Amino Acid Supplements and Recovery from High-Intensity Resistance Training

Carwyn P.M. Sharp[1] and David R. Pearson[2]

[1]*Department of Health and Human Performance, College of Charleston, Charleston, South Carolina; and* [2]*Strength Research Laboratory, Ball State University, Muncie, IN*

Abstract

Sharp, CPM and Pearson, DR. Amino acid supplements and recovery from high-intensity training. *J Strength Cond Res* 24(4): 1125–1130, 2010—The purpose of this study was to investigate whether short-term amino acid supplementation could maintain a short-term net anabolic hormonal profile and decrease muscle cell damage during a period of high-intensity resistance training (overreaching), thereby enhancing recovery and decreasing the risk of injury and illness. Eight previously resistance trained males were randomly assigned to either a high branched chain amino acids (BCAA) or placebo group. Subjects consumed the supplement for 3 weeks before commencing a fourth week of supplementation with concomitant high-intensity total-body resistance training (overreaching) (3×6–8 repetitions maximum, 8 exercises). Blood was drawn prior to and after supplementation, then again after 2 and 4 days of training. Serum was analyzed for testosterone, cortisol, and creatine kinase. Serum testosterone levels were significantly higher ($p < 0.001$), and cortisol and creatine kinase levels were significantly lower ($p < 0.001$, and $p = 0.004$, respectively) in the BCAA group during and following resistance training. These findings suggest that short-term amino acid supplementation, which is high in BCAA, may produce a net anabolic hormonal profile while attenuating training-induced increases in muscle tissue damage. Athletes' nutrient intake, which periodically increases amino acid intake to reflect the increased need for recovery during periods of overreaching, may increase subsequent competitive performance while decreasing the risk of injury or illness.

Key Words overreaching, testosterone, cortisol, muscle damage, BCAA

Address correspondence to David Pearson, dpearson@bsu.edu.

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Introduction

Physiological adaptations to training are not linear over time. Subsequently, short-term periods of greater than normal increases in training volume and/or intensity (overreaching) with ensuing tapering periods are often incorporated into an athlete's training program to induce increases in performance (9,10). However, designing and executing an optimum overreaching program are complex and delicate. The coach must increase the training stimulus beyond previous levels to induce an enhanced adaptation but must not overload the athlete too greatly, otherwise it can lead to illness, injury, and decreased performance at a crucial period in the athlete's competition cycle. Similarly, an overreaching phase should be intentionally short in duration to minimize the risk of overtraining or injury, yet paradoxically this is often the impetus for coaches to excessively increase intensity. To attenuate these risks and maximize the desired performance rebound of overreaching, enhanced recovery methods such as nutritional supplementation may be pivotal.

Nutritional support for resistance training is essential during all phases of training. Prior research has shown that resistance training alone, while it increases skeletal muscle protein synthesis (MPS), also results in an increase in protein breakdown (4,19). Although the net effect is an increase in protein synthesis, skeletal muscle remains in an overall catabolic state in the absence of adequate nutritional intervention (5,19). The ingestion or infusion of amino acids in conjunction with an acute bout of resistance training has been shown by numerous studies to significantly increase protein synthesis and yield a net anabolic state (5,7,22). However, the mechanism(s) by which this occurs remains elusive. Limited research has also examined the potential of amino acid supplementation to enhance recovery during periods of overreaching (15,20) and other physically stressful periods of training commonly experienced by athletes.

It has been shown that fluctuations in endogenous hormone levels are strongly correlated to both short- and long-term adaptations from exercise training and reflect both the catabolic and anabolic physiological state (1,12) during stress and recovery periods of training. The resistance exercise-induced hormonal response to acute resistance exercise in men is well demonstrated and includes an increase

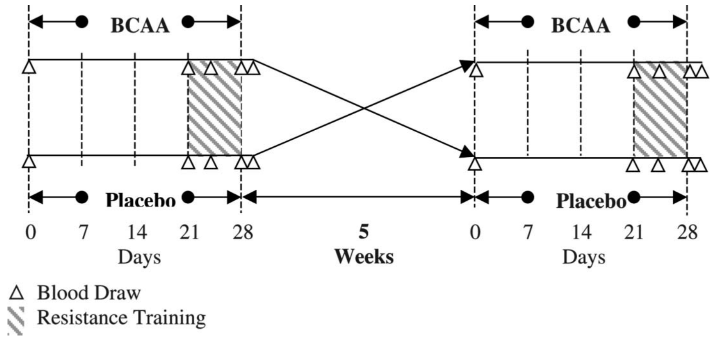

Figure 1. Schematic representation of crossover experimental design for branched-chain amino acid (BCAA) and placebo (P) supplementation and resistance training.

profile as a response to reduced skeletal muscle damage or enhanced recovery.

in serum cortisol (C); an initial decrease in testosterone (T) (14); and a decrease in the testosterone:cortisol ratio (TC), an index of overall anabolism/catabolism (3).

Thus, the purpose of this study was to examine the net hormonal effect of amino acid supplementation on the overreaching resistance training–induced hormonal stress response. We hypothesized that amino acid supplementation would enhance protein synthesis, thereby enhancing skeletal muscle repair and thus reducing plasma creatine kinase (CK) levels. It was further hypothesized that this reduction in muscle damage would reduce the hormonal stress response to training, which would be determined by evaluating plasma cortisol levels. It was also speculated that reduced skeletal muscle damage would also allow for sustained high-intensity training, thereby eliciting greater T release. Thus, it was generally hypothesized that amino acid supplementation during overreaching would result in a net anabolic hormonal profile as a response to reduced skeletal muscle damage or enhanced recovery.

Methods

Experimental Approach to the Problem

This investigation involved a balanced, cross-over, placebo-controlled, double-blind, repeated-measures design, shown schematically in Figure 1. Subjects acted as their own control. Subjects were randomly assigned to 1 of 2 treatment groups: branched chain amino acids (BCAA) or placebo (P). The amino acid composition of the supplement Nutri-Build II (per 12 capsules) consists of the following: L-Glutamine, 2000 mgs; L-leucine, 1800 mgs; L-isoleucine, 750 mgs; and L-valine, 750 mgs. The BCAA group consumed 6 g (12 capsules, which is the manufacturer's recommended daily dose) of Nutri-Build II (Nutrient Technology, Inc.) per day, whereas P consumed 12 capsules of lactose (virtually identical in size, shape, and color). Subjects consumed 6 capsules in the morning and 6 capsules in the evening with meals. Each treatment was consumed for 3 weeks (Day 0 to 21) followed by a fourth week of concurrent supplementation and resistance exercise (Day 22 to 28). This was followed by a 5-week wash-out period with no supplementation or resistance training, then a subsequent 4-week supplementation period consuming the alternative treatment.

Neither subjects nor trainers were aware which treatment was consumed. All subjects were instructed to maintain their normal daily activity levels throughout the duration of the 13-week study period. Subjects completed a 7-day dietary recall before each supplementation period and during the final supplementation period to determine their nutritional status prior to supplementation. Subjects with a dietary protein intake in excess of the recommended daily allowance (0.8 g/kg/day) were excluded from the study.

Two weeks prior to consuming any treatment, subjects' maximum strength (1 repetition maximum, or 1RM) was assessed (Cybex, Ronkonkona, New York). Strength measures

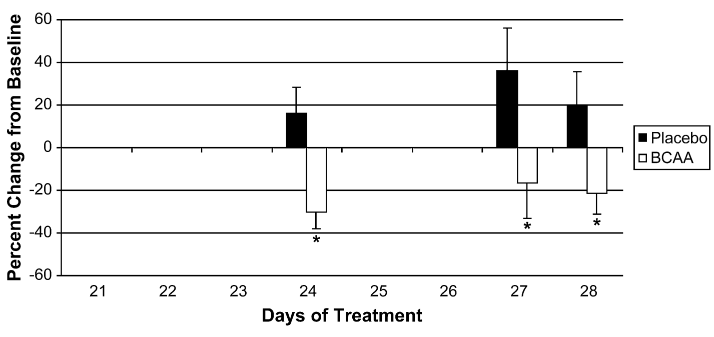

Figure 2. Mean serum cortisol levels ($\pm$ *SE*) during the final 7 days of 28 days of supplementation with either placebo or a branched chain amino acid (BCAA)–rich supplement. Blood was obtained 12 hours following the first 2 consecutive days of intense resistance training (Day 24) and 12 hours (Day 27) and 36 hours (Day 28) following the final training session. Resistance training occurred on days 22, 24, 26, and 27. $*p < 0.05$ versus baseline (Day 0); $n = 8$.

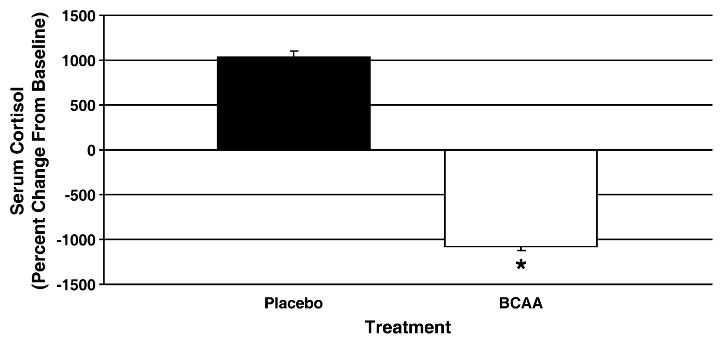

Figure 3. Serum cortisol percent change from baseline (area under the curve [AUC]) during 28 days of supplementation with either placebo or a branched chain amino acid (BCAA)–rich supplement and 7 days (4 sessions) of concomitant high-intensity total-body resistance training (overreaching) (3 × 6–8 repetitions maximum [RM], 8 exercises). Blood was obtained at baseline (day 0), 12 hours following the first 2 consecutive days of intense resistance training, and 12 hours (Day 27) and 36 hours (Day 28) following the final training session. $*p < 0.05$ versus placebo; $n = 8$. Data presented are means ± *SE*.

were completed for leg press, leg curl, leg extension, chest press, military press, latissimus pulldown, dumbbell curl, and triceps pushdown following National Strength and Conditioning Association testing recommendations (2).

Subjects

Ten healthy, recreationally active males were recruited from a university population, and 8 subjects completed the study (1 withdrew because of illness, and 1 withdrew because of injury not related to the study) (mean ± *SE*; age 22.9 ± 2 y; weight 77.9 ± 3.6 kg; height 177.1 ± 1.8 cm). All subjects completed a medical history and activity questionnaire prior to initiation of the study. All subjects had a minimum of 1 year previous resistance training experience but had not participated in resistance training in the 6 months prior to commencement of the study. Approval for conducting the study was obtained from the Ball State University Institutional Review Board, and each subject was informed of the benefits and risks of the investigation and subsequently signed an approved consent form outlining the risks associated with the experiment prior to participation. In addition, none of the subjects were taking any medications, nutritional supplements, or anabolic drugs that would confound the results of this study.

Procedures

Resistance Training. Training included 4 supervised sessions between days 22 and 28 of supplementation (Monday, Tuesday, Thursday, Friday), each consisting of 5 minutes of passive stretching followed by three sets of 6–8 repetitions at 80% of 1RM of each of the exercises outlined previously. A 60-second passive rest was observed between sets and exercises. Subjects were instructed not to cool down or engage in any heat, cold, or massage treatments for the duration of the study.

Blood Collection and Analysis. Five antecubital venous blood draws were obtained following an overnight 12-hour fast during each 4-week supplementation period (Figure 1). Samples were taken 2 days prior to and 3 weeks after supplementation and again within an hour after 2 and 4 days of training. The final sample was obtained 36 hours after the last training session. Blood samples were allowed to coagulate at room temperature then centrifuged, and the serum is frozen at −80°C until analysis.

Cortisol and testosterone concentrations were determined in duplicate from thawed serum using a solid phase ^{125}I radioimmunoassay kits (DSL-2100 and DSL-4000, respectively, Diagnostic Systems Laboratories, Inc, Webster, Texas). Creatine kinase levels were determined in duplicate using an enzymatic

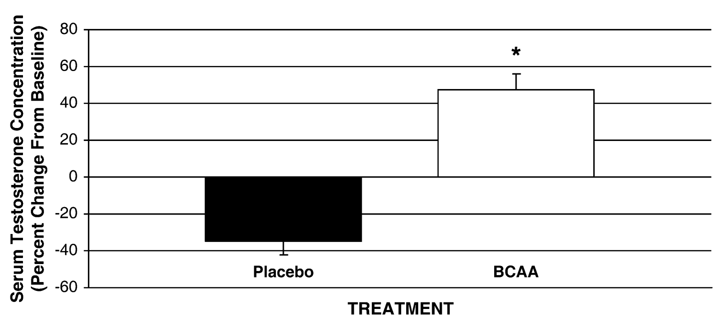

Figure 4. Serum testosterone concentration percent change from baseline (area under the curve [AUC]) during 28 days of supplementation with either placebo or a branched chain amino acid (BCAA)–rich supplement and 7 days (4 sessions) of concomitant high-intensity total-body resistance training (overreaching) (3 × 6–8 repetitions maximum [RM], 8 exercises). Blood was obtained at baseline (day 0), 12 hours following the first 2 consecutive days of intense resistance training, and 12 hours (Day 27) and 36 hours (Day 28) following the final training session. $*p < 0.05$ versus placebo; $n = 8$. Data presented are means ± *SE*.

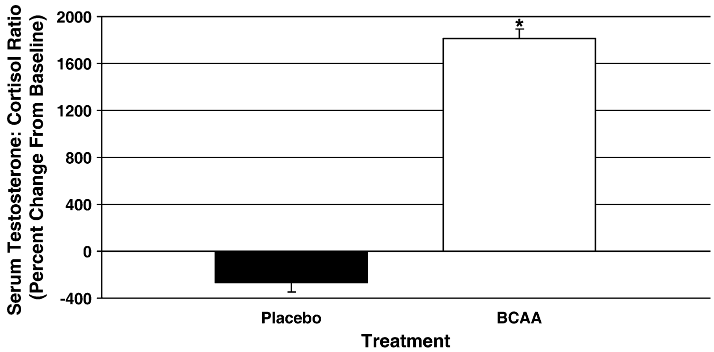

Figure 5. Serum testosterone: cortisol ratio percent change from baseline (area under the curve [AUC]) during 28 days of supplementation with either placebo or a branched chain amino acid (BCAA)–rich supplement and 7 days (4 sessions) of concomitant high-intensity total-body resistance training (overreaching) (3 × 6–8 repetitions maximum [RM], 8 exercises). Blood was obtained at baseline (day 0), 12 hours following the first 2 consecutive days of intense resistance training, and 12 hours (Day 27) and 36 hours (Day 28) following the final training session. $^*p < 0.05$ versus placebo; $n = 8$. Data presented are means ± *SE*.

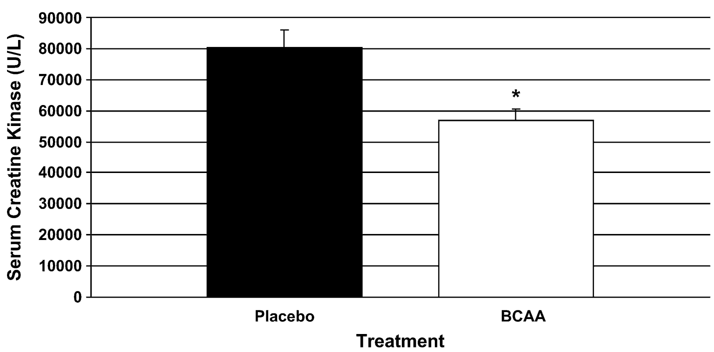

Figure 6. Mean serum creatine kinase levels (area under the curve [AUC]) during 28 days of supplementation with either placebo or a branched chain amino acid (BCAA)–rich supplement and 7 days (4 sessions) of concomitant high-intensity total-body resistance training (overreaching) (3 × 6–8 repetitions maximum [RM], 8 exercises). Blood was obtained at baseline (day 0), 12 hours following the first 2 consecutive days of intense resistance training, and 12 hours (Day 27) and 36 hours (Day 28) following the final training session. $^*p < 0.05$ versus placebo; $n = 8$. Data presented are means ± *SE*.

assay (Procedure No. 47-UV, Sigma Diagnostic, St. Louis, Missouri) and spectrophotometry (Spectronic 601, Milton Roy Company, Rochester, New York).

Statistical Analyses

A 2-way repeated measures analysis of variance (ANOVA) was used to determine differences (p-value < 0.05) between groups (P versus BCAA) over time for each variable: C, T, T:C ratio, and CK. Subsequent differences were determined using a Tukey post-hoc test when appropriate.

Area under the curve (AUC) was utilized to compare the effect of treatment over the entire treatment and training period. AUC was calculated as AUC = $\Sigma[b(c+a)/2$, where b is the time in days between the two data points (c and a) and Σ is the sum of each AUC for all subjects. Student's t-test was used to assess significance between treatments ($p \leq 0.05$).

Results

No significant change in height or weight of any subject was observed over the course of the study. No significant difference in workload during each training week was observed for any subject.

Serum cortisol concentrations, as a percent change from baseline, were significantly lower for BCAA compared to P at 2 ($p = 0.011$) and 4 days of training ($p = 0.005$) and 36 hours after the last bout of training ($p = 0.022$) (Figure 2). Total area under the curve (AUC) for serum cortisol compared to baseline was significantly lower ($p < 0.001$) for BCAA (Figure 3). Total serum testosterone levels, measured as AUC, were significantly greater ($p < 0.001$) with BCAA supplementation compared to P (Figure 4).

The net hormonal anabolic effect of supplementation, measured as the TC ratio, was also significantly greater ($p < 0.001$) for BCAA supplementation compared to P (Figure 5). Total CK levels were significantly lower ($p = 0.004$) with BCAA supplementation versus P (Figure 6).

Discussion

The major findings of this study are (a) that an amino acid supplement high in BCAA is capable of significantly decreasing the elevated cortisol response of overreaching resistance training; (b) testosterone levels may be significantly increased during overreaching training if accompanied by BCAA supplementation; and (c) markers of skeletal muscle damage (CK) in response to chronic high-intensity resistance training can be significantly decreased with concomitant BCAA ingestion in previously resistance trained men. Effective and efficient recovery protocols are critical for optimal training-induced adaptations and subsequently achieving enhanced performance-related goals. This is particularly true of athletes who utilize the rebound enhanced performance effect of overreaching (9), which occurs only with adequate recovery.

The results of the present study indicate that an amino acid supplement high in BCAA exerts an anticatabolic hormonal effect by significantly decreasing serum cortisol levels in response to resistance training overreaching. Bird et al. (6) previously reported in untrained males that essential amino acid ingestion during an acute bout of resistance exercise resulted in no significant increase in cortisol compared to baseline. Thus, our findings support those of previous investigations that amino acid ingestion is capable of attenuating exercise-induced increases in cortisol. The implications for those athletes who engage in overreaching prior to competition is a reduced risk of opportunistic infections such as upper respiratory tract infections and increased potential for maximizing the rebound effect associated with overreaching.

Our results support earlier findings, which indicate that amino acid supplementation may enhance recovery from overreaching by reducing skeletal muscle breakdown, indicated by significant decreases in serum CK levels following exercise (8).

An interesting finding of the present study was that the results outlined herein may be achieved with low relative and absolute amino acid supplementation. The amount of BCAA administered in this study was in accordance with the manufacturers recommended dosage, which was lower in absolute and relative terms than that used in other studies in this area that have shown statistically significant improvements (8,21). Insufficient plasma availability of the BCAA (a combination of low dosage and splanchnic and gastrointestinal use) may dampen their effects (16). In absolute terms, recent research indicates that a minimum of 12 g of BCAA per day (8) is required to elicit an ergogenic effect; however, the literature supports the use of up to 40 g (21) as a bolus ingestion postexercise. The current study provided 718 mg each of valine and isoleucine and 1,442 mg of leucine (i.e., total of 2.878 g) per day. This is only 24% of that used by Coombes and McNaughton (8) and a mere 7% used by Tipton and colleagues (21).

More important, in relative amounts, the current study also seems to have provided much less amino acids than the literature suggests, even with the addition of the subject's normal daily protein intake. Data from Meguid and coworkers' (16) investigation illustrate that leucine intake should be a minimum of 20 mg/kg per day to maintain a positive leucine balance (take in more than is oxidized). Therefore, it seems that 20 mg of leucine per kilogram of body weight per day is an advisable minimum for a normal adult population to meet their daily needs. The current study used a total of 1,442 mg of leucine per day, which represents an intake of $\geq$20 mg/kg per day for only 1 subject. Although this is not indicative of the total daily intake, to meet amino acid and energy demands of exercise stress, the amount of amino acids required for additional protein synthesis for tissue repair and energy oxidation is necessarily greater. Following a high-intensity training program (6 days per week) over 5 weeks in 10 previously trained sprinters and jumpers, basal fasting levels of leucine decreased by 20%, isoleucine by 21%, and valine by 18% (17). During this study by Mero and colleagues (17), total serum amino acids decreased by 19% despite a daily protein intake of 1.26 g/kg per day, which is above the recommended dietary intake of 0.8 g/kg per day. These observations concur with Hood and Terjung's (13) review of literature, which suggests an increased leucine consumption in excess of 45 mg/kg per day for regularly active individuals. Golgan's (11) more extensive review-based estimate of a leucine intake of 60 mg/kg per day, valine 50, and isoleucine 20, for those people engaged in prolonged or intense training may be more accurate. In the present study, dietary analysis showed that no subjects were consuming more than 0.7 g/kg per day of protein during the course of the study. It is likely, then, that for these virtually novice lifters, the commencement of resistance training would have increased their amino acid demands higher than that of normal individuals. As such, even with the addition of their normal dietary protein intake to that supplemented, the subjects in the present study may not have received adequate BCAA to promote an increase serum BCAA concentration required to elicit an ergogenic effect.

It is encouraging, however, that in light of the limited intake of BCAA in this study, relative to other noted studies that have found significant effects, the consistently observed trends may imply that small doses of BCAA, such as that consumed in this study, may provide sufficient BCAA availability to reduce skeletal muscle cell damage, increase testosterone, and decrease cortisol. The limited number of subjects in this study negated the ability to analyze the data according to mass. Larger sample size is consistently cited in statistical literature as reducing variability and producing more meaningful and accurate results.

Practical Applications

The goal of BCAA supplementation is to increase amino acid availability, thereby increasing substrate and energy availability for MPS and recovery and decreasing the catabolic and increasing the anabolic hormonal profile. The consumption of supplements high in BCAA by individuals and teams that have athletes ranging in mass and metabolism is likely to yield variability in results, based on mass and individual physiological differences (e.g., BCAA oxidation and skeletal muscle uptake) because heavier subjects may need to consume larger quantities of the BCAA to produce both a more anabolic hormonal profile and greater muscle membrane integrity. In conjunction, consultation with a qualified nutritional expert and the manufacturer is advised to determine the appropriate amount of supplement to be consumed to ensure adequate presentation to the skeletal muscle and other tissues because heavier subjects may need to consume larger quantities of the BCAA to produce both a more anabolic hormonal profile and greater muscle membrane integrity.

BCAA supplementation has been demonstrated to increase plasma and muscular BCAA concentrations, thereby increasing substrate availability for protein synthesis and energy production to support protein manufacture. An increase in amino acid transport postresistance training with a concomitant increase in plasma and muscle substrate availability may increase protein synthesis. In conjunction, if MPS increases postexercise, the opportunity to exacerbate protein repair and adaptation is maximized with optimum substrate and energy availability.

Tipton and colleagues (21) showed oral ingestion of essential amino acids (including the BCAA) resulted in net MPS, and, in conjunction with resistance exercise, an even greater increase in MPS has been shown (18). Thus, sufficient availability of amino acids following exercise appears necessary for maximizing increases in skeletal muscle protein synthesis following an acute bout of resistance exercise.

Acknowledgments

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