Original Research

Acute Ingestion of L-Arginine Alpha-Ketoglutarate Fails To Improve Muscular Strength and Endurance in ROTC Cadets

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ABSTRACT

International Journal of Exercise Science 6(2) : 91-97, 2013. L-Arginine Alpha-Ketoglutarate (AAKG) is purported to stimulate the release of nitric oxide, and is suggested to facilitate muscular performance by increasing blood flow and increase oxygen and nutrient delivery to the working muscle. However, the ergogenic benefit of AAKG during resistance exercise has not been established. Therefore the purpose of this study was to investigate the effects of acute AAKG ingestion in active ROTC Cadets on measures of one-repetition maximal strength (1RM) and muscular endurance. Nineteen apparently healthy males ingested either AAKG (3 g) or a placebo 45 minutes prior to resistance testing in a randomized, double-blind crossover design. Initially, blood lactate (BLA) was obtained followed by 1RM testing on the barbell bench press and leg press. Upon determination of 1RM, participants completed repetitions to failure at 60% of 1RM. Blood lactate measures were immediately taken following the final repetition. Analysis revealed no significant differences between the conditions for bench press 1RM. Additionally, there were no differences between conditions for 1RM leg press, or for number of repetitions performed for the bench press or leg press. Blood lactate values did increase significantly from baseline to post-bench press in both the AAKG ($t_{33} = 7.56$, $p < 0.01$) and placebo conditions ($t_{33} = 8.45$, $p < 0.01$). Further, BLA lactate levels were also significantly greater post leg-press in the AAKG ($t_{33} = 9.23$, $p < 0.01$) and placebo ($t_{33} = 8.10$, $p < 0.01$). The results indicate that acute AAKG supplementation provides no ergogenic benefit in this study.

KEY WORDS: Nitric oxide, resistance training, ergogenic aids

INTRODUCTION

Over the past decade dietary supplements containing L-arginine have become very popular among resistance-trained athletes. This semi-essential amino acid is intended to increase strength, power, and recovery from intense muscular exercise (1). L-arginine is used by all cells and plays a role in numerous physiological functions such as protein synthesis, synthesis of other amino acids, detoxification of ammonia, and may readily be converted α-ketoglutarate (AKG) for ATP production (1, 3). However, the purported ergogenic benefits of L-arginine probably stem from its (1) role in the synthesis of creatine; (2) contribution in the release of growth hormone and/or (3) function as a precursor in the biosynthesis of nitric oxide (NO) (4).

It is the latter that has gotten much of the attention as supplements containing L-arginine are often advertised as "nitric oxide stimulators" (NO stimulators). There is a supportive rationale for such claims as NO can be produced from L-arginine via the enzyme NO synthase (1). NO produces a potent vasodilatory effect on blood vessels thereby possibly improving muscle blood flow during resistance training, thus allowing a greater delivery of fuel substrates and removal of lactate and ammonia (4). Conversely, there is still no clear evidence to conclude L-arginine's role as a NO stimulator that augments resistance exercise performance in healthy individuals (1).

Only a few studies have investigated the effects of L-arginine on resistance training performance. Chronic L-arginine supplementation has produced mixed results with some studies observing benefits in anaerobic power (3), muscular strength (3, 5, 14), and muscular endurance (15) while others have found no effect on these same performance variables (7, 8). Stevens et al. (14) used 13 participants to assess the acute responses of L-arginine ingestion. L-arginine or a placebo (sucrose) was isocalorically administered at 45, 30 and 10 min before exercise using an isokinetic dynamometer. When compared with placebo, total work and peak torque were significantly greater while fatigue index was increased after consuming L-arginine. Additionally, Villaverde et al. (15) reported observing decreased muscular fatigue evaluated by isokinetic dynamometer following 15 days of oral L-arginine supplementation (3g/day). In contrast, Greer and Jones (8) used a double blind, cross-over design to investigate the acute effects of L-arginine α-ketoglutarate (AAKG) supplementation on muscular endurance and blood pressure responses. Twelve resistance-trained participants consumed 3,700 mg of either AAKG or placebo (maltodextrin) at two intervals (4 hr and 30 min) prior to completion of chin-ups, reverse chin-ups and push-ups to exhaustion. Blood pressure (BP) responses were monitored throughout each trial session. Results revealed that AAKG provided no ergogenic benefit during the muscular endurance tests and no differences were observed in BP across trials.

To the authors knowledge, no investigation has explored the acute ingestion of AAKG during a bout of weight training; therefore, the purpose of this study was to investigate the acute ergogenic potential of AAKG on one-repetition maximum (1RM) strength and muscular endurance, as well as its' impact on blood lactate (BLA) values in active ROTC Cadets.

METHODS

Participants

Nineteen apparently healthy, male ROTC Cadets volunteered for this investigation. Participants reported being free of any medical conditions, which would hinder their ability to perform the exercise protocol. Additionally, the cadets self-reported not using any anabolic or metabolic supplements within the previous month. All participants gave their informed consent and completed a health history questionnaire before participating in the study. All experimental procedures were approved by Institutional Review Board at Mississippi State University. Demographic data are described in Table 1.

Table 1. Subject demographic information. All data presented as mean ± standard deviation (SD).

N = 19	Mean ± SD
Age	19.42 ± 1.26
Height (cm)	176.06 ± 7.08
Weight (kg)	79.24 ± 10.57
Body Fat %	15.17 ± 4.85

Protocol

Experimental Approach to the Problem: Participants reported to the Exercise Physiology Laboratory at the same time of day for each of the three testing sessions. Each session was separated by 7 days. The first session was used to collect the participants' anthropometric data and serve as a familiarization session for the testing protocol. Participants were then randomly assigned a treatment session of either AAKG or placebo. Treatments were administered in a counterbalanced, double-blind manner, as neither investigators nor participants were aware of treatment order. The research protocol is outlined in Figure 1.

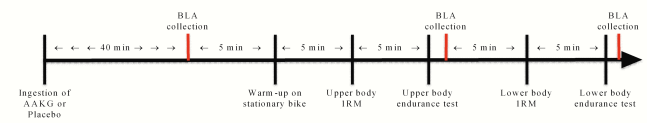

Figure 1. Progression of the experimental protocol across time.

Monitoring of Exercise and Dietary Status: Resistance trained participants were instructed to refrain from resistance training 48 h preceding testing and all participants were asked to avoid any strenuous activity 24 h prior to testing. Also, a 24 h dietary and exercise recall was completed before each trial, and participants were encouraged to follow the same nutritional intake preceding each session. Participants were also asked to abstain from taking any supplements, caffeine, or energy drinks during the investigation, as well as to refrain from alcohol intake, and medication during the 48 h period preceding testing.

Supplementation Schedule: AAKG (Healthwatchers DE Inc., Bohemia, NY) or a placebo consisting of microcrystalline cellulose (Apotheca Inc., Woodbine, IA) was provided to participants to be ingested 45 min pre-exercise with 300 ml of water. The placebo was similar in color, size, and texture to the supplement. The selected dose for this investigation was based on a review of prior research in this area (16) and amounts recommended by many currently available AAKG supplements. One week later, participants reported to the laboratory to complete the last session.

Blood Collection: A single-use lancet device was used to puncture the skin just off the center of the finger pad. The first flow of blood was wiped away, and then approximately 5µL (2mm) of blood was loaded on the lactate strip and immediately analyzed using the Lactate Pro Analyzer (LT 1710, ARKRAY Inc., Japan). Blood samples were obtained pre-exercise and immediately following both the upper and lower body muscular endurance tests.

Session 1: The preliminary session was conducted one week prior to the initiation of the two experimental sessions. This initial session included a verbal explanation of the protocol, supplement restrictions (creatine, energy drinks, caffeine, etc.), and nutritional intake (24 h recall). During this preliminary session participants were also measured for height, body mass, and body

composition. Height was measured to the nearest 0.01 cm and body mass was measured in kilograms on a physicians' balance beam scale (Healthometer 402EXP). Body composition was determined using the 3 site (abdomen, thigh, and chest) skinfold model described by Pollock and Wilmore (11).

Session 2 and 3: Participants reported to the laboratory at their prescheduled time and prepared for testing. Upon arrival, participants were questioned about their compliance in regards to their activity level and completed their 24 h dietary recall for review by a trained evaluator. If a participant failed to meet the pretesting guidelines required for participation in that day's protocol the session was rescheduled. All participants completed their scheduled sessions.

Following the evaluator's review and approval of the compliance guidelines, participants' ingested either the AAKG supplement or placebo and then rested quietly for 40 min. At the conclusion of rest period, a measurement of BLA was collected prior to warm-up. Participants then warmed up on an upright stationary bike at a pace of 60 – 70 RPM for 5 min. Next, participants performed a 2-3 warm-up sets of 10-12 repetitions using a load of 61 kg on a standard barbell bench press (Magnum D78, Milwaukee, Wisconsin). Three minutes of rest time was allotted between each set. One-repetition maximum was determined according to the methods of Earle and Baechle (2). Each participant's 1RM was determined in 3-5 sets.

Immediately following 1RM, 60% of the 1RM was placed on the bar, and participants were allowed to rest for 5 minutes, and then performed as many bench press repetitions as possible until failure occurred. Failure for the bench press in this study was defined as the inability to complete a repetition without assistance. Measurement of BLA was taken within 5 s of muscular failure.

After a 5 min recovery period, participants began a warm-up on a Cybex 45° plate loaded leg press (Cybex Inc., Medway, MA) at a load of 82 kg for 12-15 repetitions, following the identical warm-up protocol used during the bench press. Once again, immediately following 1RM determination, 60% of the 1RM was placed on the leg press, and participants were again allowed to recover for five minutes. The participants then performed as many leg press repetitions as possible until muscular failure occurred. Once again, BLA measurements were obtained within 5 s of termination of the leg press.

Statistical Analysis

Data analyses were performed using SPSS (v 18.0). Paired t-tests were performed to assess differences in performance measures (1RM, repetitions performed, total load) between conditions. Finally, BLA levels were examined utilizing repeated measures ANOVA to examine the differences in lactate changes from baseline to post-muscular endurance assessment between conditions. Significant interactions were further analyzed utilizing one-way ANOVA and paired t-tests with Bonferroni corrections with the α-level set at $p \leq 0.05$.

RESULTS

All 19 ROTC Cadets who initially volunteered completed the testing procedures. There was no order effects

observed between the 2 conditions. Performance variables for both the bench press and leg press revealed no differences between the AAKG and placebo condition for 1RM (Figure 2a), number of repetitions performed (Figure 2b), or total volume of work performed (Figure 2c).

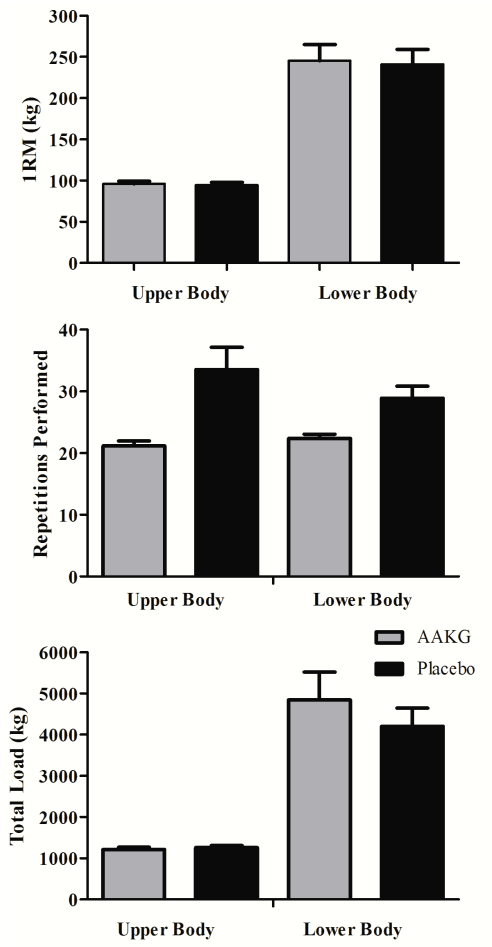

Figure 2. Results for (a) 1RM, (b) repetitions performed, and (c) total load between the AAKG and placebo conditions. No differences between the two conditions were seen for any of the variables.

Repeated measures ANOVA for BLA revealed no interaction or main effects for condition; however, a significant main effect for time was revealed ($F_{2, 58}$ = 101.13, $p < 0.01$). Blood lactate values **(**Figure 3**)** did increase significantly from baseline to post-bench press in both the AAKG (t_{33} = 7.56, $p < 0.01$) and placebo conditions (t_{33} = 8.45, $p < 0.01$) across time. Further, BLA levels were also significantly greater post leg-press in the AAKG (t_{33} = 9.23, $p < 0.01$) and placebo (t_{33} = 8.10, $p < 0.01$) across time.

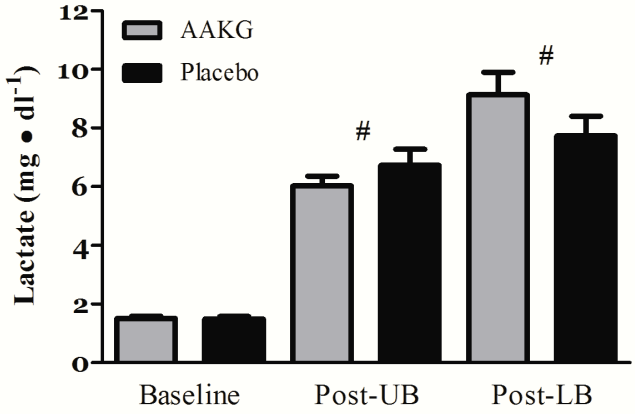

Figure 3. Blood lactate values after muscular endurance testing for the two conditions. Blood lactate increased significantly across time in both conditions (#$p < 0.01$), however there were no differences between values after upper-body (UB) or lower-body (LB) exercises.

DISCUSSION

The major findings of this study were that acute ingestion of an AAKG supplement had no effect on muscular strength, endurance, or BLA concentration during resistance exercise in ROTC Cadets. These findings serve to support previous work by Fricke (7) and Greer (8) that demonstrated no ergogenic benefits with L-arginine ingestion.

The lack of ergogenic benefits may indicate that chronic use of L-arginine supplementation may be necessary for improved muscular performance. NO has been shown to reduce contractile force in mammalian skeletal muscle, thus a single dose may be inadequate to achieve acute changes in 1RM strength (13). Campbell et al. (3) did observe increased 1RM bench

press strength in well-trained participants after 8 weeks of AAKG supplementation (12 g per day). Interestingly, improvements in strength performance weren't accompanied by muscle hypertrophy or changes in body composition even though participants lifted 4 days per week. An investigation by Elam and colleagues (5) reported increases in overall strength and lean body mass after 5 weeks of L-arginine and ornithine supplementation (5). Regrettably, this study used a posttest-only design, so the groups' initial strength and lean muscle mass values may have differed.

Similar to Greer and Jones (8), in this study AAKG supplementation provided no ergogenic benefit during upper or lower body muscular endurance testing. Furthermore, the authors speculated that AAKG supplementation may actually be counterproductive to muscular endurance performance by NO stimulated blood flow to the exercising muscle, thereby limiting a full range of motion for certain exercises.

Surprisingly, no differences were observed in BLA concentration with AAKG supplementation during muscular endurance testing. If L-arginine leads to vasodilatation of blood vessels via NO production, one might assume BLA concentration would have been reduced with AAKG use. There is some recent evidence to suggest acute L-arginine supplementation doesn't augment muscle blood flow during resistance training as much as first hypothesized (6, 12).

There are also general limitations with this study. First, L-arginine and NO production were not measured in the blood stream, thereby limiting our ability to measure oral AAKG efficacy. Secondly, an acute dose of AAKG may not be sufficient to facilitate an ergogenic effect in normal healthy individuals (10). Liu et al. (9) reported no significant difference in plasma NO_2 and NO_3 concentrations after orally supplementing ten healthy male athletes with 3000 mg of L-arginine or placebo for 3 days. Finally, the difference in methodology between this study and prior research does suggest that future studies should focus on combining repeated bouts of strength training exercises with a longer (> 10 days) AAKG loading phase.

In conclusion, acute AAKG supplementation provided no ergogenic benefit in this study. Future acute and chronic studies on L-arginine are needed to further elucidate the underlying mechanisms of action in conjunction with measurements of resistance training performance. This would provide a much better understanding of the ergogenic potential of supplements containing L-arginine.

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