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*Original Research*

# Supplementation with a Multi-ingredient Pre-workout Supplement does not Augment Resistance Training Adaptations in Females

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ABSTRACT

***International Journal of Exercise Science 12(2): 187-202, 2019.*** Multiple ingredient pre-workout supplements (MIPS) are purported to offer favorable acute metabolic changes potentially leading to improvements in body composition and training adaptations over time. However, there is limited information available regarding the long-term benefits and safety of consuming MIPS, specifically in female populations. Therefore, the purpose of this study was to investigate the effects of pre-workout ingestion on body composition, training adaptations and select markers of clinical health in recreationally active females after 7 weeks of supplementation and resistance training. Nineteen participants participated in a randomized, double-blind, placebo controlled study. Experimental testing included resting heart rate and blood pressure, blood lipid panels, body composition, resting metabolic testing and performance measurements before and after a seven-week resistance training program while ingesting either a MIPS or placebo once daily. There were no significant group x time interactions for changes in body fat percentage ($p=0.66$), fat-free mass ($p=0.87$), fat mass ($p=0.63$) or resting metabolic rate ($p=0.52$). Both groups showed significant improvements in upper ($p<0.001$) and lower body ($p<0.001$) maximal strength following the 7-week training period however no differences in upper ($p=0.74$) and lower body ($p=0.53$) strength improvements were observed between groups, respectively. No significant group x time interactions were observed for any of the markers of clinical health. In conclusion, the current study suggests that daily consumption of a MIPS does not enhance training adaptations in recreationally active females and does not appear to negatively affect resting blood pressure, heart rate and blood lipids.

KEY WORDS: Ergogenic aids, performance enhancing substances, thermogenics

## INTRODUCTION

The use of dietary supplements to enhance exercise performance and improve body composition is becoming a popular strategy among active individuals. A particular class of dietary supplements referred to as multi-ingredient pre-workout supplements (MIPS) are a type of supplement designed to be consumed prior to an exercise bout with the presumption they

will enhance the quality of that training session thereby potentially leading to an augmentation of training adaptations over time. These products often contain a variety of ingredients, which include but not limited to, caffeine, taurine, beta-alanine, creatine, amino acids and various herbal extracts. Several of these ingredients have well-researched and supported benefits, which can include enhanced energy availability, improved maximal strength, increased energy expenditure, enhanced buffering capacity of skeletal muscle and improved focus (4, 5, 7, 12, 13, 16, 36, 37, 39, 42); via their respective mechanisms of action. The wide variety of purported benefits and ingredient lists often make these products potentially advantageous for a variety of exercise or nutrition-related goals. Several investigations have examined the impact of MIPS ingestion on acute measures of exercise performance with positive results following just a single dose (4, 6, 13, 17, 39). Specifically, it appears as though acute ingestion of these supplements prior to a training session may improve training volume, anaerobic performance and subjective markers of fatigue and energy (6, 8, 13, 15, 17). These acute improvements in exercise performance and perceived workout quality may lead to enhanced training adaptations over time when combined with a structured training program. For example, Ormsbee et al. (24) reported significantly greater improvements in anaerobic power in those supplementing with a MIPS and following a resistance training program for a six-week period. Other studies have also reported enhanced training adaptations over time following MIPS supplementation in conjunction with a resistance training program (23, 34). However, the majority of this research has focused primarily on males.

In addition to enhancing exercise performance, some manufacturers also make claims of enhanced fat loss and improved body composition resulting from the thermogenic properties of specific MIPS ingredients (1, 10, 27). There is some supporting evidence of this purported benefit within the literature as acute elevations in energy expenditure following supplementation have been reported (6, 8). As evidenced, Campbell et al. (8) observed acute increases in resting metabolic rate at 60, 120, and 180 minutes post ingestion of a thermogenic supplement (similar in nature to a MIPS) when compared to placebo. Additionally, Rashti et al. (30) reported significant increases in oxygen consumption and energy expenditure in young active females following ingestion of an energy drink. However, it is important to note that acute elevations in energy expenditure may not necessarily translate to significant reductions in body mass or fat mass over time. As it stands today, there is limited evidence to suggest that long-term consumption of a MIPS will favorably alter body composition over time when combined with an exercise program of some kind, particularly across a wide-spectrum of populations (22, 25, 34, 37). Ormsbee et al. (24) were the first to note greater increases in lean body mass in resistance-trained males supplementing with a MIPS compared to placebo, following a six week resistance training and supplementation program. Similar improvements in lean body mass were seen following daily pre and post-workout ingestion of a MIPS after a six week training program (26). However, as mentioned previously the majority of these investigations have utilized

resistance-trained males as a subject group and therefore may not translate well across multiple populations, particularly in lesser-trained females.

Not only is it important to examine the efficacy of such supplements, it is also important to investigate the safety of these products as several contain various amounts of stimulants and herbal extracts. As a result, the degree to which they influence markers of clinical health, is currently unknown; particularly when consumed for extended periods or in high dosages as there is a paucity of research in this area. There are currently mixed results within the literature regarding any adverse effects following ingestion of a single dose of MIPS. Commonly reported adverse effects often include nausea, paresthesia, dizziness, headache and shortness of breath following ingestion (34); some of which are common side-effects of caffeine (12) and beta-alanine (42), two common MIPS ingredients. Previous research indicates that long-term MIPS supplementation does not appear to negatively influence biomarkers of clinical health or cardiovascular health measures in males (18, 25, 34, 38). However, currently there is limited data available regarding the long-term health implications of consuming MIPS in females with the exception of one study which did not detect any abnormal changes in hematological markers or resting vital signs after 28 days of MIPS supplementation even when participants ingested twice the recommended serving size (43).

Previous research has indicated that regular resistance training is an effective modality to improve body composition in females (19, 31). Therefore, with the available evidence regarding the acute benefits of MIPS ingestion and the limited data regarding long-term improvements from MIPS supplementation in males, it is plausible that consuming MIPS in conjunction with the completion of a resistance training program could also enhance training adaptations in females. However, currently these benefits, in addition to the safety of MIPS supplementation over an extended period (>4 weeks), have yet to be examined. Therefore, the purpose of this study was to examine the effects of 7 weeks of resistance training with supplementation of a MIPS on exercise performance, body composition, resting metabolism, blood lipids and resting vitals health in young active females.

## METHODS

*Participants*

Twenty-nine recreationally active females between the ages of 18-30 were initially recruited to participate in this study. Seven participants removed themselves from the study citing time conflicts and three removed themselves because of a lack of interest in the training program. Recreationally active was defined as having participated in at least 150 min of moderate activity per week for at least six months based on the guidelines by the American College of Sports Medicine (29). Participants could not have any contradictions to participation according to their medical history questionnaire. These contradictions included metabolic disorders, heart disease, arrhythmias, diabetes, thyroid disease, hypertension, hepatorenal, musculoskeletal, autoimmune, or neurological disease. Further exclusion criteria included those currently taking thyroid, anti-hyperlipidemic, hyperglycemic, anti-hypertensive, or anti-inflammatory

medications. Participants were also not allowed to participate if they had taken nutritional or ergogenic supplements three weeks prior to testing, or have lost or gained more than 4.5kg over the previous thirty days. All participants provided informed consent in compliance with the Human Participants Guidelines and the Institutional Review Board of the University of Wisconsin – La Crosse.

*Protocol*

This study utilized a randomized, double blind, placebo controlled design. After participant recruitment, participants attended an informational meeting to learn about the requirements of their participation, to provide written informed consent and complete demographic and health history forms. All participants then completed a baseline testing session, which included measurements of blood lipids, resting vitals, body composition, resting metabolism, and strength testing. Participants were instructed to report to the lab in a fasted (>8 hours) state with no prior exercise (>24 hours). After baseline testing, participants were randomly assigned to one of two groups to consume one serving of supplement (MIPS) or placebo (P), daily for seven weeks while completing a resistance training program and following their normal dietary habits. All participants also completed weekly side effect questionnaires and daily supplement logs to ensure supplement compliance. Following the seven-week supplementation period (within 4 days of final training session), participants returned to the lab for post-testing under similar conditions and did not consume their respective treatment on the day of testing.

Resting vitals and blood lipids: during baseline testing, resting blood pressure and heart rate were first assessed using standard clinical procedures. Blood samples were collected from fingertip to be analyzed for blood lipids. Once the finger was sterilized a Unistik 2 (Marietta, GA) lancet was used to withdraw blood. Samples were then immediately analyzed for high-density lipoprotein (HDL-C), low-density lipoprotein (LDL-C), total cholesterol (TC) and triglyceride levels using an Alere Cholestech LDX® (Alere™, Waltham, MA, USA) analyzer. This point of care analyzer has previously been shown to be a valid measure of blood lipids and results are highly correlated with values provided by the National Health Laboratory Service Controls ($r = 0.94$, $r = 0.98$, $r = 0.87$, $r = 0.94$ for total cholesterol, triglycerides, HDL cholesterol and LDL cholesterol, respectively) (28). Quality control measures were run daily according to the manufacturer instructions. Optics checks and calibration protocols were completed between each subject. Participants with triglyceride levels less than 45 mg/dl did not register on the blood panel, therefore a value for low-density lipoprotein could not be calculated. In order to derive such a value, participants who had a triglyceride measurement lower than 45 mg/dl ($n = 5$) a value of 45 mg/dl was used in order to derive their LDL using the Friedewald equation, which has been validated by Tremblay et al. (41). The following equation was used: ([LDL-C= (TC) – (HDL-C) - ([TG]/5)).

Body Composition and Metabolic Testing: height and body mass were measured using a Healthometer (Telstar LLC, Bridgeview, IL) scale. Resting metabolic rate (RMR) was assessed using indirect calorimetry via a TrueOne 2400 metabolic measurement system (ParvoMedics, Sandy, UT) in rested and fasted state. This test required participants to lie in a supine position

with a clear, plastic hood over their neck and head to determine resting oxygen uptake and energy expenditure. This test was approximately twenty minutes long with data being collected after the first fifteen minutes, during a period of five minutes when criterion variables changed less than 5%. Equipment was calibrated prior to testing and in-between every five participants. Following RMR testing, participants had their body composition assessed using air displacement plethysmography (BODPOD, Cosmed, USA). Body fat percentage, fat mass (FM), and fat-free mass (FFM) were assessed using body densities obtained from the BODPOD. To increase test accuracy, standardized volume calibrations were completed before each test. Additionally, participants were instructed to wear only compression shorts, sports bras, and a lycra swim cap during testing.

Strength Testing: following resting measurements, participants completed a ten-minute warm-up consisting of a two-minute, comfortable jog and several dynamic exercises that targeted major muscle groups of the upper and lower body. After warming up, participants completed a counter-movement vertical jump (CMVJ) test using the Just Jump System (Sports, Imports, Columbus, OH). The participants were allowed two attempts using less than maximal effort for practice. Three maximum effort CMVJ attempts were then recorded, each separated by two minutes of rest. Another attempt was allowed if the third attempt was greater than the first three. Attempts were continued until there was a decrease in jump height observed. No more than five CMVJ attempts were allowed. The best jump height was recorded and used for analysis.

All participants then completed maximal strength testing for the bench press and leg press exercises. A standard isotonic leg press and Olympic bench press (Hammer Strength, Life Fitness, USA) were used to test maximal strength for the participants' one-repetition maximum (1 RM). Prior to beginning 1RM attempts, participants completed a standardized warm-up consisting of ten repetitions at 50% of their estimated 1RM. For testing, weight was progressively added until a 1RM was acquired, with two minutes of rest in between each maximal attempt. The participants first did maximal strength testing on the leg press, then followed by four minutes of rest, began warming up on the bench press for maximal strength testing. Bench press 1RM testing followed the same procedures as the leg press 1RM test. Four minutes after testing maximal strength, muscular endurance tests were completed based on the participants' recently assessed 1RM for both upper and lower body exercises. The participants were instructed to complete as many repetitions as possible at 75% of their established 1RM until failure for the leg press and the bench press exercises, respectively. Only one attempt was given for each exercise. Participants rested for four minutes between the leg press and bench press tests.

Supplementation and Dietary Protocols: following baseline testing, participants were randomly assigned to either the supplementation group (MIPS) or placebo (PL) group. The supplementation group consumed a single serving of a commercially available MIPS (MusclePharm, Fitmiss™ Ignite™), while the control group consumed a placebo of similar texture and taste that was prepared by the supplement manufacturer. Participants were instructed to consume one scoop (7.5g), of the supplement or placebo, mixed with 14-16 oz. of

water. Participants were instructed to consume one serving thirty minutes before each exercise session and one serving following breakfast on recovery days. Participants did not consume their designated supplement on the day of post-testing. Figure 1 provides a detailed list of the supplement ingredients. Participants were instructed to follow their normal dietary habits and to record their daily food intake using a commercially available nutrition tracking system (MyFitnessPal Inc., USA). Mean weekly energy intake values were later calculated.

Resistance Training Program: participants were instructed to complete a resistance training program during the 7-week supplementation period. Training sessions consisted of full-body exercises, with various upper body push (i.e. barbell bench press, dumbbell presses, pushups, overhead presses, etc.), upper body pull (i.e. dumbbell rows, machine rows, lat pulldowns, assisted pull-ups, etc.), lower body push (i.e. barbell squats, goblet squats, leg press, lunges, etc.), lower body pull (i.e. deadlift variations, reverse lunges, hip thrusts, leg curls, etc.) and core stabilization movements. These exercises were completed with short rest intervals (~60 sec). A variety of equipment was used including: kettlebells, Olympic bars and plates, dumbbells, medicine balls, resistance bands, and body weight exercises. Participants completed three exercise sessions per week, each lasting approximately one hour. One of the three weekly sessions was completed using solely body weight exercises with no equipment necessary to allow flexibility for the participants' schedules. Each session consisted of a 5-10-minute warm-up, 8-10 full-body exercises, followed by a 5-10 minute cool down. Each exercise was completed for three sets of 10-12 repetitions with 90 seconds of rest in between sets. Participants followed a modified linear periodization model. Briefly, as training volume decreased from one week to the next within a microcycle, the load was concomitantly increased to satisfy the progressive overload principle of training and elicit the desired training adaptations. Load and rates of progression were self-selected by the participants based on ratings of difficulty. Participants were instructed to choose a load that resulted in the final two repetitions of each set being difficult, but not impossible to complete. As the number of repetitions decreased throughout the program, participants were instructed to increase the load to maintain the required level of difficulty. Participants recorded all workouts which were later analyzed for total training-load volume (sets x reps x weight lifted for all exercises) completed during each week and compared between groups.

**30 Servings** — **Fruit Punch**
Serving Size: 1 Scoop (7.2 g)
Servings Per Container: 30

| Amount Per Serving | | % DV * |
|---|---|---|
| Calories | 0 | |
| Calories From Fat | 0 | |
| Total Carbohydrates | 1 g | <1% |
| Sugars | 0 g | † |
| Calcium (as Calcium Silicate) | 34 mg | 3% |
| Proprietary FitMiss Ignite Blend | 5,700 mg | † |
| Carnosyn® Patented Beta Alanine, Choline Bitartrate, L-Tyrosine, L-Glycine, Taurine, L-Carnitine Base, Beet Root Extract (Beta Vulgaris)(High in Nitrates), Hawthorn Berry Powder (Crataegus Pinnatifida)(Fruit), Agmatine Sulfate, Caffeine Anhydrous, Huperzine A 1% (Huperzia Serrata) | | |

* Percent Daily Values (% DV) are based on a 2,000 calorie diet.
† Daily Value (DV) not established

**Other Ingredients:**
Citric Acid, Natural & Artificial Flavors, Calcium Silicate, Rice (Oryza Sativa) Extract, Sucralose, Red Beet Juice (for color), Acesulfame Potassium

**ALLERGEN WARNING: This product was produced in a facility that may also process ingredients containing milk, eggs, fish, crustacean shellfish, tree nuts, peanuts, wheat, and soybeans.**

**Figure 1. MIPS ingredient profile.**

*Statistical Analysis*

Statistical analysis was completed using the software Statistical Package for the Social Sciences (*SPSS Inc., Chicago, IL*). Baseline values were assessed using an independent t-test to ensure statistical equality between the groups. Post testing results were assessed with a two-way (group

x time) mixed factorial analysis of variance (ANOVA) to determine group differences in body fat percentage, FM, FFM, RMR, markers of clinical health and exercise performance. Alpha was set at $p<0.05$ to achieve statistical significance for all tests. If statistical difference was found, a Tukey's post-hoc test was completed to determine where between group significance occurred. All data are presented as mean ± SD.

## RESULTS

Nineteen total participants (MIPS; n = 9; PL; n=10) completed the study. Descriptive statistics for those who completed the study are represented in Table 1.

**Table 1.** Descriptive statistics of participants

| Variable | MIPS (n=9) | PL (n=10) |
|---|---|---|
| Age (yrs.) | 20.3 ± 0.5 | 19.6 ± 0.8 |
| Height (cm) | 169.9 ± 4.8 | 169.9 ± 5.8 |
| Weight (kg) | 67.8 ± 7.5 | 66.3 ± 9.5 |
| Body Fat % (%) | 29.1 ± 6.8 | 28.0 ± 7.3 |

Data presented as mean ± SD

Resting Vitals and Blood Lipids: Table 2. presents a summary of changes observed in heart rate, blood pressure and blood lipids after 7-weeks of supplementation and training. No significant group x time interactions were observed for resting heart rate ($p$ = 0.43), systolic blood pressure ($p$ = 0.18), or diastolic blood pressure ($p$ = 0.20).

**Table 2.** Changes in resting heart rate and blood pressure

| Variable | | Pre | Post |
|---|---|---|---|
| Resting Heart Rate | | | |
| (bpm) | MIPS | 83.4 ±15.8 | 84.6 ± 17.9 |
| PL | | 77.0 ± 10.0 | 81.7 ± 16.3 |
| Systolic Blood Pressure | | | |
| (mmHg) | MIPS | 114.7 ± 10.4 | 108.4 ± 11.8 |
| PL | | 109.6 ± 7.1 | 108.4 ± 5.7 |
| Diastolic Blood Pressure | | | |
| (mmHg) | MIPS | 71.3 ± 9.5 | 63.6 ± 6.9 |
| PL | | 67.4 ± 6.1 | 63.8 ± 6.9 |

Data presented as mean ± SD

Blood lipid panel results: a significant difference in triglycerides was observed at baseline between groups, as a result pre-testing measurements were used as a covariate to compare differences in triglycerides over time. No significant group x time interactions were observed for any of the blood lipid panel measurements as seen in Table 3.

Body Composition and Resting Metabolic Rate: Table 4. presents a summary of body composition and resting metabolic changes. No group x time interactions were observed regarding changes in body fat percentage (p = 0.67), FFM (p = 0.87), or FM (p = 0.63). No significant group x time interaction (p = 0.52) was observed regarding changes in RMR.

**Table 3.** Blood lipid panel results

| Variable | | Pre | Post |
|---|---|---|---|
| Triglycerides | | | |
| (mg/Dl) | MIPS | 60.6 ±31.6 | 73.9 ± 20.6 |
| PL | | 95.9 ± 28.5⁺ | 99.9 ± 57.2 |
| LDL-C | | | |
| (mmol/L) | MIPS | 77.9 ± 26.0 | 78.6 ± 30.6 |
| PL | | 83.7 ±27.5 | 83.8 ± 31.3 |
| HDL-C | | | |
| (mmol/L) | MIPS | 59.4± 19.1 | 62.6 ± 19.5 |
| PL | | 54.8 ±14.6 | 57.5 ± 13.1 |
| Total Cholesterol | | | |
| (mmol/L) | MIPS | 152.0 ±33.5 | 156.0 ± 38.4 |
| PL | | 157.4 ± 24.6 | 161.3 ± 34.4 |

Data presented as mean ± SD. ⁺Denotes significant difference between groups.

**Table 4.** Changes in body composition and resting metabolic rate

| Variable | Pre | Mid | Post |
|---|---|---|---|
| Body Fat % | | | |
| MIPS | 29.1 ± 6.7 | 27.7 ± 7.4 | 27.6 ± 6.8 |
| PL | 28.0 ± 7.3 | 26.2 ± 9.2 | 27.2 ± 8.2 |
| Body Mass (kg) | | | |
| MIPS | 67.8 ±7.5 | 68.2 ± 6.6 | 68.1 ± 6.6 |
| PL | 66.3 ± 9.5 | 66.8± 10.2 | 66.7 ± 6.6 |
| Fat-free mass (kg) | | | |
| MIPS | 47.8 ± 6.3 | 49.2 ± 6.2 | 49.0 ± 5.9 |
| PL | 47.2 ± 5.2 | 48.3 ±5.4 | 48.0 ± 5.3 |
| Fat mass (kg) | | | |
| MIPS | 19.7 ± 5.4 | 19.0 ± 5.7 | 18.8 ± 5.3 |
| PL | 18.9 ± 7.3 | 18.6 ± 8.0 | 18.7 ± 8.1 |
| RMR (kcal/d) | | | |
| MIPS | 1,631.6 ± 189.6 | NA | 1,710.6 ± 121.1 |
| PL | 1,597.6 ± 117.9 | NA | 1,621.3 ± 153.7 |

Data presented as mean ± SD

Strength and Power Performance: Table 5. presents a summary of performance related variables. Although both groups showed significant improvements in upper body and lower body maximal strength ($p < 0.05$), there were no significant group x time interactions observed as seen in Table 5. No significant group x time interactions were observed for any of the other performance variables. There were no significant differences in training load volume completed by each group during week one ($p=0.10$), week three ($p=0.85$), or week seven ($p=0.89$).

Dietary intake and side effects: no significant differences were observed for weekly mean energy intakes between groups as presented in Table 6. Reported side effects included symptoms of a "tingling" (n=2) sensation and itching in the face and/or hands (n=3) after ingestion of the MIPS.

**Table 5.** Comparison of performance measures between groups

| Variable | Pre | Post |
|---|---|---|
| CMVJ (cm) | | |
| MIPS | 43.3 ± 7.5 | 44.5 ± 9.2 |
| PL | 43.4 ± 6.8 | 44.3 ± 6.9 |
| Bench Press 1RM (kg) | | |
| MIPS | 38.3 ± 8.5 | 41.1 ± 5.4* |
| PL | 37.4 ± 9.5 | 39.7 ± 9.4* |
| Leg Press 1RM (kg) | | |
| MIPS | 173.6 ± 36.5 | 196.8 ± 38.8* |
| PL | 184.6 ±31.2 | 200.9± 36.1* |
| Bench Press to Failure (reps) | | |
| MIPS | 10.8 ± 4.8 | 10.6 ± 2.5 |
| PL | 11.3 ± 2.7 | 13.0 ± 4.2 |
| Leg Press to Failure (reps) | | |
| MIPS | 13.6 ± 4.7 | 16.1 ± 4.9 |
| PL | 17.2 ± 6.1 | 17.8 ± 6.4 |

Data presented as mean ± SD. *Denotes a significant main effect of time ($p<0.05$)

**Table 6.** Weekly mean energy intake (kcal/d)

| Group | Week 1 | Week 3 | Week 7 |
|---|---|---|---|
| MIPS | 1,737 ± 276 | 1,598 ± 252 | 1,509 ± 257 |
| Placebo | 1,465 ± 196 | 1,547 ± 255 | 1,490 ± 223 |
| All | 1,593 ± 269 | 1,571 ± 247 | 1,499 ± 232 |

Data presented as mean ± SD

## DISCUSSION

The primary aim of the current study was to examine the effects of ingesting a MIPS on select markers of clinical health, body composition, training adaptations and RMR in recreationally active females completing a 7-week resistance training program. Results of the current study suggest that supplementation with a MIPS designed for females does not result in any augmentation of training adaptations or changes in body composition and metabolism following 7-weeks of resistance training beyond those accomplished from resistance training alone. The results of the current study serve as a follow-up to Cameron et al. (6) which examined the acute effects of an identical MIPS product on exercise performance and resting metabolism. Cameron and associates (6) observed significant elevations in RMR and improvements in upper body muscular endurance, and sprint performance with participants reporting improved focus. The authors speculated that the observed acute effects may help facilitate enhanced training adaptations if MIPS supplementation was continued and used in conjunction with a resistance training program. However, that hypothesis was not supported by the results of the current study. The same MIPS was also investigated by Vogel et al. (43) who reported no abnormal changes in hematological markers or resting vital signs among a similar population as that used within the current study. Together, these results suggest that this particular MIPS does not appear to adversely affect select markers of clinical health but may not improve training adaptations within this type of population over a 7-week period.

While ingestion of a MIPS may transiently increase RMR in the short term as was observed previously by Cameron et al. (6) this does not appear to translate to any sustained increases in RMR over time, particularly when RMR is assessed in the absence of MIPS ingestion as was the case in the current study. Because chronic MIPS supplementation does not appear to influence RMR, this likely explains the lack of any significant changes in body composition, particularly fat loss. In agreement with the current findings, Ormsbee et al. (25) also did not observe any significant changes in body composition or fat mass following an 8 week supplementation period with a MIPS. Conversely, others have found significant improvements in body composition, predominantly reductions in body fat (22, 27). An important factor that needs to considered when various MIPS products are compared is the ingredient profile. As an example, the dose of caffeine in various MIPS products may serve as a potential cause for differing outcomes between studies, particularly when examining changes in body composition or RMR over time due to its thermogenic properties (1, 3) and subsequent potential to increase daily energy expenditure over the long-term. As with any class of dietary supplements, there are several different ingredients in varying amounts often included in MIPS. Further, the ingredient profiles are often listed as "proprietary blends" and therefore the specific ingredients amounts are not always disclosed (11). These discrepancies may account for the mixed results reported in the literature regarding long-term changes in RMR and body composition following long-term MIPS use. Proprietary blends present challenges when comparing different MIPS products utilized in various studies.

In the current study, MIPS supplementation did not enhance strength measures or FFM beyond that of resistance training alone, suggesting that ingestion of a single daily serving of a MIPS does not enhance training adaptations when taken over a seven-week period. Both groups did demonstrate increases in one repetition maximum strength for both upper and lower body while no changes were observed for muscular endurance. Again, returning to the results previously reported by Cameron et al. (6), which indicated acute MIPS can improve exercise performance, the results of the current study suggest that acute MIPS benefits do not appear to translate to an augmentation of training adaptations with continued use. The ability of a MIPS to amplify training adaptations when combined with a structured training program appears to be somewhat unclear within the literature. Ormsbee et al. (24, 26) reported no significant improvements in upper or lower body strength in resistance-trained males after 6 weeks of supplementing with a MIPS while completing a structured training program. Conversely, Spillane et al. (38) observed significantly greater increases in upper and lower body strength following 28 days of resistance training while consuming pre and post-multi-ingredient supplementation. Several other MIPS supplementation studies also reported significant improvements in exercise performance including improvements in muscular endurance, maximal strength and power (23, 33, 34, 44). These inconsistencies within the literature are again likely attributable to differences in ingredient profiles across products, length of each supplementation period or from differences in training regimens and the training status of participants. Additionally, some of the aforementioned studies were as short as 4 weeks whereas others were as long as 9 weeks. Depending on the mechanism of action of the various ingredients and the training status of the individuals, the length of supplementation periods may also

influence differences in training outcomes. Finally, certain products may also contain ingredients that are designed more for eliciting increases in muscle hypertrophy and strength such as creatine, beta-hydroxy-beta-methylbuterate or various amino acids (21). However, some products may contain ingredients that are more focused on promoting weight loss through different thermogenic or lipolytic mechanisms such as caffeine, green tea extract and L-carnitine (21). Although the amount of caffeine in the current MIPS was not listed on the ingredient label, it was specifically designed for women and likely contained a lower caffeine content than a similar MIPS intended for males. Therefore, the caffeine content or other ingredient amounts, in the current MIPS may have been below the recommended threshold required (12) to confer any ergogenic value when ingested over time; as the post-testing was conducted in the absence of the MIPS.

It appears that long-term supplementation of MIPS does not appear to negatively influence cardiovascular health measures in males (18, 25, 34, 38). However, there is limited data available regarding the long-term health implications of consuming MIPS in females. To date, Vogel et al. (43) are the only group that has examined the effects of extended MIPS ingestion on resting hemodynamic variables in females which is pertinent to the current study as the same MIPS was studied. Vogel et al. (43) did not detect any abnormal changes in resting vital signs after 28 days of MIPS supplementation even when participants ingested twice the recommended serving size. Results of the current study suggest that a longer supplementation period (7 weeks) with the same MIPS also does not appear to elicit any serious adverse effects when consumed daily. Specifically, MIPS supplementation did not appear to alter resting or systolic blood pressure. However, diastolic blood pressure was found to be lower at the conclusion of the study in the MIPS group compared to placebo, though this difference was not statistically significant. Previous studies have observed decreases in DBP after long-term supplementation with a MIPS or caffeinated product (9, 18) which is somewhat contradictory as one of the primary active ingredients in MIPS, caffeine, stimulates sympathetic activity which can lead to increased heart rate and blood pressure immediately following ingestion. However, it is important to note that when the participants were tested at pre and post-testing, they abstained from consuming their designated supplement and therefore were not influenced by any residual sympathomimetic effect of previously consumed caffeine as the half-life of caffeine is 4-6 hours. (2). The post-testing protocol (with or without MIPS ingestion the day of) is an important factor when interpreting MIPS supplementation results. Some MIPS, the current one included, also contain beetroot extract, which is high in nitrate content and has been shown to reduce blood pressure by increasing vasodilation through increased nitric oxide production (14, 35). However, without knowing the exact amount of beetroot extract within the MIPS it is difficult to infer whether MIPS consumption may influence long-terms changes in blood pressure. More research is needed to determine the impact of chronic MIPS supplementation on different cardiovascular parameters as MIPS are a class of dietary supplements that often contain high amounts of caffeine or other stimulatory agents that could be problematic for certain populations.

In the current study, no statistically significant differences were found between groups for lipid panel measurements following the 7-week supplementation period. Similar results have been

observed in previous studies, which investigated the effects of MIPS ingestion on various whole blood and serum markers of clinical health (25, 34, 38, 43). Especially worth noting, is the previously mentioned study by Vogel et al. (43) who reported no significant changes in clinical health markers even when two servings of a MIPS (the same product used in the current study) were consumed daily for a 28 day period. While not statistically different, there was a trend towards increased HDL-C levels in both groups over the seven-week period in the current study. It is known that regular aerobic and resistance training can lead to modestly raised HDL-C and lower LDL-C levels (20). However, this is not a one size fits all method and positive changes in lipid panel results resulting from exercise may vary based on baseline triglyceride and HDL-C levels as well as physiologic characteristics of each individual person (20). Differences in certain vitamins and minerals or other nutritional components may also influence certain health-related outcomes and therefore the lack of detailed information regarding macronutrient and micronutrient intakes throughout the duration of the study is a limitation of the current design. Further, it is possible that participants under-reported energy intakes, particularly as the measured RMR values are fairly similar to reported energy intake. Unfortunately, inadequate dietary reporting is always a risk with self-reported dietary intakes (32). In an attempt to address this issue, all participants received instructional training on how to accurately assess and enter all food consumed throughout the study period. Further, MyFitnessPal has been shown to be a valid tool to assess dietary intake (40).

There is limited evidence of any non-cardiovascular or hematological-based adverse effects from MIPS supplementation. Shelmadine et al. (34) reported that participants supplementing with MIPS experienced side effects including nausea, dizziness, headache and shortness of breath following ingestion acute ingestion. Other studies have reported a "tingling sensation" and "itchiness" following MIPS ingestion (6, 43) which is likely attributable to the beta-alanine contained within the products (42) and does not impose any serious health risks. Participants in the current study also reported occasional sensations (paresthesia-like) that were similar in description to previous reports, which have investigated beta-alanine containing products.

In conclusion, daily supplementation with a MIPS for 7 weeks in conjunction with a training program does not appear to enhance training adaptations nor elicit any positive changes in body composition in an active female population, completing resistance training 3 times per week at the current recommended dosage. MIPS ingestion was not associated with any negative hematological or metabolic side effects in recreationally active females. Further, minimal side effects and no significant deleterious effects on markers of clinical health were detected following supplementation. More research examining the effects of different MIPS products and training protocols in an active female population is warranted because of the lack of studies being done with this population.

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