The Effect of β-Hydroxy β-Methylbutyrate on Muscular Strength and Body Composition in Collegiate Football Players

JACK RANSONE,1 KERRI NEIGHBORS,2 ROBERT LEFAVI,3 AND JOSEPH CHROMIAK4

1College of Education, Oklahoma State University, Stillwater, Oklahoma 74078; 2Oklahoma Dietetics Association, Stillwater, Oklahoma 74078; 3College of Health Professions, Armstrong Atlantic State University, Savannah, Georgia 31419; 4College of Education, Mississippi State University, Starkville, Mississippi 39762.

ABSTRACT
This study assesses the effects of daily β-hydroxy β-methylbutyrate (HMB) supplementation on muscular strength (bench press, squats, and power cleans) and body composition (body weight and body fat) among collegiate football players undergoing a strenuous exercise program. Subjects were collegiate football players (n = 35) training under the supervision of certified strength coaches averaging 20 hours of weekly exercise. In the first supplementation period, 16 of the 35 subjects were supplemented with 3 g of HMB per day for 4 weeks; the other 19 received a placebo followed by a 1-week washout period and then a second supplementation period in a randomized double-blind crossover, placebo design. There were no significant changes (p > 0.05) in muscular strength, including bench press, squats, and power cleans, among the subjects. There were also no significant changes (p > 0.05) in body composition, including body fat and body weight. Very little clinical evidence exists for supplementing HMB in athletic populations.

Key Words: athlete, ergogenic aid, exercise, HMB, protein


Introduction

Athletes are constantly searching for means of improving performance through dietary supplements that promise performance enhancing or ergogenic benefits. The most common dietary supplements in the market include creatine monohydrate, β-hydroxy β-methylbutyrate (HMB), antioxidant vitamins, amino acids, caffeine, and protein powder (1, 7, 8, 12, 19, 33). Sales of supplements, bars and beverages formulated to enhance athletic performance and recovery reached $1.26 billion in 1997 and are expected to increase (29). In the last few years, HMB, a byproduct of the essential amino acid leucine, has become one of the best-selling sports supplements (5). Because it is found in both plant and animal foods, including catfish and grapefruit, and is a metabolite of an amino acid, HMB has been classified as a dietary supplement (7, 11, 19, 36). It has been estimated that a 70-kg human would produce from 0.2 to 0.4 g HMB each day, depending on dietary leucine intake (28).

The proposed effects of HMB supplementation are numerous (14, 17, 24, 28). It has been hypothesized that HMB supplementation reduces the catabolic effects of resistance training (27, 28, 32). Recent investigations have shown that rigorously trained HMB-supplemented subjects significantly gain more strength and lean body mass than unsupplemented subjects (27, 28, 38). It has been suggested that HMB may reduce low-density lipoprotein cholesterol (24), but not all studies have shown alterations in blood lipid concentrations with HMB supplementation (10). To date, no adverse effects have been seen in animals or humans supplemented with HMB (6, 10, 24, 26, 38).

The effect of HMB supplementation on strength and body composition in individuals undergoing rigorous resistance training has been tested (9, 34). In one investigation, body fat significantly decreased and lean body mass increased in the HMB-supplemented subjects (27). The development of fat-free mass was reflected in a 55% greater gain in the bench press lift. The effect of HMB on body fat has been validated in a few animal and human studies (4, 25, 27, 37). HMB treatment increases beta-oxidation of palmitate by 30%, decreased lactate dehydrogenase (LDH) by 25%, and increased cellular expression of creatine kinase by 25%. These data suggest that HMB exerts several ef-
fected on muscle cells, potentially increasing the cell’s oxidative capacity, stabilization of cell membrane, and enhancing the expression of muscle-specific proteins. Also, the increase in fatty acid oxidation may explain some of the decrease in muscle fat proposed with HMB supplementation in humans.

The exact mechanism whereby HMB influences muscle metabolism is unknown; however, there are two hypotheses. HMB may act as a precursor to cellular muscle repair by stimulating proteinosis, which would increase collagen synthesis and connective tissues (33, 37). The net effect of these actions would be a reduction in recovery time, which could potentially increase strength and lessen the risk of overtraining. The other hypothesis suggests that HMB may regulate enzymes responsible for muscle tissue breakdown. There is evidence that HMB supplementation decreases biochemical markers of muscle breakdown among strength trainers and directly decreases the degradation of muscle protein in vitro (2–4, 24, 27, 28, 30). The objective of this research was to conduct a randomized controlled trial to evaluate the effects of daily HMB supplementation on muscular strength and body composition among collegiate football players undergoing a strenuous exercise program.

Methods

Experimental Approach to the Problem

This study was experimental in nature and followed a randomized double blind crossover, placebo design. The subjects were assigned randomly to one of 2 experimental groups. In the first supplementation period, 16 of the 35 subjects were supplemented with 3 g of HMB per day for 4 weeks; the other 19 received placebo. There was a 1-week washout period, and the subjects received the other supplement for 4 weeks.

Subjects

The subjects (n = 35) were National Collegiate Athletic Association Division I football players at a major Midwestern university training under the supervision of certified strength coaches. All subjects (Table 1) had at least 4 years of strength-training experience and adhered to the similar regimens of volume, averaging 20 hours of weekly exercise.

Each subject gave written, informed consent to participate in these experiments after the purpose, procedures, and known risks of the tests were explained in accordance with the University Institutional Review Board. Each subject completed a physical evaluation and medical history questionnaire designed to evaluate health status, medication, and previous injury status. Any indication of a possible health problem that might compromise the safety of subjects or the validity of the study excluded the individual from the present investigation.

Exercise Training

Each subject participated in supervised exercise sessions (Table 2) approximately 4 hours per day for 4 days each week throughout the 9-week experimental period prior to the start of the competitive season. A warm-up consisting of 10 minutes each of jogging and stretching preceded each practice session. Both strength and endurance exercises were performed each day of practice. Strength exercises were performed at 10 exercises per session, with 8–12 sets per exercise and 2–10 repetitions per set. The endurance drills consisted of speed and tempo exercises; they were performed with 26–30 seconds recovery time between repetitions and full recovery between sets.

Testing Procedures

The 9-week double blind, crossover design required 2 stages of supplementation: (a) HMB and (b) placebo. One week lapsed between the end of the first 4-week treatment period and the beginning of the second 4-week treatment period. A previous investigation showed that HMB levels returned to basal levels by the fourth day postsupplementation (17). Consequently, each subject underwent both treatments with an intervening washout period of 7 days. Following the washout period, subjects crossed over to the other treatment and the protocol was repeated. All subjects reported to the test site prior to initiating the treatment schedules to complete a release of pertinent demographic information.

During the first supplementation period, subjects were asked to ingest either 750-mg capsules of HMB or placebo capsules containing an inert substance (methylcellulose) for 28 days. The subjects were instructed to take 4 capsules a day: 2 with breakfast, 1 with lunch, and 1 with dinner. The total intake of HMB was 3 g per day. The rationale of taking the capsules with meals was to enhance compliance. The supplements were distributed at the beginning and 2 weeks into each supplementation period. Therefore, 56 cap-

Table 1. Demographic data.*

<table>
<thead>
<tr>
<th>Age (y)</th>
<th>Height (in.)</th>
<th>Weight (kg)</th>
<th>Body fat (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>X = 21.3 ± 1.2</td>
<td>72.1 ± 0.2</td>
<td>97.6 ± 18.8</td>
<td>12.4 ± 7.0</td>
</tr>
<tr>
<td>range = 19.2–23.6</td>
<td>range = 69.0–75.0</td>
<td>range = 74.1–138.6</td>
<td>range = 3.8–28.5</td>
</tr>
</tbody>
</table>

* All values are at pretest.
Table 2. Exercise program.

<table>
<thead>
<tr>
<th>Type of exercise</th>
<th>Drill/lift</th>
<th>Distance</th>
<th>Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm-up every session</td>
<td>10 min jogging</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10 min stretching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endurance (speed) 2</td>
<td>Parachute</td>
<td>4 × 40 yards</td>
<td>Full between sets, 26–30 s between</td>
</tr>
<tr>
<td>sessions/wk</td>
<td></td>
<td></td>
<td>repetitions</td>
</tr>
<tr>
<td></td>
<td>Surgical tubing</td>
<td>4 × 50 yards</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stadium steps</td>
<td>4 flights</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Box jumps</td>
<td>2 × 20 s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Foot ladder</td>
<td>4 × 20 yards</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Medicine ball</td>
<td>2 × 10 yards</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Metabolic training (position-specific running patterns)</td>
<td>6 × 50 yards</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Endurance (tempo) 2</td>
<td>50-yard dash</td>
<td>Full between sets, 26–30 s between</td>
</tr>
<tr>
<td>sessions/wk</td>
<td>Metabolic training</td>
<td>2 × 5</td>
<td>repetitions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 × 50 yards</td>
<td></td>
</tr>
<tr>
<td>Strength 4 sessions/wk</td>
<td>Snatch pulls, power pulls, push press, split</td>
<td>8–12 sets</td>
<td>Full between sets, 1–2 min between</td>
</tr>
<tr>
<td>(70–90% RM†)</td>
<td>snatches, incline plyometric push-ups,</td>
<td></td>
<td>repetitions</td>
</tr>
<tr>
<td>10 lifts/session)</td>
<td>step-ups, jump squats, seated power pass,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>leg curls, squats, bench press, 2-way E-Z</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>curls, front squats, incline bench, upright row,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>step-ups, sumo deadlift, military press, let curls, 2-way latissimus pull-down, 2-way E-Z curls, triceps push-down, close grip, hang clean, up-right row, pullover press, dumbbell rows</td>
<td>2–10 repetitions</td>
<td></td>
</tr>
</tbody>
</table>

* Not all drills or lifts performed at each exercise session.
† RM = repetitions maximum.

Sutures were given 4 times: at the beginning and midway through both supplementation periods. Constant verbal reinforcement was given to ensure the subjects adhered to the protocol. All capsules were produced to be identical by the nutritional supplement manufacturer (Twin Laboratories Inc., Hauppauge, NY). The subjects were instructed not to alter their lifestyles or dietary practices during the investigation. In addition, they were asked to report whether there were any side effects.

Prior to supplementation and on the day following each 28-day supplementation period, subjects reported to the testing site, having been instructed not to eat for 3 hours prior to testing. In order to obtain the most accurate and maximal exercise effort, vigorous physical activity was discouraged for 24 hours prior to the scheduled test appointment. Subjects were instructed to report to the testing site well hydrated and nourished, and a full night’s sleep was strongly recommended. A battery of tests involving muscular strength and body composition was performed. Subjects were tested in groups and competition was stressed. A 10-minute warm-up and stretching period preceded each testing session. All strength tests used 3–5 repetition maximum (RM) efforts allowing prediction of 1RM effort (22). Strength tests included the bench press, power cleans, and squats, recorded to the nearest pound. Body composition was assessed using body weight and the Jackson and Pollock (thigh, chest, and abdominal) equations to determine body density for healthy male athletes (15). For the dietary analysis, food frequency questionnaires were evaluated using the exchange lists for meal planning of American Diabetes Association, Inc. and the American Dietetic Association (35).

**Statistical Analyses**

Comparisons between the placebo and HMB treatments were made using a randomized split-plot factorial analysis of covariance to compare the mean differences between tests. Tukey post-hoc analyses were performed to determine the differences between means using a level of significance set at 0.05. The repeated factors were treatment in reference to HMB/placebo and order of testing. The covariates are maximal strength values, body weight, and sum of body fat skinfolds.

**Results**

There were no differences for muscular strength (Table 3), including bench press ($p > 0.05$), power cleans ($p > 0.05$), and squats ($p > 0.05$).
containing protein, whereas those in the placebo group received a nutrient beverage. The study was not maintained after 6 weeks, and sub-

The greater increase in fat-free mass observed early in male and female subjects (31). However, in one study, the greater increase in fat-free mass observed early in the study was not maintained after 6 weeks, and subjects in the HMB group received a nutrient beverage containing protein, whereas those in the placebo group did not (28). In another study, the increase in fat-free weight after 4 weeks of HMB supplementation was 1.4 kg, compared with 0.9 kg in the placebo group, and the p value was 0.08 (31). Other studies have reported that HMB supplementation during 4 weeks of resistance training does not alter body fat (20). The lack of effect of HMB on 1RM strength for the bench press, squat, and power cleans in the current study is consistent with other studies reporting no effect on 1RM strength (10, 20). HMB supplementation to men and women during 4 weeks of resistance training increased upper-body strength, but not lower-body strength, compared with placebo (31). HMB increased peak isometric torque and peak isokinetic torque at several concentric and eccentric velocities, but did not affect 1RM strength for several exercises (11). Another study reporting increased strength gains with HMB supplementation did not measure 1RM strength, but based this conclusion on greater work-

load increases in the HMB group (28). Finally, an increase in upper-body but not lower-body strength was reported following 4 weeks of HMB supplementation (31).

Based on blood enzyme levels and urinary 3-meth-
yhistidine excretion, it appears that HMB reduces muscle damage and muscle protein degradation during the first few weeks of initiating training or increasing the workload (10, 28). An additional study reported that plasma creatine phosphokinas-

e levels "tended" to be lower with HMB supplementation after 4 weeks of resistance training (31), and another study found no significant differences between placebo- and HMB-supplemented groups after 4 weeks of strength training (20). HMB supplementation reduced the increase in serum creatine phosphokinase and lactate dehydrogenase concentrations following a 20-km run (17). It appears that HMB may be most effective when initiating an exercise training program or increasing the workload of a training program.

This subject population in this study represented a group targeted by supplement companies due to their training regimen and competitive nature (1, 7). Although no training table was available during the experimental period, it was the assumption of the investig-
tors that these subjects are representative of a typical collegiate athlete in terms of diet and exercise habits. In short-term recall situations, the food frequency questionnaire has the potential to underestimate en-

ergy and nutrient intake (18). Other limitations of food frequency questionnaires include intake data being compromised when multiple foods are grouped with-
in single listings, and they are dependent on the ability of the subject to describe their diet (21). Athletes may tend to focus more on eating and body composition than nonathletes. Consequently, desire for weight change and level of dietary consciousness may also se-

verely bias reported food intake in food frequency

<table>
<thead>
<tr>
<th>Table 3. Muscle strength values.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>Bench press</td>
</tr>
<tr>
<td>Power cleans</td>
</tr>
<tr>
<td>Squats</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 4. Body composition results.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>-----------------------------------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

*HMB = β-Hydroxy β-methyl butyrate.

In addition, there were no significant differences for body composition (Table 4), body fat (p > 0.05), or weight (p > 0.05). The repeated factor of treatment with reference to HMB/placebo and order of testing was not significant (p > 0.05). The food frequency questionnaire was evaluated using the exchange list for meal planning of American Diabetes Association, Inc. and the American Dietetic Association (34). Reported mean caloric intake, based on analysis of food frequency questionnaires, was 2,600 cal, consisting of 43–45% carbohydrate, 21–23% protein, and 33–35% fat. The experimental period, which comprised the summer months of June, July, and August, did not include a training table that would have allowed close monitoring of the dietary intake.

**Discussion**

Daily supplementation of HMB in collegiate football players undergoing a strenuous exercise program did not alter muscular strength, total body weight or percent body fat. The exercise protocol followed in this investigation is consistent with a previous investigation (13), which determined that exercise 4–5 times per week is an optimal choice in developing strength, endurance, and muscle mass. Our study is consistent with other studies showing no effect of HMB on body fat (9, 20). One study reported a greater decline in percent body fat with HMB supplementation with a p value of 0.08 (31). Studies have reported greater increases in fat-free mass following strength training in trained and untrained male subjects (11), and in untrained male and female subjects (31). However, in one study, the greater increase in fat-free mass observed early in the study was not maintained after 6 weeks, and subjects in the HMB group received a nutrient beverage containing protein, whereas those in the placebo group did not (28). In another study, the increase in fat-free weight after 4 weeks of HMB supplementation was 1.4 kg, compared with 0.9 kg in the placebo group, and the p value was 0.08 (31). Other studies have reported that HMB supplementation during 4 weeks of resistance training does not alter body fat (20). The lack of effect of HMB on 1RM strength for the bench press, squat, and power cleans in the current study is consistent with other studies reporting no effect on 1RM strength (10, 20). HMB supplementation to men and women during 4 weeks of resistance training increased upper-body strength, but not lower-body strength, compared with placebo (31). HMB increased peak isometric torque and peak isokinetic torque at several concentric and eccentric velocities, but did not affect 1RM strength for several exercises (11). Another study reporting increased strength gains with HMB supplementation did not measure 1RM strength, but based this conclusion on greater work-load increases in the HMB group (28). Finally, an increase in upper-body but not lower-body strength was reported following 4 weeks of HMB supplementation (31).

Based on blood enzyme levels and urinary 3-methyl-
yhistidine excretion, it appears that HMB reduces muscle damage and muscle protein degradation during the first few weeks of initiating training or increasing the workload (10, 28). An additional study reported that plasma creatine phosphokinase levels "tended" to be lower with HMB supplementation after 4 weeks of resistance training (31), and another study found no significant differences between placebo- and HMB-supplemented groups after 4 weeks of strength training (20). HMB supplementation reduced the increase in serum creatine phosphokinase and lactate dehydrogenase concentrations following a 20-km run (17). It appears that HMB may be most effective when initiating an exercise training program or increasing the workload of a training program.

This subject population in this study represented a group targeted by supplement companies due to their training regimen and competitive nature (1, 7). Although no training table was available during the experimental period, it was the assumption of the investigators that these subjects are representative of a typical collegiate athlete in terms of diet and exercise habits. In short-term recall situations, the food frequency questionnaire has the potential to underestimate energy and nutrient intake (18). Other limitations of food frequency questionnaires include intake data being compromised when multiple foods are grouped within single listings, and they are dependent on the ability of the subject to describe their diet (21). Athletes may tend to focus more on eating and body composition than nonathletes. Consequently, desire for weight change and level of dietary consciousness may also severely bias reported food intake in food frequency.
questionable (16). Previous research showed the subjects’ average total caloric need in this study was approximately 4,310 cal per day. Depending on several factors, such as metabolic rate, activity level, and football position, the total caloric needs range from 39.0 to 45.7 cal·kg⁻¹·d⁻¹ (23). Therefore, the reported mean intake of total calories consumed (2,600 cal per day) during this study is much lower than the football players’ estimated needs. The breakdown of macronutrients (44% carbohydrate, 22% protein, and 34% fat) consumed by the football players in this study is fairly consistent with macronutrient ratios reported in the literature (23). However, given the relatively low total caloric intake of these subjects and the macronutrient breakdown, the subjects’ intake of carbohydrates may have been suboptimal.

The lack of strength gains in the current investigation suggests that subjects may have been over-trained. The volume of exercise in this study was higher than most other HMB-supplementation studies. Although HMB may be most effective when increasing training volume or intensity, the extremely high total training load may have attenuated the potential effectiveness of HMB to reduce muscle damage or protein breakdown.

Practical Applications

This study was designed to assess the effect of daily HMB supplementation on muscular strength and body composition among collegiate football players undergoing a strenuous exercise program. Recognizing that caution should be observed in generalizing from this study’s results, it was concluded that supplementation of HMB had no effect on muscular strength or body composition during an intensive strength and conditioning program on well-trained collegiate football players. Prior research suggests that HMB may be most effective when initiating an exercise training program or increasing the workload of a training program. Research has also demonstrated that HMB may induce small increases in strength and fat-free mass by reducing muscle damage and protein breakdown. However, the extremely high total training load in the current investigation may have attenuated the potential effectiveness of HMB to reduce muscle damage or protein breakdown. Additional research is needed before HMB can be recommended as an ergogenic supplement to reduce muscle protein catabolism during training periods when volume and intensity are increased.

References


Address correspondence to Dr. Jack Ransone, ransone@okstate.edu.