wilcoxon matched-pairs signed rank test was performed to determine if differences existed for the POMS.

Results

There were significant differences in the incongruent task for the Stroop test where the treatment group had faster reaction times than the placebo group at the 45-minute post-consumption (reaction time: treatment 862 ± 160 ms, placebo 942 ± 204 ms, $p = 0.0424$) (Figure 2, Table 2). There were no significant differences in the Stroop tests in congruent scores at either time interval or the incongruent at the 90-minute interval (Table 2). The effect size of the Incongruent 45-min post Cohen's d = 0.436 (small effect size). There were no significant findings in the overall Stroop effects either. There are no significant differences in either time interval for the Cold Pressor Task (Table 3), the vertical jump (Table 4), or the Profile of Mood States (POMS)(Table 5).

Figure 2. Incongruent Condition 45-min post



The response time to the incongruent condition on the Stroop task

Table 2: Response Times for the Stroop

	Treatment	Placebo
45-min Post		
Congruent	746±153	805±181
Incongruent	862±160*	942±204
Stroop	127±111	140±122
90-min Post		
Congruent	677±158	712±143
Incongruent	804±160	838±163
Stroop	127±88	126±80

Data are expressed as the mean±SD. *The treatment had a faster response time than the placebo for the incongruent task at 45-min post-consumption (p=0.0424). There were no other differences between the groups.

Table 3: Cold Pressor Task

	Treatment	Placebo
Baseline		
Systolic BP	133±15 mmHg	133±19 mmHg
Diastolic BP	77±7 mmHg	76±10 mmHg
Heart rate	68±11 BPM	71±13 BPM
45-min Post		
Systolic BP	151±16 mmHg	144±15 mmHg
Diastolic BP	98±16 mmHg	93±15 mmHg
Heart rate	80±15 BPM	79±12 BPM
90-min Post		
Systolic BP	144±14 mmHg	145±15 mmHg
Diastolic BP	94±12 mmHg	94±15 mmHg
Heart rate	77±10 BPM	79±12 BPM

Data are expressed as the mean±SD. There were no differences between groups.

Heart rate measured in beats per minute (BPM) and blood pressure measure in millimeters of Mercury (mmHg) were assessed at 1-minute post cold-water immersion of the hand.

Table 4: Vertical Jump

	Treatment	Placebo
45-min Post	56±11	55±8
90-min Post	57±12	56±9

Data are expressed as the mean±SD. There were no differences between groups.

Jump height was measured in centimeters.

Table 5: Profile of Mood States

	Treatment	Placebo
45-min Post		
TMDS	-2.2±15.9	0.2±14.3
Anger	1.9±2.2	1.5±2.0
Confusion	2.9±3.0	3.9±2.8
Depression	1.1±3.4	0.9±1.8
Fatigue	2.2±2.9	3.0±3.3
Tension	5.9±5.7	4.3±3.5
Vigor	16.3±6.4	12.9±7.8
90-min Post		
TMDS	-1.7±15.0	-4.4±13.1
Anger	1.5±1.8	1.2±1.4
Confusion	3.0±2.5	3.5±2.2
Depression	0.5±2.2	0.4±0.8
Fatigue	2.3±3.0	2.1±3.3
Tension	5.5±4.8	3.5±2.6

Vigor	14.5±6.8	15.1±8.1

Data are expressed as the mean±SD. There were no differences between groups.

Legend: TMDS – total mood disturbance score

Discussion

The MIPS had little effect on any of the parameters assessed in this investigation with the exception of the incongruent test. There was no significant difference in times between groups in reaction during the congruent tasks or in the overall Stroop Effect. The investigation also did not find any improvements in performance in the POMS, vertical jump, or the Cold Pressor Test. We also performed a Psychomotor Vigilance Test (PVT) that did not yield any significant results. One of the primary ingredients in this MIPS study was caffeine. In previous studies involving caffeine, reaction time improvements have been observed (i.e., via the psychomotor vigilance task) using energy drinks (ED) rather than MIPS[21].

In a study by Mangrini et al. consuming an energy drink versus a placebo showed no significant difference in push-up performance improvements from baseline to retest[4]. Beck et. al. also reported no significant benefit in muscular endurance at 80% of 1-repetition maximum (1RM) on bench press[22]. Fye et al. di find improvements in time to fatigue in NCAA cross country runners, and Ivy et al. saw improvements in cyclist during 1-hour trials[2,7]. It is possible that there is a difference in the ergogenic effects of caffeine on cardiovascular endurance versus muscular endurance, or the performance threshold of events with longer times show significant improvement versus performance in events with shorter times.

Resistance trained subjects that consumed either placebo or six mg of caffeine per kilogram of body weight saw improvements in 1RM back squat and seated medicine ball throws, yet again showed no improvement in muscular endurance[23]. The study by Beck et al. did not find any significant improvement in muscular endurance, but they did find an increase in 1RM bench press[22]. Therefore, in our current study we investigated the effects of MIPS and whether it would help in muscular power of physical performance. We did not see a significant difference between the treatment and the placebo group in vertical jump.

Adenosine receptors in the central nervous receptors (CNS) are the primary targets for antagonism when consuming caffeine [24]. One study

investigated the effects of caffeine and vigilance on Special Forces personnel by McLellan et al., during 27 hours of wakefulness, vigilance was maintained, and running performance was improved [25]. Our current investigation found that 45 minutes after consumption of a MIPS with caffeine and L-citrulline as the primary ergogenic aides, reaction time of the treatment group was significantly better than the placebo group during the incongruent tasks of the Stroop test. Our investigation used a dose of caffeine less than the normal range of 3 to 6 mg per kg of body weight. The 155 mg dose of caffeine is less than 3mg of caffeine per kg of body weight that is likely needed to induce an ergogenic effect. L-citrulline (one of the other primary ingredients in this MIPS) has also been shown to improve cognitive function [14]. This shows that in sports, jobs, and other activities that require elevated levels of vigilance, caffeine and L-Citrulline would be beneficial ergogenic aides, and MIPS is a suitable delivery system to achieve benefits from caffeine and L-Citrulline.

However, our study has some inherent limitations. Because there are multiple ingredients within the MIPS, it is not possible to determine which ingredient(s) contributed the most to the ergogenic effect. Caffeine is perhaps the only ingredient that is present in all MIPS; thus, it would be of interest to future researchers to include a caffeine-only positive control. The caffeine amount in this product is not very much, and we also did not test participants for caffeine sensitivity. Prior caffeine use before the fasting period could have also confounded the results.

Conclusions

The acute consumption of a multi-ingredient pre-workout supplement significantly improved incongruent reaction time performance in exercise trained adults. It is likely that caffeine and L-Citrulline are the primary active ingredients that produce these effects. However, one cannot entirely dismiss the role of other ingredients.

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