

Research article

Effect of a pre-workout energy supplement on acute multi-joint resistance exercise

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Abstract

The effect of a pre-workout energy supplement on acute multi-joint resistance exercise was examined in eight resistance-trained college-age men. Subjects were randomly provided either a placebo (P) or a supplement (S: containing caffeine, taurine, glucuronolactone, creatine, β -alanine, and the amino acids; leucine, isoleucine, valine, glutamine and arginine) 10 minutes prior to resistance exercise. Subjects performed 4 sets of no more than 10 repetitions of either barbell squat or bench press at 80% of their pre-determined 1 repetition-maximum (1RM) with 90 seconds of rest between sets. Dietary intake 24 hours prior to each of the two training trials was kept constant. Results indicate that consuming the pre-workout energy drink 10 minutes prior to resistance exercise enhances performance by significantly increasing the number of repetitions successfully performed ($p = 0.022$) in S (26.3 ± 9.2) compared to P (23.5 ± 9.4). In addition, the average peak and mean power performance for all four sets was significantly greater in S compared to P ($p < 0.001$ and $p < 0.001$, respectively). No differences were observed between trials in subjective feelings of energy during either pre ($p = 0.660$) or post ($p = 0.179$) measures. Similarly, no differences between groups, in either pre or post assessments, were observed in subjective feelings of focus ($p = 0.465$ and $p = 0.063$, respectively), or fatigue ($p = 0.204$ and $p = 0.518$, respectively). Results suggest that acute ingestion of a high-energy supplement 10 minutes prior to the onset of a multi-joint resistance training session can augment training volume and increase power performance during the workout.

Key words: Ergogenic aid, resistance exercise, caffeine, nutritional supplement.

Introduction

Pre-workout energy drinks continue to gain popularity among recreational and competitive athletic populations. Up to 70% of adolescents and young adults have reported using at least one nutritional supplement and high-energy drinks are among the most popular (Alves and Lima, 2009; Froiland et al., 2004; Hoffman et al., 2008a). Reports suggest that 30% of this population regularly consume energy drinks and is second only to multivitamins in regards to type of supplement used (Hoffman et al., 2008a). Both aerobic and anaerobic athletes use pre-workout energy drinks because of their potential ergogenic effects and they have attracted the attention of many competitive and recreational athletes as a legal ergogenic aid (Sokmen et al., 2008).

Caffeine, the most common ingredient in energy drinks, has been shown to be an effective ergogenic aid for endurance exercise by delaying fatigue and increasing

time to exhaustion (Astorino and Roberson, 2010; Doherty and Smith, 2004; Graham et al., 1998; Graham and Spriet, 1995; Hoffman et al., 2007). This delay in fatigue is thought to be related to caffeine's ability to alter exercise metabolism by enhancing fat oxidation, thereby preserving muscle glycogen content (Spriet, 1995). Although caffeine has been suggested to augment strength and power performance by enhancing muscle contraction efficiency through accelerated mobilization of intracellular calcium from the sarcoplasmic reticulum (Kalmar, 2005) and/or by enhancing glycolytic regulatory enzyme kinetics (Spriet, 1995), evidence demonstrating its ergogenic benefit during anaerobic performance has been limited.

Caffeine is often combined with other ingredients to provide a synergistic effect, increase ergogenic potential, and increase the probability of a performance response from energy drinks. Several recent studies have demonstrated that a pre-exercise, energy supplement (containing caffeine with taurine, glucuronolactone, creatine, and amino acids) can delay fatigue and improve the quality of resistance exercise (Hoffman et al., 2008b; Ratamess et al., 2007). The combination of these ingredients has been shown to significantly improve the volume of training (number of repetitions performed during a bout of resistance exercise) and augmenting the growth hormone and insulin response to the training session (Hoffman et al., 2008b).

Recently, a new energy drink, Amino Impact™, has been developed containing many of these ingredients (plus beta-alanine) and has been marketed towards endurance and strength and power athletes. Walsh et al. (2010) have recently shown that this supplement significantly increases time to exhaustion during a moderate-intensity endurance run and improves subjective feelings of focus, energy, and fatigue. Thus, the purpose of this study is to examine the acute effects of this pre-workout energy supplement on delaying fatigue (determined by increases in training volume) during an acute multi-joint resistance exercise session in healthy, physically active college-aged men.

Methods

Subjects

Eight resistance-trained men (20.6 ± 0.7 y; 1.76 ± 0.07 c; 78.2 ± 14.1 kg; 5.4 ± 1.9 yrs of resistance training experience) underwent two testing sessions administered in a randomized and double-blind fashion. Following an explanation of all procedures, risks, and benefits associated

with the study, each subject gave his written consent prior to participation. The study was approved by the College's Institutional Review Board. Subjects completed a medical history and physical activity questionnaire to determine eligibility. Subjects who were smokers, taking regular medication, or with any known metabolic, cardiovascular disease, or psychiatric disorder were excluded from the study. Subjects were required to have been free of any nutritional supplements or ergogenic aids for 6 weeks preceding the study, and were asked to refrain from taking any additional supplements during the course of the study.

Study design

The study was administered in a randomized and double-blinded manner. Subjects were instructed to choose between two multi-joint exercises, barbell squat ($n = 4$) or bench press ($n = 4$) based on their familiarity. Subjects reported to the Human Performance Lab on three separate occasions. During each visit subjects were requested to refrain from any physical activity for 24 hours prior to the visit and to refrain from performing the specific exercise for 72 hours prior to the testing session. During the first visit, each subject's one repetition-maximum (1-RM) was assessed for their respective exercise. During the following two visits, the subjects ingested either the pre-workout energy supplement (S) or a placebo (P) and then remained seated for 10 minutes. Subjects then performed 4 sets of no more than 10 repetitions at 80% 1-RM of their respective exercise and were given 90 seconds of rest between sets. The total number of repetitions performed for each set and the average and peak power of each repetition was recorded. Subjects were given questionnaires each trial immediately before and after the protocol. The questionnaires measured feelings of energy, focus, and fatigue using visual analog scales. The two trials occurred at the same time of day and were separated by approximately one week.

Maximal strength testing

The 1-RM tests were performed using methods previously described by Hoffman (2006). Each subject performed a warm-up set using a resistance that was approximately 40-60% of his perceived maximum, and then performed 3-4 subsequent trials to determine the 1-RM. A 3 – 5 minute rest period was provided between each trial. No bouncing of the bar on the chest was permitted for the bench press exercise, as this would have artificially augmented strength results. Bench press testing was performed in the standard supine position: the subject lowered an Olympic weight lifting bar to mid-chest level and then pressed the weight until his elbows were fully extended. The squat exercise required the subject to place an Olympic bar across the trapezius muscle at a self-selected location. Each subject descended to the parallel position which was attained when the greater trochanter of the femur reached the same level as the knee. The subject then ascended until full knee extension. A research assistant was used to ensure subjects reached the parallel position for each repetition of the squat. The same research assistant was used for each subject to insure that exercise technique was consistent between sessions.

Power measures

Power output during the squat and bench press exercises was measured for each repetition with a Tendo™ Power Output Unit (Tendo Sports Machines, Trencin, Slovak Republic). The Tendo™ unit consists of a transducer attached to the end of the barbell which measured linear displacement and time. Subsequently, bar velocity was calculated and power was determined when barbell load was entered into the microcomputer. Both peak and mean power output were recorded for each repetition and used for subsequent analysis. Test-retest reliability for the Tendo unit in our laboratory has consistently shown $R > 0.90$.

Dietary analysis

Subjects recorded their dietary intake 24 hours prior to each of the two training trials and total calories, % protein, % fat, and % carbohydrates were calculated using a dietary analysis program (FoodWise, McGraw-Hill).

Questionnaires

Subjects were instructed to assess their subjective feelings of focus, energy and fatigue using a 10 cm visual analog scale (VAS). The VAS was assessed immediately before commencing exercise (PRE), and immediately post-exercise (IP). Subjects were asked to assess via a mark their feelings at that time with words anchored at each end of the VAS. Questions were structured as "My level of focus is:" with low and high serving as the verbal anchor representing the extreme ratings. Similarly, "My level of energy is:" was anchored with the verbal cues "low" and "high", while "My level of fatigue:" was anchored with the verbal cues "high" and "low". For fatigue, a higher score indicated less fatigue. The validity and reliability of VAS in assessing fatigue and energy has been previously established (Lee et al., 1991).

Supplement

During each trial, subjects ingested either the supplement or a placebo. The supplement is commercially marketed as 'Amino Impact™' (Koach, Sport and Nutrition, Oviedo, FL) and consisted of 26 g of a powder containing an energy matrix (2.05 g of taurine, glucuronolactone and caffeine), a proprietary amino acid matrix (7.9 g of L-leucine, L-isoleucine, L-valine, L-arginine and L-glutamine), 5 g of di-creatine citrate, and 2.5 g of β -alanine and mixing it with 500 ml of water. The nutritional composition per serving of the supplement was 40 calories with 0 g of fat. The placebo consisted of 500 ml of water sweetened with 3 g of sucralose (Splenda®, McNeil Nutritionals, Fort Washington, PA) and colored with red food coloring (McCormick Red Food Coloring, McCormick & Company Hunt Valley, MD) to make it indistinguishable in appearance. The nutritional composition of the placebo was 0 calories with 0 g of fat.

Statistical analysis

Performance data were analyzed using paired student's T-tests. Comparisons of subjects' measures of focus, energy and fatigue were accomplished using a repeated measures analysis of variance. In the event of a significant F-ratio, LSD post-hoc tests were used for pairwise comparisons.

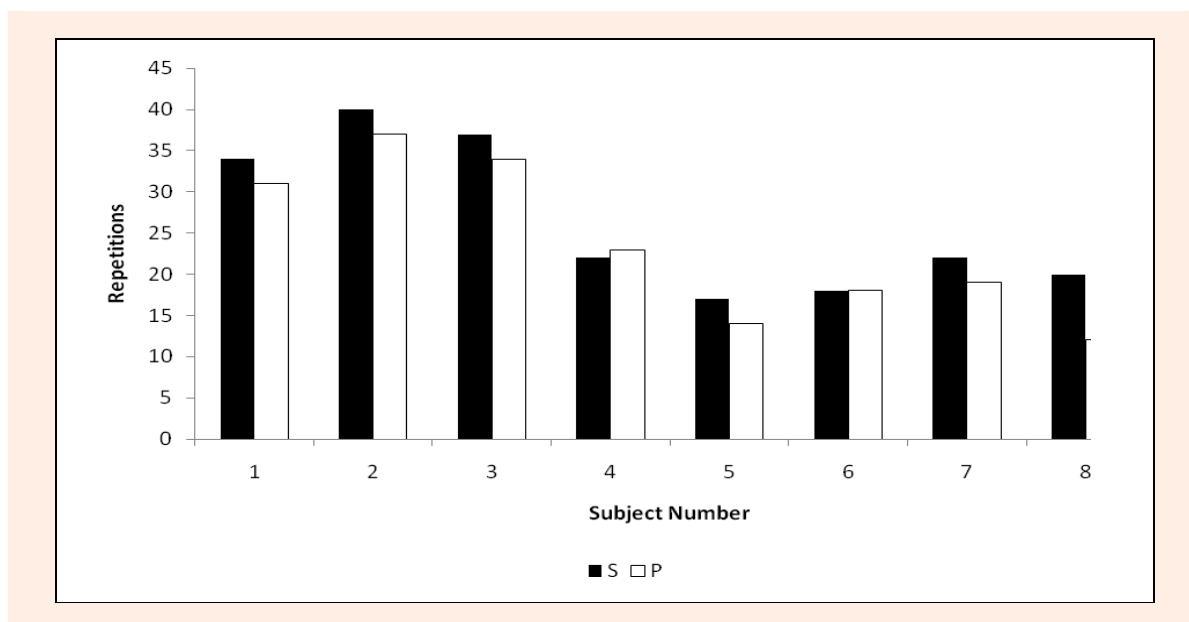


Figure 1. Individual subject repetition response during exercise bouts. S = Supplement; P = Placebo.

A criterion alpha level of $p \leq 0.05$ was used to determine statistical significance. All data are reported as mean \pm SD.

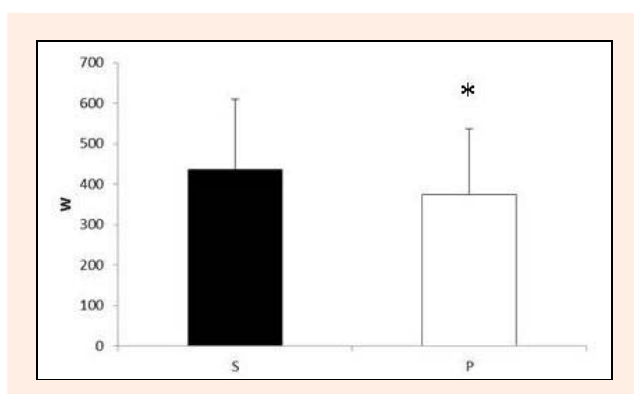


Figure 2. Average peak power performance during exercise bout. S = Supplement; P = Placebo; * Significant difference ($p < 0.05$) seen between groups.

Results

The total number of repetitions performed during the four sets of a multi-joint exercise was significantly greater ($p = 0.022$, $ES = 0.301$) during S (26.3 ± 9.2 repetitions) than during P (23.5 ± 9.4 repetitions). The individual results for each subject on repetitions performed during the S and P trials are shown in Figure 1. Six of the eight subjects performed more repetitions during S than in P. In addition, the average peak and mean power performance for all four sets was significantly greater in the S trial than the P trial ($p < 0.001$, $ES = 0.533$ and $p < 0.001$, $ES = 0.287$ respectively) (see Figures 2 and 3). No differences were observed between trials in subjective feelings of energy during either pre ($p = 0.660$) or post ($p = 0.179$) measures. Similarly, no differences between groups, in either pre or post assessments, were observed in subjective feelings of focus ($p = 0.465$ and $p = 0.063$, respectively), or fatigue ($p = 0.204$ and $p = 0.518$, fatigue).

Analysis of dietary intakes revealed no significant difference between the groups in either caloric intake or macronutrients percentages. The average caloric intake for S and P in the 24 hours prior to the exercise protocol was 1962.3 ± 629 kcal and 1805.5 ± 767 kcal, respectively. The average macronutrient intake was $23.2 \pm 8.2\%$ protein, $25.8 \pm 6.9\%$ fat and $51.2 \pm 6.7\%$ carbohydrate for S, and $27.7 \pm 8.4\%$ protein, $32.1 \pm 9.6\%$ fat and $40.2 \pm 8.8\%$ carbohydrate for P.

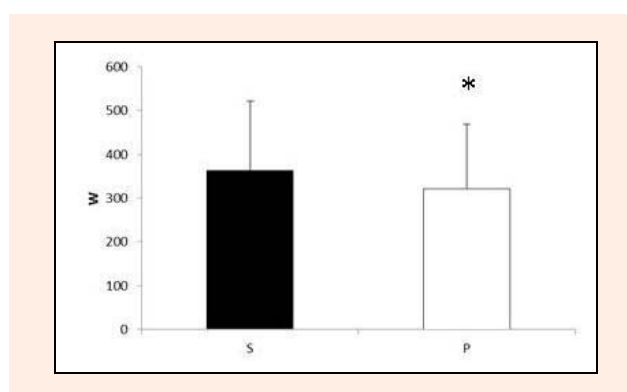


Figure 3. Average mean power performance during exercise bout. S = Supplement; P = Placebo; * Significant difference ($p < 0.05$) seen between groups.

Discussion

The results of this study indicated that an acute ingestion of the pre-workout supplement Amino Impact™ containing caffeine, taurine, glucuronolactone, creatine, β -alanine, and amino acids significantly increased the number of repetitions performed in a multi-joint resistance exercise, and resulted in significantly greater peak and mean power performance during the workout. These results confirm previous studies that have shown that a pre-workout energy drink similar in composition to the one examined in this study can effectively increase training volume within an acute bout of resistance exercise

(Hoffman et al., 2008b; Ratamess et al., 2007).

Caffeine likely played an important role in the results observed in this study. Caffeine acts as a competitive inhibitor of adenosine, increases secretions of excitatory neurotransmitters, dopamine and glutamate, and may allow increased voluntary activation and increase the excitability of the motor neurons (Daly et al., 1981; Kalmar and Cafarelli, 1999). Caffeine has been shown to increase work output, time to exhaustion, anaerobic power, and training volume (Astorino and Roberson, 2010; Beck et al., 2008; Sokmen et al., 2008). The ergogenic effects of caffeine during resistance exercise or high intensity anaerobic exercise protocol have been seen in doses ranging from 2- 6 mg·kg⁻¹ (Forbes et al., 2007; Hudson et al., 2008; Woolf et al., 2008). The relative concentration of caffeine provided in this study was slightly lower than that seen in these other studies, but similar to that found in other studies that have shown an improved quality of workout, as reflected by an enhanced volume of training (Hoffman et al., 2008b; Ratamess et al., 2007). The lower amount of caffeine is likely offset by the combination of other stimulatory ingredients in the supplement.

Taurine and glucuronolactone are often combined with caffeine to form an 'energy matrix' in many energy drinks. Previous studies have shown that taurine ingestion alone can improve endurance performance by increasing time until exhaustion (Miyazaki et al., 2004; Yatabe et al., 2009; Zhang et al., 2008). Although taurine has been shown to enhance force production in skinned fast-twitch fibers (Bakker and Berg, 2002; Hamilton et al., 2006), its ability to enhance resistance exercise performance in human subjects by itself remains unclear. To our knowledge the independent ergogenic effects of glucuronolactone have not been studied. Therefore, it is difficult to draw conclusions on its ergogenic effects. The combination of caffeine, taurine, and glucuronolactone has yielded significant improvements in training volume in several studies (Forbes et al., 2007, Hoffman et al., 2008b; Ratamess et al., 2007).

Additional ingredients found in the supplement included the branched-chain amino acids (BCAA). During prolonged physical activity BCAA ingestion has been shown to counteract or delay fatigue by decreasing the concentration of tryptophan and the synthesis of serotonin (Davis et al., 2000; Fernstrom, 2005). Serotonin may contribute to central and mental fatigue during prolonged endurance activity (Davis et al., 2000), and decreases in this neurotransmitter may have an important role in minimizing or delaying performance decrements during fatiguing exercise. The results of this study suggest a possible contributory role of BCAA towards a delay in fatigue during resistance exercise. In addition, the combination of both arginine and BCAA has recently been shown to attenuate muscle proteolysis during endurance exercise (Matsumoto et al., 2007). Whether this occurs during resistance exercise deserves further study. The role of glutamine is not well understood. Glutamine is a non-essential amino acid that effectively modulates the immune response to exercise and possibly improves athletic performance by enhancing recovery and reducing muscle damage (Castell and Newsholme, 1998; Favano et al.,

2008). However, its role in enhancing acute resistance exercise performance is not clear. No studies have reported acute ergogenic effects of glutamine ingestion on resistance exercise performance (Antonio et al., 2002). Glutamine may have a more important role on recovery aspects from high-intensity resistance exercise.

The additional ingredients found in Amino Impact™ include both creatine and β-alanine. The efficacy of these ingredients has been well-documented during prolonged training studies, but is generally not known to have a role in enhancing acute resistance exercise performance (Hoffman and Stout, 2008). However, recent investigations have expanded the potential role that creatine may have during acute exercise. Specifically, phosphocreatine and the creatine kinase system play an important role in mediating brain and neural function (Shulman et al., 2004; Stocker et al., 2007). It is thought that 20% of the body's energy consumption may occur in the brain (Shulman et al., 2004), thus an efficient ATP/PC replenishment system would be critical for normal brain function. Creatine is thought to provide important neuroprotection for the brain through enhancing energy metabolism in brain tissue, promoting antioxidant activities, improving cerebral vasculature (improved brain circulation) and acting as a brain cell osmolyte that can protect the brain against hyper-osmotic shock (Andres et al., 2008). Creatine's neuroprotective properties may also include stabilization of mitochondrial membranes, stimulation of glutamate uptake into synaptic vesicles and balance of intracellular calcium homeostasis (Ellis and Rosenfeld, 2004). These physiological roles for creatine suggest a potential neuroprotective effect that may become important during exhausting exercise. Walsh et al., (2010) using the same supplement albeit during an exhaustive endurance exercise protocol, suggested that acute creatine ingestion may contribute to enhanced subjective feelings of focus, energy and fatigue during endurance exercise. The results of this study were unable to support this hypothesis. This is likely related to the difference in the mode of exercise and in the duration of exercise between the two studies.

Conclusion

In conclusion, the consumption of a pre-workout energy supplement containing caffeine, taurine, glucuronolactone, creatine, β-alanine, and amino acids consumed 10 minutes prior to a bout of resistance exercise enhances the total number of repetitions performed during the exercise bout and average power outputs for each repetition during the workout were significantly greater when using the supplement compared to placebo.

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Key points

- Consumption of a pre-workout energy supplement containing caffeine, taurine, glucuronolactone, creatine, β -alanine, and amino acids consumed 10 minutes prior to a bout of resistance exercise enhances the total number of repetitions performed during the exercise bout.
- Power outputs for each repetition during the workout were significantly greater when using the supplement compared to placebo.
- Ingestion of supplement did not have any significant effect on subjective measures of fatigue, energy and focus.

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