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*Nutrition and Health* 2012 21: 263

DOI: 10.1177/0260106013510999

*Article*

Nutrition and Health
2012, Vol 21(4) 263–273

DOI: 10.1177/0260106013510999
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# The effects of 8 weeks of heavy resistance training and branched-chain amino acid supplementation on body composition and muscle performance

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## Abstract

**Purpose:** This study determined the effects of 8 weeks of heavy resistance training combined with branched-chain amino acid (BCAA) supplementation on body composition and muscle performance. **Methods:** Resistance training was performed by 19 non-resistance-trained males (three sets of 8–10 repetitions) four times/week, for 8 weeks, while also ingesting 9 g/day of BCAA or 9 g/day of placebo (PLAC) on the exercise days only (one-half of total dose 30 min before and after exercise). Data were analyzed with separate 2 $\times$ 2 analysis of variance (ANOVA) ($p < 0.05$). **Results:** For total body mass, neither group significantly increased with training ($p = 0.593$) and also, there were no significant changes in total body water ($p = 0.517$). In addition, no training- or supplement-induced ($p = 0.783$) changes occurred with fat mass or fat-free mass ($p = 0.907$). Upper-body ($p = 0.047$) and lower-body strength ($p = 0.044$) and upper- ($p = 0.001$) and lower-body muscle endurance ($p = 0.013$) increased with training; however, these increases were not different between the groups ($p > 0.05$). **Conclusion:** When combined with heavy resistance training for 8 weeks, supplementation with 9 g/day of BCAA 30 min before and after exercise had no preferential effects on body composition and muscle performance.

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**Keywords**
Amino acid, body composition, exercise, muscle mass, muscle performance, muscle strength, supplementation, weight training

## Introduction

Branched-chain amino acids (BCAA) make up approximately one-third of skeletal muscle tissue within the human body and consist of leucine, isoleucine and valine (Mero, 1999). Not only are BCAAs a key component of muscle tissue, they have been shown to increase muscle protein synthesis (MPS) (Shimomura et al., 2004). Furthermore, the effects of BCAAs, particularly leucine, on MPS are shown to be augmented when combined with a single bout of resistance exercise (Blomstrand et al., 2006; Karlsson et al., 2004), and appear to increase activity of the Akt/mTOR pathway. Even though the specific mechanism by which BCAAs are able to regulate MPS still remains to be determined (Nair and Short, 2005), based on results from studies employing a single bout or resistance exercise, it is plausible to consider that supplementing with BCAAs during resistance training may provide a nutritional platform for increasing MPS that will subsequently lead to an augmentation in muscle mass and performance beyond that provided by resistance training alone.

There are data to suggest that BCAA supplementation may be of ergogenic value, as it was shown that 30 days of BCAA supplementation in the absence of resistance training improved fat-free mass and isometric grip strength (Candeloro et al., 1995). In addition, 12 weeks of resistance training combined with leucine supplementation is shown to significantly increase muscle strength, but not fat-free mass (Ispoglou et al., 2011). In lieu of the results from single bout resistance exercise studies, the assumption for the ergogenic effects of BCAA supplementation with training is practical, based on the premise that intense exercise decreases the availability of BCAAs, which may impede muscle growth and repair, along with the contention that the supplementation with BCAA is known to increase the availability and subsequent utilization of BCAAs necessary for increasing MPS (Shimomura et al., 2006).

There is a resistance training study involving essential amino acid (EAA) supplementation (Antonio et al., 2000), and also studies where BCAAs (Kerksick et al., 2006) and leucine (Coburn et al., 2006) were co-ingested with whey protein; all three studies show that BCAA has no preferential beneficial effects. Although presently there appear to be no studies that have attempted to determine the effects of BCAA supplementation only when combined with resistance training; nevertheless, because of the positive results accompanying the studies using BCAA supplementation with single resistance exercise bouts, the sport/nutritional supplement industry has become inundated with BCAA products, each with hefty claims alleging dramatic increases in MPS that will ultimately lead to augmented muscle size and strength, in conjunction with resistance training. Due to the fact that resistance training studies show no preferential effects in muscle mass and performance from EAAs and BCAAs (Antonio et al., 2000; Kerksick et al., 2006), caution must be used when attempting to extrapolate results from studies involving only a single bout of resistance exercise, to the adaptations that occur from many successive bouts of resistance exercise involved with resistance training programs. Therefore, the purpose of this study was to compare the effects of 8 weeks of heavy resistance training with BCAA supplementation on body composition and muscle performance. Specifically, we hypothesized that BCAA supplementation, when combined with heavy resistance training, would provide no greater effects than placebo on muscle strength and endurance, and on fat mass and fat-free mass.

## Methods

### *Participants*

Our double-blind study participants were 19 healthy, untrained (no regular, consistent resistance training, i.e. thrice weekly, for at least 1 year prior to the onset of the study) males between the ages of 18–35 and with a body mass index (BMI) between 18.5–30 $kg/m^2$. Enrollment was open to men of all ethnicities. Only participants considered as low risk for cardiovascular disease and with no contraindications to exercise, as outlined by the American College of Sports Medicine (ACSM), and who had not consumed any nutritional supplements (excluding a daily multi-vitamin) 3 months prior to the study were allowed to participate. All participants provided written informed consent and were cleared for participation by passing a mandatory medical screening. All eligible subjects signed university-approved informed consent documents and approval was granted by the Institutional Review Board (IRB) for Human Subjects. Additionally, all experimental procedures involved in the study conformed to the ethical considerations of the Helsinki Code.

### *Baseline and familiarization*

Participants expressing interest in the study were interviewed on the phone or via e-mail and those we believed met eligibility criteria were invited to attend an entry/familiarization session, where they completed a medical history questionnaire and underwent a general physical examination. Eligible participants were then familiarized to the study protocol, by verbal and written explanation outlining the study design, and were then given an appointment time to perform the baseline/pre-supplementation assessments. At this time, participants were instructed to refrain from exercise for 48 hours and to record their dietary intake for 4 days prior to baseline testing. Participants were told to record all caloric food or beverages ingested during the 4-day period prior to baseline testing.

### *Body composition*

Total body mass (kg) was determined on a standard dual beam balance scale (Detecto, Bridgeview, IL). Percent body fat, fat mass, and fat-free mass were determined using DEXA (Hologic Discovery Series W, Waltham, MA). Quality control calibration procedures were performed on a spine phantom (Hologic X-CALIBER Model DPA/QDR-1 anthropometric spine phantom) and a density step calibration phantom, prior to each testing session. Total body water volume was determined by bioelectric impedance analysis

(Xitron Technologies Inc., San Diego, CA), using a low-energy, high-frequency current (500 micro amps at a frequency of 50 kHz).

## Muscle strength and endurance assessments

Participants performed muscle strength and endurance tests on the free-weight bench press and angled leg press exercises prior to the first dose of supplement and at the beginning of the resistance training program, and after 8 weeks of supplementation and resistance training. Muscle strength was assessed using the one-repetition maximum (1-RM) method. Participants warmed up by completing 10 repetitions, at approximately 50% of the estimated 1-RM. The participant rested for 1 minute, and then completed three to five repetitions at approximately 70% of the estimated 1-RM. We then increased the weight conservatively, and the participant attempted to lift the weight for one repetition. If the lift was successful, the participant rested for 2 minutes before attempting the next weight increment. This procedure was continued, until the participant failed to complete the lift. The 1-RM recorded was the maximum weight that the participant was able to lift for one repetition. After a 5-min rest period, muscle was then assessed using the free-weight bench press and angled leg press exercises, by having participants perform as many repetitions as possible with 75% of their 1-RM.

## Supplementation protocol

Participants were assigned an 8-week supplementation protocol, consisting of the daily oral ingestion of 12 capsules containing either 9 g of a BCAA supplement (L-leucine 4.5 g, L-isoleucine 2.25 g, L-valine 2.25 g (AST Sport Science, Colorado Springs, CO)) or 9 g of placebo (guar gum (Nutrition for Optimum Wellness, Bloomingdale, IL)). One-half of the total daily dosage (six capsules) was ingested 30 min prior to each exercise session, while the remaining one-half (six capsules) was ingested no later than 30 min following each exercise session. The supplements were ingested four times/week, on the exercise days only. We monitored supplementation compliance by participants returning empty containers of their supplement following the 8 weeks of supplementation, and also by having them complete a weekly supplement compliance questionnaire.

## Resistance training protocol

Participants engaged in a periodized, heavy resistance training program of 4 days/week, split into two upper- and two lower-body workouts each week, for a total of 8 weeks (Shelmadine et al., 2009; Spilane et al., 2009, 2011; Willoughby et al., 2007). The upper-body program consisted of nine exercises (bench press, lat pull, shoulder press, seated row, shoulder shrug, chest fly, biceps curl, triceps press down and abdominal curl) twice per week and the lower-body program consisted of seven exercises (leg press, back extension, step up, leg curl, leg extension, heel raise and abdominal crunch) performed twice per week. Participants performed three sets of 10 repetitions with as much weight as they could lift per set (typically 70–80% of 1RM). Rest periods between exercises and sets lasted no longer than 2 minutes. Resistance training sessions were conducted on the university campus fitness center and participants were required to document their training progress in exercise diaries, for bi-weekly review by our study personnel.

### Statistical analyses

Statistical analyses were performed by utilizing separate repeated-measure 2-factor (treatment groups (2) x time point (2)) analysis of variance (ANOVA) for each criterion variable. In addition, for all statistical analyses not meeting the sphericity assumption for the within-subjects analyses, a Huynh-Feldt correction factor was applied to the degrees of freedom, in order to adjust (increase) the critical F-value to a level that would prevent the likelihood of committing a type I error. All statistical procedures were performed using SPSS 19.0 software (Chicago, IL) and a probability level of $\leq 0.05$ was adopted throughout.

## Results

### Participant demographics

A total of 22 participants began the study; however, three dropped out due to reasons unrelated to the study. As a result, 19 participants completed the study. The PLAC group ($n = 9$) had an average (SD) age of 20.40 $\pm$1.33 years, height of 176.04 $\pm$17.43 cm, and total body mass of 80.02 $\pm$7.92 kg. The BCAA group ($n = 10$) had an average age of 21.30 $\pm$2.36 years, height of 178.11 $\pm$18.33 cm and a total body mass of 80.95 $\pm$8.33 kg.

### Supplement compliance, reported side effects, and dietary analysis

All participants appeared to have exhibited 100% compliance with the supplementation and resistance training protocol: We were able to complete the required dosing regimen and testing procedures. Over the course of the 8 weeks, no participants in either group reported any side effects. The diet logs were used to analyze the average caloric and macronutrient consumption (Table 1). No significant Group x Time interactions existed for total calories ($p = 0.439$) or the gram amounts of protein ($p = 0.797$), carbohydrate ($p = 0.351$) and fat ($p = 0.637$). In addition, no significant main effects for Time existed across the testing sessions for total calories ($p = 0.272$), protein ($p = 0.329$), carbohydrate ($p = 0.105$) and fat ($p = 0.415$).

### Body composition

For total body mass, there was no significant Group x Time interaction ($p = 0.593$), nor was there a significant Time main effect ($p = 0.547$). For total body water, there was no significant Group x Time interaction ($p = 0.854$). There was also no significant Time main effect observed ($p = 0.517$). For fat-free mass, we observed no significant Group $\times$ Time interaction ($p = 0.544$) or a Time main effect ($p = 0.907$). For fat mass, there was no significant Group $\times$ Time interaction ($p = 0.995$) or Time main effect ($p = 0.783$) (Table 2).

**Table 1.** Means (SD) for dietary intake variables for the PLAC and BCAA groups.

| Variable | Pre-Test | Post-Test | Time ($p \leq 0.05$) | Group × Time ($p \leq 0.05$) |
|---|---|---|---|---|
| Calories (kcals) | | | 0.272 | 0.439 |
| PLAC | 2409.44 (±435.64) | 2325.11 (±482.67) | | |
| BCAA | 2778.54 (±594.01) | 2618.87 (±704.24) | | |
| Carbohydrate (g) | | | 0.105 | 0.351 |
| PLAC | 321.88 (±121.46) | 279.22 (±98.94) | | |
| BCAA | 376.03 (±96.64) | 309.07 (±72.63) | | |
| Protein (g) | | | 0.329 | 0.797 |
| PLAC | 100.47 (±41.06) | 91.25 (±30.63) | | |
| BCAA | 106.48 (±16.88) | 92.38 (±35.39) | | |
| Fat (g) | | | 0.415 | 0.637 |
| PLAC | 94.36 (±28.25) | 87.43 (±22.29) | | |
| BCAA | 95.45 (±21.50) | 95.31 (±37.19) | | |

BCAA: Branched-chain amino acids; PLAC: placebo.

**Table 2.** Means (SD) for body composition variables for the PLAC and BCAA groups.

| Variable | Pre-Test | Post-Test | Time ($p \leq 0.05$) | Group × Time ($p \leq 0.05$) |
|---|---|---|---|---|
| Body mass (kg) | | | 0.547 | 0.593 |
| PLAC | 80.02 (±7.92) | 80.21 (±7.42) | | |
| BCAA | 79.12 (±7.98) | 82.24 (±9.74) | | |
| Body water (kg) | | | 0.066 | 0.517 |
| PLAC | 44.42 (±3.66) | 45.33 (±4.02) | | |
| BCAA | 42.57 (±2.51) | 43.08 (±2.74) | | |
| Fat-free mass (kg) | | | 0.393 | 0.907 |
| PLAC | 57.43 (6.85) | 57.65 (5.13) | | |
| BCAA | 56.11 (2.83) | 57.25 (2.89) | | |
| Fat mass (kg) | | | 0.514 | 0.783 |
| PLAC | 15.25 (7.09) | 15.94 (7.34) | | |
| BCAA | 14.24 (8.91) | 13.56 (7.99) | | |

BCAA: branched-chain amino acids; PLAC: placebo.

## *Muscle performance*

For upper-body strength, there was not a significant Group × Time interaction ($p = 0.262$), but there was a significant Time main effect ($p = 0.047$). For lower-body strength, a significant Group × Time interaction ($p = 0.955$) was not observed; however, there was a significant Time main effect ($p = 0.044$). For upper-body muscle endurance, there was no significant Group × Time interaction ($p = 0.525$), but there was a significant Time main effect ($p = 0.001$). For lower-body endurance, there was no significant Group × Time interaction ($p = 0.774$); however, there existed a significant Time main effect ($p = 0.013$) (Table 3).

**Table 3.** Means (SD) for muscle performance variables for the PLAC and BCAA groups.

| Variable | Pre-Test | Post-Test | Time ($p \leq 0.05$) | Group × Time ($p \leq 0.05$) |
|---|---|---|---|---|
| Upper-body strength (kg/kg) | | | 0.047[a] | 0.262 |
| PLAC | 1.07 (±0.27) | 1.17 (±0.31) | | |
| BCAA | 1.08 (±0.23) | 1.19 (±0.24) | | |
| Lower-body strength (kg/kg) | | | 0.044[a] | 0.955 |
| PLAC | 4.30 (±0.89) | 5.07 (±1.24) | | |
| BCAA | 4.88 (±0.97) | 5.61 (±1.26) | | |
| Upper-body endurance (reps) | | | 0.001[a] | 0.525 |
| PLAC | 11.10 (±4.37) | 16.70 (±4.47) | | |
| BCAA | 10.66 (±3.50) | 18.66 (±6.65) | | |
| Lower-body endurance (reps) | | | 0.013[a] | 0.774 |
| PLAC | 17.77 (±5.91) | 29.33 (±11.11) | | |
| BCAA | 20.77 (±16.45) | 38.10 (±17.99) | | |

[a]Denotes a significant main effect for Time ($p < 0.05$).
BCAA: Branched-chain amino acids; PLAC: placebo.

## Discussion

The purpose of this study was to examine the effects of 8 weeks of BCAA supplementation in conjunction with heavy resistance training, on body composition and muscle performance. Despite the apparent propensity for BCAA to increase MPS, as demonstrated in previous studies involving a single bout of resistance exercise (Drummond et al., 2009; Liu et al., 2001), we hypothesized that there would not be an increase in muscle mass and performance in the BCAA group, with an 8-week program of resistance training. The major findings of the study support our hypothesis, as we observed that 8 weeks of BCAA supplementation had no preferential effect on body composition and muscle performance, when ingested in conjunction with heavy resistance training.

A previous study shows that, in the absence of resistance training, 30 days of BCAA supplementation at a dose of 14 g daily (50% L-leucine, 25% L-isolecine and 25% L-valine) to significantly increase fat-free mass and isometric hand-grip strength, with no change in arm muscle area (Candeloro et al., 1995). Furthermore, a similar, repeated study shows 30 days of BCAA supplementation at a dose of 14 g daily (50% L-leucine, 25% L-isolecine and 25% L-valine) to also significantly increase hand-grip strength, without a change in arm muscle area (De Lorenzo et al., 2003). The earlier study by Candeloro et al. (1995) concluded that the BCAA supplementation seemed to increase fat-free mass, primarily through enhanced protein synthesis. In both of these studies no control nor placebo groups were involved; therefore, making a conclusive determination as to whether BCAA supplementation definitively increased isometric strength, or that there was a protein synthesis-induced enhancement in fat-free mass, is not possible.

However, a more recent study involving 10 weeks of total-body resistance training twice weekly, combined with the daily ingestion of L-leucine at a dose of 4 g immediately after each exercise session (three equal doses throughout the day on non-exercise days), shows a significant increase in muscle strength compared to a carbohydrate placebo, even though there were no differences in either fat mass nor fat-free mass (Ispoglou et al., 2011). Even though the leucine dose and the frequency of upper- and lower-body resistance training in the Ispoglou et al. (2011) study are the same as those in our present study, the fact that we failed to show preferential increases in muscle strength for the BCAA group could be due to the fact the length of our resistance training program was 4 weeks less.

In the present study, our results demonstrated that, in regards to body composition, there were no changes in dietary intake and body composition that could be attributed to resistance training nor the supplementation protocol. Despite muscle strength and endurance of the upper- and lower-body becoming significantly increased with resistance training, there was no preferential effect from BCAA supplementation. Even though our results disagree with previous studies (Candeloro et al., 1995; De Lorenzo et al., 2003; Ispoglou et al., 2011), they are in agreement with others. For example, for 6 weeks of resistance training thrice weekly using a total-body protocol combined with 18 g/day of EAA (total dose of 9 g of BCAA), in which on exercise days only one-half of the supplement dose was ingested within 30 min before and the remaining one-half within 30 min after the exercise session, it was shown to be ineffective at preferentially improving body composition and muscle performance, compared to placebo, in untrained women (Antonio et al., 2000). In addition, 10 weeks of resistance training four times weekly (two upper-body and two lower-body exercise sessions) combined with the daily ingestion (on exercise and non-exercise days) of 3 g of BCAAs contained within 40 g of whey protein and 5 g of glutamine was also shown to be ineffective at producing any differential responses in body composition and muscle performance in men, when compared to a group ingesting whey and casein protein and another ingesting carbohydrate (Kerksick et al., 2006). Relatedly, 8 weeks of unilateral knee extensor training thrice weekly, combined with the ingestion of 6 g of leucine and 20 g of whey protein, in which one-half of the supplement dose was ingested within 30 min before and the remaining one-half after the exercise session, on exercise days (and one-half the dose on non-exercise days) demonstrated no preferential improvement in body composition and muscle strength, compared to a group ingesting carbohydrate and another group receiving no supplement (Coburn et al., 2006).

In the present study, neither group experienced any significant improvements in body composition, even though both groups underwent increases in muscle performance; however, the combined ingestion of BCAAs with 8 weeks of heavy resistance training did not produce any preferential improvements in muscle performance, compared to placebo. Both groups showed similar results, indicating the improvements were simply due to the resistance training. Our results are in agreement with several previous studies that have utilized EAA alone (Antonio et al., 2000) or BCAA and leucine, when combined with whey protein (Coburn et al., 2006; Kerksick et al., 2006). In the present study, the improvements in muscle performance were expected, due to the nature of the resistance training protocol, especially since the participants were untrained. Although, due to the heavy resistance training program utilized, we did expect significant improvements in body composition, especially since the participants were untrained.

Even though there were slight improvements in the body composition in the BCAA groups compared to placebo, these results were not significantly different.

When interpreting the results from the present study, a number of considerations must be taken into account, germane to most all exercise training studies involving humans. First, there is a possibility that with a larger group of participants, there could have been more significant results. Second, while we did not observe any significant changes in dietary intake in either of the groups, it should be emphasized that we relied on self-reporting of dietary intake, which may not provide an accurate account of actual dietary intake. Third, the participants were provided with their respective supplements and required to document their compliance with the supplementation protocol; therefore, supplement ingestion was not directly supervised. In addition, while the participants were required to document their resistance training sessions, and the training journals were reviewed, the sessions were not directly supervised by study personnel. As a result, both of these issues may have compromised the study outcomes. Fourth, we had participants ingest the supplements only on exercise days. It is possible that having them ingest the supplements even on non-exercise days may be warranted. Furthermore, it is also possible that 9 g on BCAA is not an adequate enough dosage to manifest anabolic and ergogenic adaptation in skeletal muscle during heavy resistance training. In light of these considerations, more studies are needed to determine if longer-term resistance training, combined with BCAA supplementation, could have preferential effects.

In recent years, as research efforts have continued to focus on BCAAs as a means of increasing MPS in both the young and old, and in a variety of exercise scenarios, the popularity of BCAA supplementation has increased in the mainstream media. This is mostly due to nutritional supplement companies marketing their BCAA products as a means of increasing muscle mass and performance, when one engages in resistance training; however, at the present time there are insufficient data with BCAA supplementation to substantiate these claims. The present study provides important information to the coach/practitioner, and both competitive and non-competitive athletes, to help address consideration of the effectiveness of BCAA supplementation. Because both groups showed similar results regarding body composition, our results suggest there to be no need for supplementing with BCAAs during extended periods (i.e. 8 weeks) of heavy resistance training. Therefore, based on the data presented herein, the results from the present study suggest that when combined with heavy resistance training for 8 weeks, 9 g/day of BCAA supplementation taken 4 days/week, before and after exercise, has no preferential effects on body composition and muscle performance.

## Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

## Declaration of conflicting interests

The authors declare that there are no conflicts of interest.

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