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Effects of Pre-Workout Supplements on Power Maintenance in Lower Body and Upper Body Tasks

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Abstract: Recently, the use of pre-workout supplements has become popular. Research has shown their ability to increase performance for single bouts but little exists showing their ability to maintain this increase in performance over multiple bouts. Purpose: To investigate the effects of supplements on power production and the maintenance of upper and lower body tasks. Methods: Twenty-three males (22.9 ± 3.6 years, 175.6 ± 6.5 cm, 86.9 ± 15.1 kg, 19.1 ± 8.4 BF% mean ± standard deviation (SD)) were familiarized with the testing protocols and maximal bench press performances were attained (109.1 ± 34.0 kg). Utilizing a double-blind crossover design, subjects completed three trials of five countermovement vertical jumps before and after a high-intensity cycle sprint protocol, which consisted of ten maximal 5 s cycle ergometer sprints utilizing 7.5% of the subject's body weight as resistance, with 55 s of recovery between each sprint. Subjects ingested in a randomized order a commercially available pre-workout supplement (SUP), placebo + 300 mg caffeine (CAF), or a placebo (PLA). Peak power (PP), mean power (MP), and minimum power (MNP) were recorded for each sprint. Subjects performed a velocity bench press test utilizing 80% of their predetermined one repetition maximum (1RM) for 10 sets of 3 repetitions for maximal speed, with one-minute rests between sets. Maximal velocity from each set was recorded. For analysis, bike sprint and bench press data were normalized to the placebo trial. Results: Cycle sprint testing showed no significant differences through the testing sessions. In the bench press, the peak velocity was higher with both the SUP and CAF treatments compared to the placebo group (1.09 ± 0.17 SUP, 1.10 ± 0.16 CAF, and 1 ± 0 PLA, $p < 0.05$) and the supplement group was higher than the PLA for mean velocity (1.11 ± 0.18 SUP and 1 ± 0 PLA, $p < 0.05$). Vertical jump performance and lactate levels were not significantly different (RMANOVA showed no significant differences from any treatments). Conclusions: Supplementation with a pre-workout supplement or placebo with caffeine showed positive benefits in performance in bench press velocity.

Keywords: pre-workout; power production; anaerobic; bench press

1. Introduction

The use of pre-workout supplements has gained popularity among many individuals to help increase both anaerobic and aerobic performance [1,2]. A number of supplement companies offer pre-workout supplements that are optimized with a variety of ingredients, with a number that are found frequently in all products. Ingredients such as creatine, branch-chain amino acids (BCAAs), and caffeine, to name a few, are all combined into one proprietary blend. The theory is that these ingredients will complement each other by increasing energy and focus and by delaying fatigue, which provides a synergistic effect on performance. Previous studies on pre-workout supplements have shown an increase in the number of successful repetitions during resistance training, greater peak power, increased choice reaction time, increased lower body muscular endurance, and reduced fatigue, along with an increase in perceived alertness, focus, and energy levels [3–6]. Individually, ingredients such as creatine have been shown to increase growth hormone and testosterone concentrations during exercise, decrease lactate levels, and increase power output [7,8] but work much better as a chronic effect [9,10]. Caffeine supplementation has been shown to increase muscular endurance [5] and muscular strength [6] along with increases in peak and mean power out [11,12].

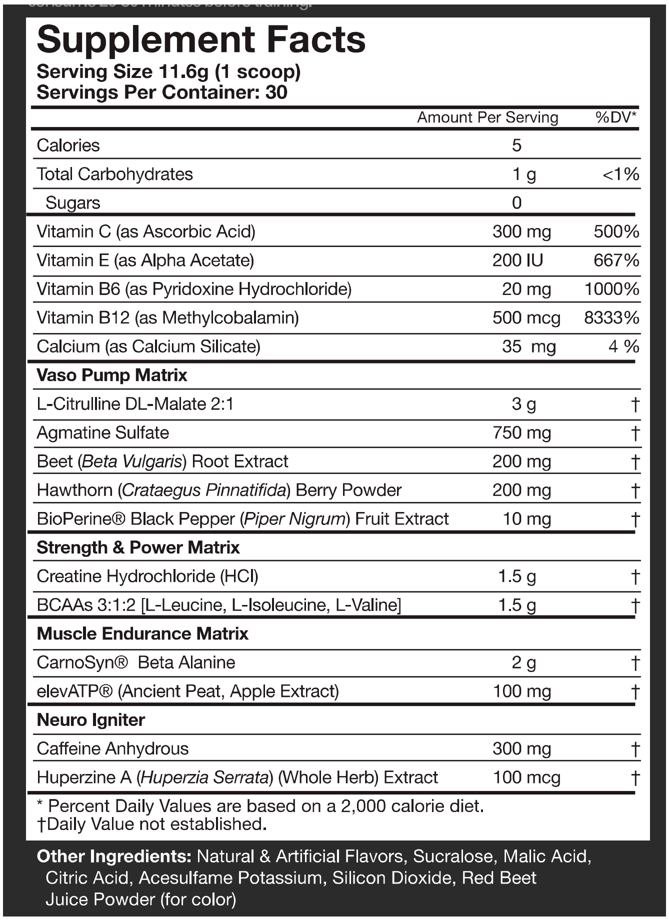
A number of other compounds have been put into pre-workout supplements in order to enhance performance both acutely and chronically. Supplements that increase nitric oxide levels, specifically citrulline malate and beetroot extract, have been shown to enhance performance [13–19]. Citrulline has been shown to have effects after being chronically ingested at 6 grams per day for 3 weeks [14] or at loads relative to body size [15]. However, some research has shown that it can have an acute effect on total work that can be performed in a training session when given at a dosage of 8 grams in men [16]. Other vasodilators such as beetroot (*Beta vulgaris*) have been shown to enhance performance with chronic supplementation [17], with mixed results from acute consumption where it does and does not work [18]. Furthermore, beetroot juice has not always been shown to be effective with aerobic performance in highly trained individuals [19]. Overall, beta-alanine has been shown to have positive effects on exercise performance that lasts for 30 s to 2 min; however, these effects are typically observed with chronic supplementation [20,21]. A recent supplement on the market is ancient peat and apple extract, which is sold under the label of "elevATP". This supplement has been shown to increase blood levels of ATP [22], increase exercise levels in sedentary individuals from a single dose [23], and enhance responses to chronic resistance training [24]. The supplement Huperzine has been shown to have positive effects on brain function, specifically decreasing cognitive deficits and oxidative stress in the rodent model after hypobaric hypoxia [25], and has been shown in conjunction with other supplements to enhance upper body strength endurance performance [6] and anaerobic sprint performance [26].

The current research shows how the use of pre-workout supplements and the various ingredients that compose them may improve performance parameters such as peak power; however, there is limited research on whether a pre-workout supplement allows for this improvement of peak power to be maintained throughout the session. The purpose of this research study is to investigate the effects of pre-workout supplementation on power production and maintenance during a high-intensity cycle ergometry sprint, vertical jump, and bench press performance. The research study will also evaluate vertical jump performance and lactate response in exercise. We hypothesize that the supplement will have a positive effect on all of those metrics.

2. Materials and Methods

2.1. Experimental Design

After approval from the institutional review board in the spring of 2015 at Eastern Kentucky University this study was conducted. This study involved four testing sessions separated by 3–9 days and was approved by the Eastern Kentucky University's Institutional Review Board. Each testing session was completed at the same time of day plus or minus half an hour. There were at least 3 but no more than 9 days between each testing session. Subjects were asked to refrain from hard training for 24 h before each training session and abstain from caffeine consumption. Subjects were instructed to eat the same diet 24 h before each testing session. The first visit was for familiarization for the subjects. The second through fourth visits involved the subjects performing the complete testing protocol of cycle sprints, vertical jump, and barbell bench test under the three treatments (supplement (SUP), placebo + caffeine (CAF), and placebo (PLA)) utilizing a double-blind crossover design. The SUP was one serving of Muscle Pharm Assault Black (Figure 1), the CAF was 25 grams of maltodextrin with 300 mg of caffeine flavored to match the supplement, and the PLA was 25 grams of maltodextrin flavored to match the supplement. Twenty minutes after ingestion of the treatment, the subjects completed a warm-up on the cycle ergometer at a self-selected resistance for 5 min. Subjects then performed stretching as needed before starting the testing portion of the session.



Supplement Facts
Serving Size 11.6g (1 scoop)
Servings Per Container: 30

	Amount Per Serving	%DV*
Calories	5	
Total Carbohydrates	1 g	<1%
Sugars	0	
Vitamin C (as Ascorbic Acid)	300 mg	500%
Vitamin E (as Alpha Acetate)	200 IU	667%
Vitamin B6 (as Pyridoxine Hydrochloride)	20 mg	1000%
Vitamin B12 (as Methylcobalamin)	500 mcg	8333%
Calcium (as Calcium Silicate)	35 mg	4 %
Vaso Pump Matrix		
L-Citrulline DL-Malate 2:1	3 g	†
Agmatine Sulfate	750 mg	†
Beet (*Beta Vulgaris*) Root Extract	200 mg	†
Hawthorn (*Crataegus Pinnatifida*) Berry Powder	200 mg	†
BioPerine® Black Pepper (*Piper Nigrum*) Fruit Extract	10 mg	†
Strength & Power Matrix		
Creatine Hydrochloride (HCl)	1.5 g	†
BCAAs 3:1:2 [L-Leucine, L-Isoleucine, L-Valine]	1.5 g	†
Muscle Endurance Matrix		
CarnoSyn® Beta Alanine	2 g	†
elevATP® (Ancient Peat, Apple Extract)	100 mg	†
Neuro Igniter		
Caffeine Anhydrous	300 mg	†
Huperzine A (*Huperzia Serrata*) (Whole Herb) Extract	100 mcg	†

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

Other Ingredients: Natural & Artificial Flavors, Sucralose, Malic Acid, Citric Acid, Acesulfame Potassium, Silicon Dioxide, Red Beet Juice Powder (for color)

Figure 1. Assault Black Supplement Nutritional Information.

2.2. Subject Information

Twenty-three recreationally trained men (mean ± SD; age: 22.9 ± 3.7 years; height: 1.76 ± 0.07 m; weight: 86.9 ± 15.1 kg) participated in this study. All subjects were screened for general health and drug/supplement consumption. Resting blood pressure and heart rate were recorded. Exclusion criteria for this study included the subject reporting any major health conditions, having a high resting blood pressure or heart rate (BlP (blood pressure)> 140/90, HR (heart rate) > 90 bpm), chronically consuming supplements, and/or having any orthopedic issues that would interfere with the exercise performance.

2.3. Familiarization

During the first testing session, a written informed consent document was reviewed and signed by each subject, followed by a familiarization trial of the cycle sprints, which was loaded with a mass of 0.075 kg/kg of body mass. Measurement of the subject's standing, double overhand reach, and two familiarization vertical jumps were performed. The subject's 1 repetition maximum (1RM) barbell bench press was also determined using standard strength testing methodology.

2.4. Subject Testing

2.4.1. Lactate Testing

The subject's blood lactate, using a Lactate Plus lactate meter (Nova Biomedical, Waltham, MA, USA), was taken after the treatment was ingested, which served as the baseline measurement for that testing session. The subject's blood lactate was retested again 4–5 min after the cycle sprint testing was completed and again after the bench press testing was completed.

2.4.2. Vertical Jump

After the completion of the subject's 5 min cycle warm-up, the subject performed 5 maximal countermovement vertical jumps utilizing the Vertec (Power Systems, Knoxville, TN, USA). With the subject's dominant hand, subjects reached as high as they could with the highest marker touched being the height recorded. Subjects were given a one-minute rest between each jump trial. The vertical jump measurements were taken both pre and 5 min post cycle sprint testing.

2.4.3. Cycle Sprint Protocol

A Monark (Monark Exercise AB, Vansbro, Sweden) model 894E mechanically-braked cycle ergometer at a resistance of 7.5% of the subject's body weight was used for the cycle sprint testing. The testing protocol consisted of pedaling at a pace of approximately 70 rpm for 1 min and 55 s followed by a 5 s all-out sprint. The subject then returned to pedaling at a pace of 70 rpm for 55 s followed by another 5 s all-out sprint. This process continued until a total of 10 all-out sprints were completed. The subjects then performed a 1–2 min cooldown, with the subject pedaling at a self-selected pace. The maximum/peak power output (highest, single power measurement produced during each of the ten, 5 s cycle sprints), mean power output (the average of power measurements produced during each of the ten, 5 s cycle sprints), and minimum power output (lowest, single power measurement produced during each of the ten, 5 s cycle sprints) were recorded for each sprint.

2.4.4. BP (Bench Press) Testing

Following the second round of vertical jump performance, the subjects performed a warm-up on the barbell bench press with the empty barbell (20.4 kg) followed by 50% and then 70% of their 1RM. Warm-up sets were given a two-minute rest period between each. The subjects then performed 10 sets of 3 maximal velocity repetitions at 80% of their predetermined 1RM. There was a one-minute rest period between each set that started the moment the barbell was returned to the rack. A linear position transducer (Gymaware, Sydney, Australia) unit was used for determining barbell velocity and power (both peak and mean) output for each repetition.

2.4.5. Statistical Analyses

Data collected from each testing session was entered into Microsoft Excel and then analyzed utilizing SPSS (v.23. IBM SPSS Inc., Chicago, IL, USA). The lactate data was first transformed so that each testing session score was relative to the first measurement of the session. The lactate data was then analyzed utilizing a repeated measures general linear model with least square distance (LSD) post hoc analysis through the course of the testing session by treatment. The cycle sprint, vertical jump, and bench press data were analyzed for best performance in each session, then normalized to the placebo treatment. Total mean and peak power performance in the cycle sprint testing, vertical jump, and total mean and peak velocity performance in the bench press testing were then analyzed by treatment using an ANOVA with LSD post hoc analysis. Data are presented as the mean and standard deviation (SD) throughout the paper.

3. Results

3.1. Familiarization Data

Preliminary testing during the subjects' familiarization is listed in Table 1.

Table 1. Familiarization data.

Test	Performance
Bench Press 1RM	89.1 ± 24.5 kg
Bike Peak Performance	887.78 ± 23.42 W
Bike Mean Performance	809.39 ± 20.84 W
Bike Power Drop	316.37 ± 19.33 W
Vertical Jump	68.8 ± 9.2 cm

Mean ± Standard Deviation.

3.2. Lactate

Lactate results are reported in Table 2. Overall, there was a significant time effect on the lactate levels ($p < 0.05$) (Table 2). Post hoc testing for treatment effects found no significant differences among any of the treatment groups.

Table 2. Lactate data.

Time	Lactate (mM)
Pre Cycle	2.3 ± 1.42
Post Cycle	12.86 ± 3.81 *,†
Post Bench Press	8.32 ± 3.42 *

* Denotes significance of $p < 0.05$ to pre-cycle data; † Denotes significance of $p < 0.05$ to post bench press data.

3.3. Vertical Jump

The highest vertical jump performed in each of the five jump series was used for analysis. Pre-cycle sprints, vertical jump performance was 69.9 ± 9.2 cm and post cycle sprints vertical jump was 68.0 ± 9.1 cm. There was no significant difference in vertical jump performance between the pre and post cycle sprint performances.

3.4. Cycle Sprints

Bike sprint performance for the subjects on average across each treatment is depicted in Figure 2. There was a significant decrease in peak power, mean power, and minimum power across the cycle sprint trials ($p < 0.05$). Post hoc testing for treatment effects on performance found no significant differences due to supplementation but there was a significant time effect.

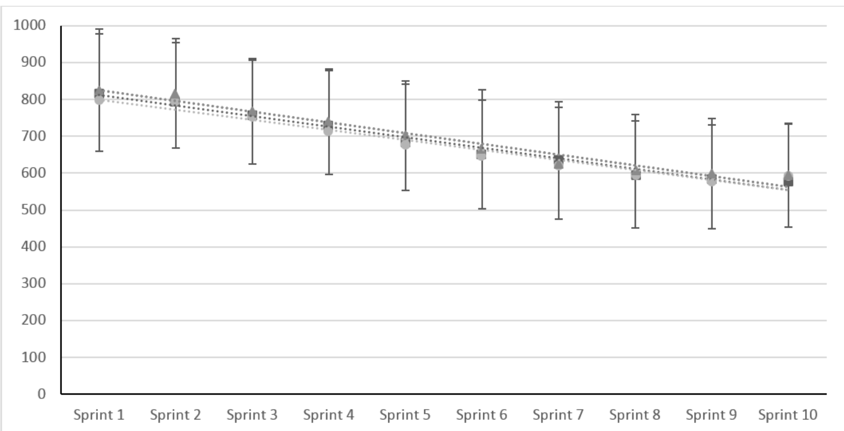


Figure 2. Graph for Wingate peak power performance (watts) across each of the ten sprints with lines for each different treatment. ● = CAF (caffeine) trial, ▪ = PLA (placebo) trial, ▲ = SUP (supplement).

3.5. Bench Press

The mean subject performance for the average and peak power in the bench press is graphically expressed, regardless of treatment, in Figure 3. The average performance of the peak velocity across the ten trials after normalization to placebo (all data in arbitrary units) was 1.09 ± 0.17 with SUP, 1.10 ± 0.16 with CAF, and 1 ± 0 with PLA and the average performance of the mean velocity across the ten trials was 1.11 ± 0.18 with SUP, 1.07 ± 0.11 with CAF, and 1 ± 0 with PLA. Bench press peak velocity performance was significantly higher with the SUP and CAF compared to the PLA ($p = 0.046$, Cohen's d = 0.83, and $p = 0.032$, Cohen's d = 0.88) and mean velocity performance was significantly higher in the SUP group over the PLA group ($p = 0.021$, Cohen's d = 0.86 respectively). Cohen's d scores for each of the significant differences suggest a moderate to large effect.

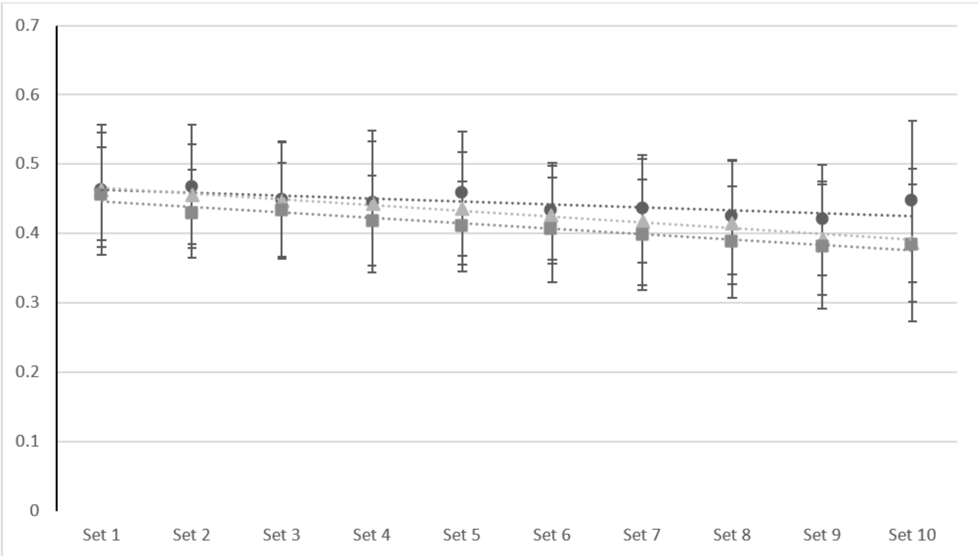


Figure 3. Graph for the best rep of mean velocity performance (m/s) in the bench press across each of the ten sets with lines for each different treatment. ● = PLA trial, ▪ = SUP trial, ▲ = CAF.

4. Discussion

Overall, this study showed limited evidence to support the use of either caffeine or this supplement as a means to enhance performance. However, there were a few testing metrics that did see improvements and that can have some applicability to training or sports performance. This information presents a few future questions and directions that research in this area should go to delve further into any potential effects.

Previous research suggested that a pre-workout supplement with similar ingredients improved lower body muscular endurance [4], whereas other past studies involving similar pre-workout supplements have shown no power increases during anaerobic power tests with the use of a pre-workout type supplement [27]. The results of this study also did not find any significant effect on power performance increases over the length of the high-intensity cycle testing battery for any of the treatment conditions. This could be due to a number of different reasons such as differences in caffeine dosage, testing duration, and supplement tolerance. The cycle test did lead to a significant decrease in performance over the trials so it was, in fact, fatiguing but this was not mediated by any condition.

For the upper-body testing portion of the testing, a significant difference was shown in the bench press velocity performance both acutely and chronically. Bench press peak velocity was higher for both the supplement and CAF treatments than the PLA (supplement: 0.689 ± 0.15 m/s, CAF: 0.69 ± 0.13 m/s, PL: 0.644 ± 0.11 m/s). This supplement could be utilized as a means to enhance velocity output throughout a training session; however, caffeine seems to give just as great of an enhancement in performance. This is likely due to the caffeine in the supplement being the ingredient with the greatest effect.

In past research examining the use of beta-alanine supplementation on improving jump performance, one of the individual ingredients within the SUP, resulted in an improvement in maximal and mean power during countermovement jumps [28]. The results from the countermovement vertical jump test from this study did not show the same response, likely due to the lack of chronic supplementation or the much lower dosage. However, the dosage of the individual ingredients in the supplement was in line with previous research; the chronic supplementation of creatine, nitrate supplements, and beta-alanine are known to be effective after a certain period of use [9,17,18,20,21].

There was a significant blood lactate response to the bike sprints. This could possibly be attributed to the increased production of carnosine from the beta-alanine within the SUP, which in past research has shown to help buffer the hydrogen ions from the lactic acid [29]. However, lactate levels showed no statistical significances between the treatments for any of the time points recorded.

The supplement did show positive effects on upper body velocity performance but further research into the effectiveness of supplementation for power output maintenance in both upper and lower body anaerobic activities is needed. The findings from this particular study are encouraging as they highlight the effectiveness of pre-workout supplementation when exercising for increased upper body anaerobic performance. The increase in acute performance in a training session has been shown in the literature but the maintenance of this upper body performance has not been observed [30].

Further research is warranted to understand the appropriate dosage and timing for the most effective use of this pre-workout supplement with recreationally trained athletes. Dosing with a set serving amount might not adequately give performance benefits to all individuals who participate, and instead dosing with body weight relative amounts seem to give better results. Additionally, researching with higher level, strength/power athletes is desirable. The current research design though suitable could be improved by adding in more repetitions to the cycle ergometer and bench presses to find whether further fatigue would have a greater effect. Additionally, parsing the supplement into more of its constituents over additional trials (for example, caffeine with beta-alanine) could further elucidate any potential synergistic effects. Finally, administering the supplement chronically and then providing a washout period with subjects could further show efficacy since a number of ingredients have been shown in the literature to be more effective with chronic supplementation [6,9,14,15].

5. Conclusions

Overall, there was a positive effect on power maintenance in the bench press exercise by supplementing with either caffeine or the supplement compared to the placebo. There were no significant differences in the cycle sprint performance and vertical jumps. Further research must be performed in this area to show if and how much of an effect pre-workout supplementation can have on power maintenance in a training session.

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Author Contributions: Michael T. Lane and Mark T. Byrd both designed the study, implemented it, analyzed the data, and wrote the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Council for Responsible Nutrition (CRN). *More Consumers Consider Themselves "Regular" Supplement Users, Annual Survey Results Show*; Press Release; Council for Responsible Nutrition: Washington, DC, USA, 2007.
2. Natural Marketing Institute (NMI). *Health and Wellness Trends*, 8th ed.; Natural Marketing Institute: Harleysville, PA, USA, 2007; pp. 1–10.
3. Gonzalez, A.M.; Walsh, A.L.; Ratamess, N.A.; Kang, J.; Hoffman, J.R. Effect of a pre-workout energy supplement on acute multi-joint resistance exercise. *J. Sports Sci. Med.* **2011**, *10*, 261–266. [PubMed]
4. Spradley, B.D.; Crowley, K.R.; Tai, C.-Y.; Kendall, K.L.; Fukuda, D.H.; Esposito, E.N.; Moon, S.E.; Moon, J.R. Ingesting a pre-workout supplement containing caffeine, B-vitamins, amino acids, creatine, and beta-alanine before exercise delays fatigue while improving reaction time and muscular endurance. *Nutr. Metab.* **2012**, *9*, 28–36. [CrossRef] [PubMed]
5. Harty, P.S.; Erickson, J.L.; Cameron, M.; Camic, C.; Doberstein, S.; Luedke, J.; Jagim, A.R. The acute effects of a multi-ingredient pre-workout supplement on exercise performance. *Int. J. Exerc. Sci. Conf. Proc.* **2017**, *11*, 22.
6. Jagim, A.R.; Jones, M.T.; Wright, G.A.; St Antoine, C.; Kovacs, A.; Oliver, J.M. The acute effects of multi-ingredient pre-workout ingestion on strength performance, lower body power, and anaerobic capacity. *J. Int. Soc. Sports Nutr.* **2016**, *13*, 11. [CrossRef] [PubMed]
7. Rahimi, R.; Faraji, H.; Vatani, D.S.; Qaderi, M. Creatine supplementation alters the hormonal response to resistance exercise. *Kinesiology* **2010**, *42*, 28–35.
8. Oliver, J.M.; Joubert, D.P.; Martin, S.E.; Crouse, S.F. Oral creatine supplementation's decrease of blood lactate during exhaustive, incremental cycling. *Int. J. Sport Nutr. Exerc. Metab.* **2013**, *23*, 252–258. [CrossRef] [PubMed]
9. Baker, T.P.; Candow, D.G.; Farthing, J.P. Effect of preexercise creatine ingestion on muscle performance in healthy aging males. *J. Strength Cond. Res.* **2016**, *30*, 1763–1766. [CrossRef] [PubMed]
10. Cooper, R.; Naclerio, F.; Allgrove, J.; Jimenez, A. Creatine supplementation with specific view to exercise/sports performance: An update. *J. Int. Soc. Sports Nutr.* **2012**, *9*, 33. [CrossRef] [PubMed]
11. Beck, T.W.; Housh, T.J.; Schmidt, R.J.; Johnson, G.O. The acute effects of a caffeine-containing supplement on strength, muscular endurance, and anaerobic capabilities. *J. Strength Cond. Res.* **2006**, *20*, 506–510. [PubMed]
12. Timmins, T.D.; Saunders, D.H. Effects of caffeine ingestion on maximal voluntary contraction strength in upper- and lower-body muscle groups. *J. Strength Cond. Res.* **2014**, *28*, 3239–3244. [CrossRef] [PubMed]
13. Gonçalves, L.D.S.; Salles Painelli, V.; Yamaguchi, G.; de Oliveira, L.F.; Saunders, B.; da Silva, R.P.; Maciel, E.; Artioli, G.G.; Roschel, H.; Gualano, B. Dispelling the myth that habitual caffeine consumption influences the performance response to acute caffeine supplementation. *J. Appl. Physiol.* **2017**, *123*, 213–222. [CrossRef] [PubMed]
14. Bendahan, D.; Mattei, J.P.; Ghattas, B.; Confort-Gouny, S.; Le Guern, M.E.; Cozzone, P.J. Citrulline/malate promotes aerobic energy production in human exercising muscle. *Br. J. Sports Med.* **2002**, *36*, 282–289. [CrossRef] [PubMed]
15. Giannesini, J.; Fur Patrick, Y.J.; Verleye, C.M.; Le Guern, M.E.; Bendahan, D. Citrulline malate supplementation increases muscle efficiency in rat skeletal muscle. *Eur. J. Pharmacol.* **2011**, *667*, 100–104. [CrossRef] [PubMed]
16. Pérez-Guisado, J.; Jakeman, P.M. Citrulline malate enhances athletic anaerobic performance and relieves muscle soreness. *J. Strength Cond. Res.* **2010**, *24*, 1215–1222. [CrossRef] [PubMed]
17. Breese, B.C.; McNarry, M.A.; Marwood, S.; Blackwell, J.R.; Bailey, S.J.; Jones, A.M. Beetroot juice supplementation speeds O_2 uptake kinetics and improves exercise tolerance during severe-intensity exercise initiated from an elevated metabolic rate. *Am. J. Physiol.-Regul. Integr. Comp. Physiol.* **2013**, *305*, R1441–R1450. [CrossRef] [PubMed]
18. Cermak, N.M.; Res, P.; Stinkens, R.; Lundberg, J.O.; Gibala, M.J.; van Loon, L.C.J. No Improvement in endurance performance after a single dose of beetroot juice. *Int. J. Sport Nutr. Exerc. Metab.* **2012**, *22*, 470–478. [CrossRef] [PubMed]
19. Boorsma, R.K.; Whitfield, J.; Spriet, L.L. Beetroot juice supplementation does not improve performance in elite 1500-m runners. *Med. Sci. Sports Exerc.* **2014**, *46*, 2326–2334. [CrossRef] [PubMed]

20. Quesnele, J.J.; Laframboise, M.A.; Wong, J.J.; Kim, P.; Wells, G.D. The effects of beta-alanine supplementation on performance: A systematic review of the literature. *Int. J. Sport Nutr. Exerc. Metab.* **2014**, *24*, 14–27. [CrossRef] [PubMed]
21. Hobson, R.M.; Saunders, B.; Harris, B.R.C.; Sale, C. Effects of β-alanine supplementation on exercise performance: A meta-analysis. *Amino Acids* **2012**, *43*, 25–37. [CrossRef] [PubMed]
22. Reyes-Izquierdo, T.; Nemzer, B.; Argumedo, R.; Shu, C.; Huynh, L.; Pietrzkowski, Z. Effect of the dietary supplement elevatp on blood atp level: an acute pilot clinical study. *J. Aging Res. Clin. Pract.* **2013**, *2*, 178–184.
23. Izquierdo, T.R.; Nemzer, B.; Argumedo, R.; Cervantes, M.; Pietrzkowski, Z. The Effect of Elevatp™ on exercise output: A single dose, blinded, three-way cross-over study. *J. Nutraceuticals Food Sci.* **2016**, *3*, 56–60.
24. Joy, J.M.; Falcone, P.H.; Vogel, R.M.; Mosman, M.M.; Kim, M.P.; Moon, J.R. Supplementation with a proprietary blend of ancient peat and apple extract may improve body composition without affecting hematology in resistance-trained men. *Appl. Physiol. Nutr. Metab.* **2015**, *40*, 1171–1177. [CrossRef] [PubMed]
25. Shi, Q.; Fu, L.; Ge, D.; He, Y.; Ran, L.; Liu, Z.; Wei, J.; Diao, T.; Lu, Y. Huperzine a ameliorates cognitive deficits and oxidative stress in the hippocampus of rats exposed to acute hypobaric hypoxia. *Neurochem. Res.* **2012**, *37*, 2042–2052. [CrossRef] [PubMed]
26. Martinez, N.; Campbell, B.; Franek, B.; Buchanan, L.; Colquhoun, R. The effect of acute pre-workout supplementation on power and strength performance. *J. Int. Soc. Sports Nutr.* **2016**, *13*, 29. [CrossRef] [PubMed]
27. Green, J.M.; Wickwire, P.J.; McLester, J.R.; Gendle, S.; Hudson, G.; Pritchett, R.C.; Laurent, C.M. Effects of caffeine on repetitions to failure and ratings of perceived exertion during resistance training. *Int. J. Sports Physiol. Perform.* **2007**, *2*, 250–259. [CrossRef] [PubMed]
28. Bescós, R.; Sureda, A.; Tur, J.A.; Pons, A. The effect of nitric-oxide-related supplements on human performance. *Sports Med.* **2012**, *42*, 99–117. [CrossRef] [PubMed]
29. Hoffman, J.R.; Kang, J.; Ratamess, N.A.; Hoffman, M.W.; Tranchina, C.P.; Faigenbaum, A.D. Examination of a pre-exercise, high energy supplement on exercise performance. *Int. J. Sport Nutr. Exerc. Metab.* **2009**, *6*, 2. [CrossRef] [PubMed]
30. Gross, M.; Bieri, K.; Hoppeler, H.; Norman, B.; Vogt, M. Beta-alanine supplementation improves jumping power and affects severe-intensity performance in professional alpine skiers. *Int. J. Sport Nutr. Exerc. Metab.* **2014**, *24*, 665–673. [CrossRef] [PubMed]