

10-1-2000

Effects of Calcium β -HMB Supplementation During Training on Markers of Catabolism, Body Composition, Strength and Sprint Performance

Richard B. Kreider
University of Memphis

Maria Pontes Ferreira
Wayne State University, maria.pontes.ferreira@fulbrightmail.org

Michael Greenwood
University of Memphis

M. Wilson
University of Memphis

Pamela Grindstaff
University of Memphis

See next page for additional authors

Recommended Citation

Kreider, R.B., Ferreira, M., Greenwood, M., Wilson, M., Grindhaff, P., Plisk, S., Reinardy, J., Cantler, E., and Almada, A.L. (2000) Effects of calcium B-HMB supplementation during training on markers of catabolism, body composition, strength, and sprint performance. *Journal of Exercise Physiology*. 3(4): 48-59.
Available at: <http://digitalcommons.wayne.edu/nfsfrp/7>

Authors

Richard B. Kreider, Maria Pontes Ferreira, Michael Greenwood, M. Wilson, Pamela Grindstaff, Steven Plisk, Jeff Reinardy, Edward Cantler, and Anthony L. Amalda

JEPonline
Journal of Exercise Physiologyonline

Official Journal of The American
Society of Exercise Physiologists (ASEP)

ISSN 1097-9751

An International Electronic Journal
Volume 3 Number 4 October 2000

Exercise Nutrition

Effects of Calcium β -HMB Supplementation During Training on Markers of Catabolism, Body Composition, Strength and Sprint Performance

R.B. KREIDER, M. FERREIRA, M. GREENWOOD, M. WILSON, PAMELA GRINDSTAFF, S. PLISK, J. REINARDY, E. CANTLER AND A.L. ALMADA

Exercise & Sport Nutrition Laboratory, Department of Human Movement Sciences & Education, Department of Intercollegiate Athletics, The University of Memphis, Memphis, TN

R.B. KREIDER, M. FERREIRA, M. GREENWOOD, M. WILSON, PAMELA GRINDSTAFF, S. PLISK, J. REINARDY, E. CANTLER AND A.L. ALMADA. **Effects of Calcium β -HMB Supplementation During Training on Markers of Catabolism, Body Composition, Strength and Sprint Performance.** *JEPonline*, 3(4):48-59, 2000. Calcium β -hydroxy β -methylbutyrate (HMB) supplementation has been reported to reduce catabolism and promote gains in strength and fat free mass in untrained individuals initiating training. However, the effects of HMB supplementation on strength and body composition alterations during training in athletes is less clear. This study examined the effects of 28-d of calcium HMB supplementation during intense training on markers of catabolism, body composition, strength, and sprint performance. In a double-blind and randomized manner, 28 NCAA division I-A football players were matched-paired and assigned to supplement their diet for 28-d during winter resistance/agility training (~8 hr/wk) with a carbohydrate placebo supplement (P) or the P supplement with 3 g/day of HMB as a calcium salt (HMB). Prior to and following supplementation: dietary records and fasting blood samples were obtained; body composition was determined via DEXA; subjects performed maximal effort bench press, barbell back squat, and power clean isotonic repetition tests; and, subjects performed a repeated cycle ergometer sprint test (12 x 6-s sprints with 30-s rest recovery) to simulate a 12-play drive in football. Results revealed no significant differences between the placebo and HMB supplemented groups in markers of catabolism, muscle/liver enzyme efflux, hematological parameters, body composition, combined lifting volume, or repetitive sprint performance. Results indicate that HMB supplementation (3 g/day) during off-season college football resistance/agility training does not reduce catabolism or provide ergogenic benefit.

Key Words: β -hydroxy β -methylbutyrate, Exercise, Sport Nutrition, Dietary Supplementation, Ergogenic Aids

INTRODUCTION

The leucine metabolite β -hydroxy β -methylbutyrate (HMB) has recently become a popular dietary supplement purported to promote gains in fat-free mass (FFM), reduce body fat, and increase strength during resistance-training. The rationale for this is that leucine and metabolites of leucine such as β -ketoisocaproate (KIC) have been reported to inhibit protein degradation (1,2). The anti-proteolytic effects of leucine and KIC have been suggested to be regulated by the leucine metabolite HMB (2). Animal studies indicate that HMB is synthesized from KIC primarily as a byproduct of leucine metabolism and that approximately 5% of oxidized leucine is converted to HMB (3). Further, adding HMB to dietary feed improved colostrum milk fat and sow performance (4), tended to improve the carcass quality of steers (5), decreased markers of catabolism during training in horses (6), and improved several markers of immune functions in chickens (7,8). Based on these findings, it has

been hypothesized that supplementing the diet with leucine and/or HMB in humans may inhibit protein degradation during periods associated with increased proteolysis such as resistance training.

Although much of the available literature on HMB supplementation in humans is preliminary in nature, there are several recently published articles and abstracts that support this hypothesis. In this regard, leucine infusion has been reported to decrease protein degradation in humans, suggesting that leucine may serve as a regulator of protein metabolism (1). Moreover, Nissen and colleagues reported some evidence that untrained men (2) and women (2,9) initiating a resistance-training program experienced greater gains in fat free mass (FFM) and/or strength when administered either 1.5 to 3 g/d of HMB (as the calcium salt) for 3 to 4-wks. These gains were associated with significantly less muscle enzyme efflux as well as urinary 3-methylhistidine excretion, suggesting that subjects ingesting HMB experienced less catabolism during training (2). Vukovich and coworkers (10) reported that 8-wks of HMB supplementation (3 g/d as the calcium salt) significantly increased FFM (-0.58 vs 1.5%), reduced fat mass (0.27 vs. -2.2%), and promoted greater gains in upper and lower extremity 1 RM strength in a group of elderly men and women initiating training. Likewise, Panton and colleagues (11) reported that HMB supplementation during 8-weeks of resistance training increased functional ability to get up, walk, sit down in a group of elderly subjects. Finally, Gallagher and associates (12) evaluated the effects of HMB supplementation (0.38 and 0.76 mg/kg/day) during 8-weeks of resistance training in previously untrained men. The investigators reported that HMB supplementation promoted significantly less muscle creatine kinase excretion and greater gains in muscle mass (in the 0.38 mg/kg/day group only) than subjects taking a placebo. Collectively, these preliminary findings suggest that supplementing the diet with 1.5 to 3 g/d of HMB may enhance training-induced changes in FFM and strength in untrained subjects initiating training (2,7,13).

Whether HMB supplementation reduces markers of whole body catabolism and/or promotes greater gains in FFM and strength during training in well-trained athletes is less clear. Nissen and colleagues (2) reported that calcium HMB supplementation (3 g/d of HMB as the calcium salt) ingested with the vitamin/mineral fortified carbohydrate/protein meal replacement powder) significantly increased FFM (~2.7 kg) during the first 3 to 4-wks of a 7-wk off-season college football resistance-training program in comparison to subjects ingesting an isoenergetic amount of orange juice. However, there were no significant differences between groups in FFM after 7-wks of resistance training. Additionally, it was unclear whether the gains in FFM observed were due to HMB supplementation, ingesting the vitamin/mineral fortified carbohydrate/protein supplement, and/or a synergistic effect of HMB and one or more of the ingredients contained in vitamin/fortified carbohydrate/protein supplement. In another study, Vukovich and colleagues (13) reported that 14-d of HMB supplementation (3 g/d as the calcium salt) during training promoted significantly greater increases in time to exhaustion, lactate threshold, and VO_2 peak in trained cyclists (10). This finding suggests that HMB supplementation may provide some ergogenic value during intense exercise. However, the mechanism for the increases observed remain to be determined. More recently, Kreider and colleagues (14) administered a vitamin/mineral fortified carbohydrate/protein power containing either 0, 3, or 6 g/d of HMB to experienced resistance trained athletes for 28 days of training. Results revealed that although trends were observed, HMB supplementation did not significantly affect markers of muscle degradation, muscle mass, or strength.

Although HMB supplementation appears to enhance training adaptations in untrained subjects initiating training, additional research is necessary before definitive conclusions can be made regarding the ergogenic value HMB supplementation in athletes. The purpose of this study was to determine whether HMB supplementation during intense resistance/agility training affects markers of whole body catabolism, body composition, isotonic lifting volume, and/or repetitive sprint performance in college football players.

METHODS

Subjects

28 NCAA division I-A college football players undergoing winter/spring off-season resistance/agility training volunteered to participate in this study. Subjects were informed as to the experimental procedures and signed informed consent statements in adherence with the human subjects guidelines of The University of Memphis and the American College of Sports Medicine. Subjects were descriptively (mean \pm standard deviation) 20.0 \pm 1.5 yrs, 96.9 \pm 18 kg, 183 \pm 3 cm tall, 17.4 \pm 7 % body fat and had 1 repetition maximums (1RMs) of 138 \pm 22 kg in the bench press, 210 \pm 35 kg in the back barbell squat, and 117 \pm 15 kg in the power hang clean.

Subjects signed statements indicating that they were not taking anabolic steroids and that they were aware that they may be subject to random drug testing during the study, according to NCAA regulations. During the conduct of the study, 15 subjects were randomly selected by the NCAA for drug testing during two independent screenings. All drug tests were negative for the presence of anabolic/androgenic steroids according to NCAA criteria. In addition, there was no history of athletes at this university testing positive for anabolic/androgenic steroids in the previous 9 years of NCAA testing.

Experimental Design

Subjects maintained their normal training table provided diet throughout the study. Meals consisted of *ad libitum* intake of a primary entree and a limited number of side entrees served at the team training table meals. Consequently, although the athletes were allowed to select their own foods and ingest food outside of the training table, diets of the athletes were similar. Moreover, subjects were not allowed to have ingested creatine, HMB, or beta-agonists for an 8-wk period prior to the start of supplementation. Subjects were also instructed not to ingest any other nutritional supplements, proposed ergogenic aids, or non-prescription drugs during the course of the study.

Prior to the start of supplementation, subjects participated in two familiarization sessions and performed pre-supplementation testing during the first two weeks of winter resistance training. In the first familiarization session the procedures of the study were explained, the subjects were weighed, and training and medical history forms were completed. In addition, the subjects practiced the cycle ergometer sprint test to be used in the study. This test was designed to simulate a 12-play drive in football. Consequently, subjects performed 12 x 6-s maximal effort sprints on computerized cycle ergometer with 30-sec of rest between each sprint at a standardized work rate. Subjects performed one additional practice sprint trial prior to pre-supplementation testing. Complete details of the sprint protocol used in this investigation are provided in the Procedures section of this manuscript. Subjects were also instructed how to report nutritional intake by a Registered Dietitian.

Pre-supplementation assessments included: 1.) a 4-d nutritional intake assessment (including one weekend day); 2.) donation of an 8-h fasting venous blood sample; 3.) measurement of total body mass, total body water, and body composition; 4.) performance of low repetition maximal effort isotonic bench press, back barbell squat and power hang clean tests; and, 5.) performance of a 12 x 6-s sprint test with 30-s rest recovery between sprints on a computerized cycle ergometer.

In a double-blind and randomized manner, subjects were then matched by total body mass and team position and were assigned to supplement their diet for 28-d with either placebo containing 99 g/d of glucose, 3 g/d of taurine, 1.1 g/d of disodium phosphate and 1.2 g/d of potassium phosphate (P) or the P supplement with 3 g/d of HMB as the calcium salt (HMB). Supplements were prepared in powder form by an independent food science lab and had identical texture, taste and appearance. Supplements were independently packaged in generic foil packets for double-blind administration. Subjects mixed the supplement powder into approximately 0.25 L of water and ingested the solution with morning, mid-day and evening meals.

Supplement packets were administered in blindly coded boxes containing a 15-d supply of the supplements. Subject compliance in taking the supplements was verified by having a research assistant collect empty supplement packets throughout the study. Subjects had to turn in all empty packets in order to receive the next 15-d supply of supplements. In addition, subjects had to turn in all empty packets throughout the remainder of the study to receive the incentive for participating in the study (i.e. 4 cans of Phosphagain, *Experimental & Applied Sciences, Golden, CO*). Consequently, compliance in taking the supplements was excellent.

During the 4-wk supplementation period, subjects participated in a standardized resistance and agility training program. The program consisted of 5 hr/wk of heavy resistance-training conducted on Monday, Tuesday, Thursday, and Friday afternoons, as well as a 3 hr/wk of agility/sprint training conducted at 6:00 am on Monday, Wednesday, and Friday mornings. Primary lifts performed included bench press, incline bench press, shoulder press, lateral pull downs, seated cable rows, upright rows, abdominals, squats, hip sled, gluteal/hamstring raises, power hang cleans, and clean and jerk. Lifts were prescribed in a structured program on a weekly rotation of lifts/sets/repetitions within a 4-wk microcycle (e.g. 1 to 3 sets of 2-8 repetitions, at intensities ranging from 60 to 95% of 1 RM). Agility training consisted of high intensity sprint and football agility drills. All training was performed under the supervision of certified strength coaches and/or assistant football coaches. Attendance was monitored and subjects who missed workouts were required to make them up according to team policy.

Following the 28-d supplementation period, subjects underwent post-supplementation assessments in a similar manner as the pre-supplementation tests. Therefore, diet was recorded for 4-d; a fasting venous blood sample was collected; body mass, body water, and body composition were determined; subjects performed the maximal effort low repetition test on the isotonic bench press, barbell back squat, and power clean; and, the subjects performed the 12 x 6-s cycle ergometer sprint test with 30-s of passive recovery between sprints.

Procedures

Nutritional intake was monitored for 4-d prior to the initiation of supplementation and during the final week of supplementation. This was accomplished by having a Registered Dietitian and research assistants evaluate and record all food/fluid ingested during training table meals. In addition, subjects reported any additional food/fluids ingested between meals during this period. Nutritional records were analyzed by a Registered Dietitian using the Food Processor III nutritional analysis software (*Nutritional Systems, Salem, OR*).

Subjects observed an overnight 8-h fast prior to donating blood samples. Venous blood samples were obtained between 6:00 and 7:30 am via venipuncture from an antecubital vein in the forearm using standard phlebotomy procedures. Venous blood was collected into 10 mL serum separation tubes (SST) and a 5 mL anticoagulant tube (K₃). The SST tubes were centrifuged at 5,000 rev/min for 10-min using a Biofuge 17R centrifuge (*Heraeus Inc., Germany*). Samples were refrigerated and then shipped overnight in cold containers to Corning Clinical Laboratories (*St. Louis, MO*) for clinical analysis. A complete clinical chemistry panel (31 items) was run on serum samples using the Technicon DAX model 96-0147 automated chemistry analyzer using standard clinical procedures (*Technicon Inc., Terry Town, NY*). Cell blood counts with percent differentials were run on whole blood samples using a Coulter STKS automated analyzer using standard procedures (*Coulter Inc., Hialeah, FL*).

Total body mass was measured on a calibrated digital scale with a precision of ± 0.02 kg (*Sterling Scale Co., Southfield, MI*). Total body water was estimated (15) using a Valhalla 1990b Bioelectrical Impedance Analyzer (*San Diego, CA*). Whole body (excluding cranium) body composition measurements were determined using a Hologic QDR-2000 dual energy x-ray absorptiometer (DEXA) with the Hologic version V 7, REV F software (*Waltham, MA*) using procedures previously described (16,17). DEXA measures the amount of bone, fat, and

fat-free/soft tissue mass which falls within a standardized density ranges using dual energy x-ray absorptiometry methodology. The DEXA scans regions of the body (right arm, left arm, trunk, right leg, and left leg) to determine the amount of bone mass, fat mass, and fat-free/soft tissue mass within each region. The scanned bone, fat, and fat-free/soft tissue mass for each region are then subtotaled to determine whole body (excluding cranium) values. Percent body fat was calculated by dividing the amount of measured fat mass by total scanned mass (sum of bone mass, fat mass, and fat-free/soft tissue mass). DEXA has been shown to be a highly reliable ($r=0.99$) and precise method (coefficient of variation of 0.5-1%) for determining individual body composition segments (18,19,20,21).

Subjects were positioned according to standardized criteria during the initial scan. DEXAs were performed under the supervision of a certified radiology technician. Quality control (QC) calibration procedures were performed on a spine phantom (Hologic X-CALIBER Model DPA/QDR-1 anthropometric spine phantom) prior to each testing session according to procedures previously described (16,22,17). Mean coefficients of variation in bone mineral content (BMC) and bone mineral density (BMD) measurements ranged between 0.41 to 0.55% throughout the life of the unit. Test-retest reliability studies performed on male athletes with this DEXA machine yielded mean deviation for total BMC and total fat free/soft tissue mass of 0.31% with a mean intraclass correlation of 0.985 (16).

Subjects performed maximal effort repetition tests on the isotonic bench press, squat, and power hang clean in order to determine lifting volume according to procedures previously described (17). This strength testing approach was selected in consultation with the strength coaches because it more closely represented the type of resistance-training the athletes were involved in during the study (i.e., a 4-wk periodized cycle of mid-range repetitions). The athletes warm-up and then perform a maximal effort repetition test with a weight that the strength coaches estimated the athlete could lift between 4 to 8 times, based on training lifting performance. Lifting volume was determined by multiplying the amount of weight lifted by the number of repetitions performed. Total lifting volume was determined by adding the sum of bench press, squat and power hang clean lifting volumes. All isotonic test sets were performed under supervision of the certified strength coaches using standardized lifting criteria (23,24,25).

The sprint tests were performed on a computerized CardioO₂TM cycle ergometer equipped with toe clips at a standardized work rate of 3.85 J/kg/rev (*ErgometR_x Corp., St. Paul, MN*). Seat position was standardized between trials. The ergometer was connected via an RS232 parallel interface to a Dell 466/Le Optiplex computer (*Dell Computer Corp., Austin, TX*) using *ErgometR_x CardioscribeTM* and *ExerscribeTM* software (*ErgometR_x Corp., St. Paul, MN*). Crank frequency was measured using a crystal referenced optic encoder with a precision range of 0 to 200 rev/min and an accuracy of ± 1 rev/min. Pedal torque was determined by a calibrated strain gauge with a range of 0 to 2,000 W and an accuracy of $\pm 1\%$. Data were collected and downloaded into the computer at 2Hz.

Statistical Analysis

Nutritional, hematological, body composition, and strength data were analyzed by a 2 x 2 repeated measures analysis of variance (ANOVA) using SPSS for Windows Version 8.0 software (*SPSS Inc., Chicago, IL*). Delta scores (post - pre values) were calculated on selected variables and analyzed by one-way ANOVA. In order to normalize differences between groups in pre-supplementation sprint performance, Day 28 work data were analyzed by analysis of covariance (ANCOVA) using Day 0 data as the covariate. Power estimates based on this experimental design revealed estimated power values of 0.15, 0.72, and 0.98 for small (0.25), moderate (0.75), and large (1.25) effects, respectively. Observed power ranged from 0.05 to 0.99 for group, time, and interaction alpha levels. Data are presented as mean \pm standard deviation. Data were considered significantly different when the probability of error was 0.05 or less.

RESULTS

Side Effects

Subjects tolerated the supplementation protocol well with no reports of medical problems/symptoms in post-study questionnaires administered in a blinded manner. In addition, no significant medical complications were observed and/or treated by the athletic training staff during the study.

Nutritional Intake

Table 1 presents dietary analysis data for the P and HMB groups. No significant interactions were observed between P and HMB groups in mean relative daily energy intake, carbohydrate intake, or fat intake. Protein intake significantly decreased in the P group following supplementation (0.3 g/kg) and was significantly lower than the HMB group. Additionally, overall mean energy and carbohydrate intake in the P group was significantly lower than the HMB during the course of the study.

Table 1. Mean daily dietary intake data for the P and HMB groups.

Variable	Group	Day 0	Day 28	p	
Energy Intake (kcal/kg/d)	P	41.7±10.0	36.9±10.2	Group	0.06
	HMB	46.7±14.2	47.3± 8.9	Time	0.32
				Group x Time	0.20
Carbohydrate (g/kg/d)	P	4.7±1.2	4.8±1.2	Group	0.04
	HMB	5.6±2.3	6.0±1.1	Time	0.47
				Group x Time	0.66
Protein (g/kg/d)	P	1.8±0.4	1.5±0.5 [#]	Group	0.19
	HMB	1.8±0.5	1.9±0.4 [*]	Time	0.30
				Group x Time	0.04
Fat (g/kg/d)	P	1.8±0.5	1.4±0.4	Group	0.66
	HMB	1.8±0.4	1.5±0.3	Time	0.001
				Group x Time	0.30

Data are means±standard deviations, *Represents p<0.05 difference from P group.

[#] Represents p<0.05 difference from HMB group., ['] Represents p<0.05 difference from Day 0.

Blood Chemistry Profiles

Table 2 presents selected markers of whole body catabolism and muscle/liver enzymes. No significant interactions were observed between the P and HMB groups in any of these variables. Additionally, no significant interactions were observed between P and HMB groups in serum total protein, albumin, globulin, alkaline phosphatase, γ -glutamyltransferase, glucose, sodium, potassium, chloride, calcium, ionized calcium, phosphorus, total cholesterol, triglycerides, high density lipoproteins, low density lipoproteins, very low density lipoproteins, leukocytes, neutrophils, lymphocytes, monocytes, eosinophils, basophils, hemoglobin, hematocrit, total bilirubin, total iron, platelets, red blood cells, red blood cells distribution width, mean corpuscular volume, or mean platelet volume.

Body Composition

Table 3 presents body composition data obtained on days 0 and 28 of supplementation while Figure 1 presents mean changes in body composition data from day 0 values. Training resulted in significant increases in total body mass, lean/soft tissue mass, and bone mass while decreasing body fat percentage for both groups.

However, no significant differences were observed between groups in changes in total body weight, total body water, scanned mass, lean/soft tissue mass, fat mass, bone mass, or percent body fat.

Table 2. Selected markers of catabolism for the P and HMB supplemented groups.

<i>Variable</i>	<i>Group</i>	<i>Day 0</i>	<i>Day 28</i>	<i>p</i>	
<i>Creatinine</i> ($\mu\text{mol/L}$)	P	104 \pm 9	109 \pm 13	Group	0.43
	HMB	104 \pm 14	114 \pm 13		
<i>Urea Nitrogen</i> (mmol/L)	P	4.4 \pm 1.3	6.4 \pm 1.0	Time	0.23
	HMB	5.6 \pm 1.3	6.1 \pm 1.4	0.003	
<i>Urea Nitrogen/ Creatinine Ratio</i>	P	12.3 \pm 3.4	14.7 \pm 2.6	Group x Time	0.85
	HMB	12.4 \pm 3.2	13.4 \pm 3.4	0.40	
<i>Uric Acid</i> ($\mu\text{mol/L}$)	P	416 \pm 114	561 \pm 91	Group	0.93
	HMB	391 \pm 91	578 \pm 133	0.20	
<i>CK</i> (IU/L)	P	251 \pm 132	427 \pm 226	Time	0.33
	HMB	271 \pm 219	515 \pm 323	0.001	
<i>LDH</i> (IU/L)	P	158 \pm 13	176 \pm 21	Group x Time	0.34
	HMB	147 \pm 23	172 \pm 24	0.40	
<i>AST</i> (IU/L)	P	21.0 \pm 4.2	20.5 \pm 5.6	Time	0.53
	HMB	21.2 \pm 5.8	22.8 \pm 6.7	0.001	
<i>AST</i> (IU/L)	P	27.5 \pm 9.9	25.5 \pm 12.2	Group x Time	0.78
	HMB	26.8 \pm 10.7	24.1 \pm 8.4	0.26	
				Group	0.10
				Time	0.81
				Group x Time	

Data are means \pm standard deviations

Strength

No significant differences were observed between groups in changes in bench press lifting volume (P -5 \pm 134; HMB -9 \pm 182 kg, $p=0.95$), squat lifting volume (P 267 \pm 308; HMB 111 \pm 358 kg, $p=0.23$), power clean lifting volume (P 921 \pm 326; HMB 1,140 \pm 470 kg, $p=0.17$), or total lifting volume for all three lifts combined (P 1,184 \pm 517; HMB 1,241 \pm 697 kg, $p=0.80$).

Sprint Performance

Figure 2 presents Day 0 and Day 28 mean work (J) responses observed for the P and HMB groups during the 12 x 6-s sprints. ANCOVA revealed no significant differences between groups in work performed during the repeated cycling tests.

Table 3. Body composition values observed on day 0 and 28 of supplementation for the P and HMB supplemented groups.

Variable	Group	Day 0	Day 28		p
Body Mass (kg)	P	96.9±18.2	97.7±18.1	Group	0.97
	HMB	96.9±18.1	98.2±18.1	Time	0.007
				Group x Time	0.54
Scanned Body Mass (kg)	P	90.2±17.1	91.0±16.8	Group	0.93
	HMB	90.1±16.8	91.5± 16.7	Time	0.004
				Group x Time	0.85
Lean Tissue Mass (kg)	P	69.8±8.7	71.1±8.5	Group	0.72
	HMB	71.1± (9.1	72.4±9.3	Time	0.001
				Group x Time	0.91
Fat Mass (kg)	P	17.2±10.3	16.7±9.9	Group	0.69
	HMB	15.9± 8.2	15.1±9.6	Time	0.17
				Group x Time	0.81
Bone Mass (kg)	P	3,132±465	3,154±469	Group	0.91
	HMB	3,105±503	3,136±500	Time	0.007
				Group x Time	0.65
Body Fat (%)	P	18.0±8.0	17.3±7.7	Group	0.71
	HMB	16.7±6.0	16.5±6.3	Time	0.03
				Group x Time	0.22
Total Body Water (L)	P	62.3±10.5	62.3±10.6	Group	0.95
	HMB	62.5±10.6	62.7±10.1	Time	0.79
				Group x Time	0.78

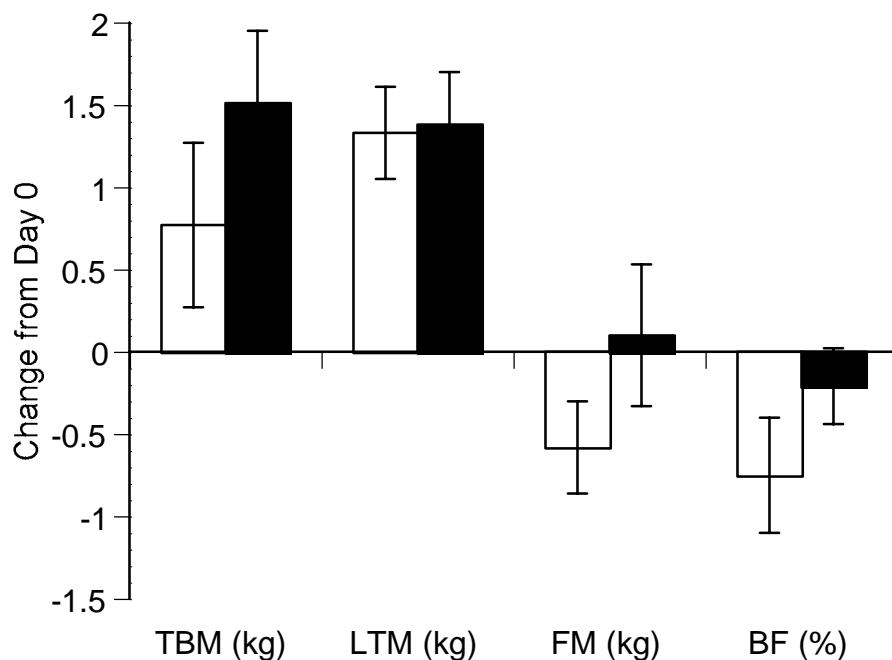


Figure 1. Changes in DEXA determined scanned total body mass (TBM), soft/lean tissue mass (LTM), fat mass (FM) and percent body fat (BF) observed for the placebo (open bars) and HMB (dark bars) supplemented groups. Data are means \pm standard deviations.

DISCUSSION

Previous studies indicate that HMB supplementation (1.5 or 3 g/d of HMB as the calcium salt) during 2 to 8-wks of training promoted significantly greater changes in FFM, fat loss, and/or strength while decreasing markers of catabolism in untrained men and women initiating a resistance-training program (12,18). With regards to athletes, HMB supplementation (3 g/d of HMB as the calcium salt) with a carbohydrate/protein meal replacement supplement during 7-wk of off-season college football resistance-training has been reported to promote greater gains in FFM during the first 3 to 4-wks of training in comparison to ingesting an isocaloric amount of orange juice (2). Additionally, HMB supplementation (3 g/d of HMB as the calcium salt) during endurance training has been reported to promote greater gains in lactate threshold in trained cyclists (10,13). Collectively, these studies suggest that HMB supplementation may enhance training-induced adaptations.

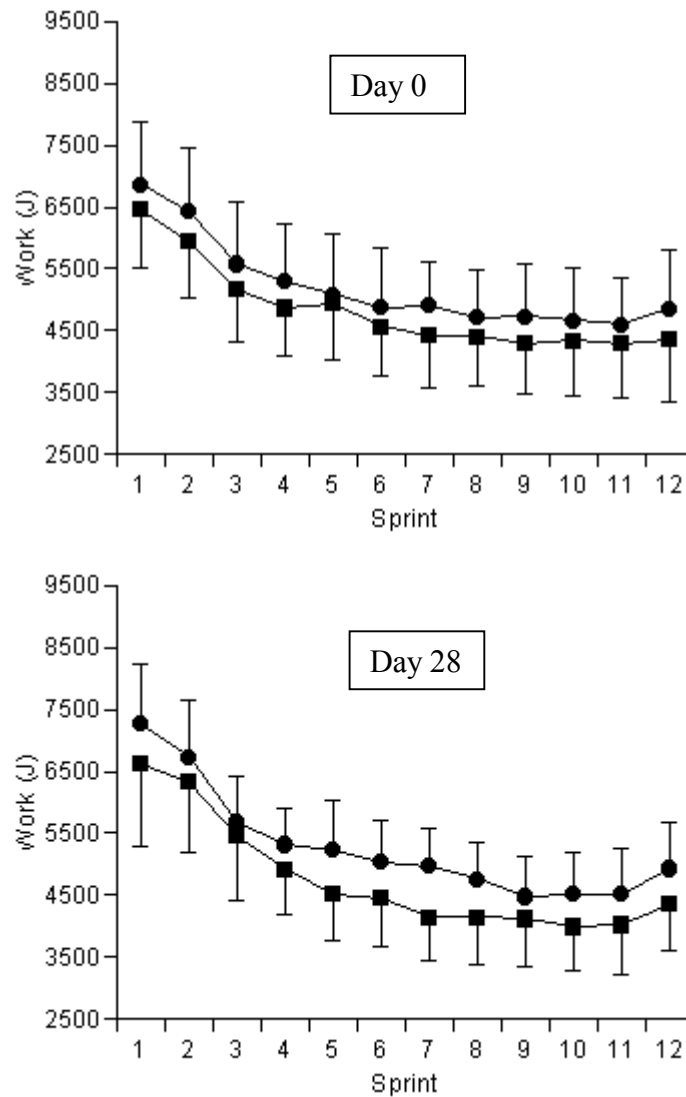


Figure 2. Pre- (■) and post-supplementation (●) work responses for performing the 12 x 6-s cycle ergometer sprints with 30-s rest recovery between sprints for days 0 and 28. Data are means \pm standard deviations.

Results of the present study, however, do not support these previous findings. In this regard, calcium HMB supplementation (3 g/d) during intense off-season resistance/agility football training did not significantly affect markers of whole-body anabolic/catabolic status, muscle enzyme efflux, body composition, or total combined isotonic lifting volume. Moreover, HMB supplementation had no effects on repetitive sprint performance simulating a 12-play drive in football. These findings indicate that HMB supplementation during intense training provides no ergogenic value to college football players during off-season training. These results support previous findings from our lab indicating that supplementing the diet with a vitamin and mineral fortified carbohydrate/protein powder containing 3 and 6 g/d of HMB for 28-d during resistance-training did not significantly affect markers of catabolism, body composition, or strength in male weight lifters (14).

There are several possible reasons for the discrepancy in results observed among studies. First, it is possible that 4-wks of HMB supplementation (3 g/d) does not affect crude markers of anabolic/catabolic status, muscle and liver enzyme efflux, body composition, strength, or sprint capacity in well-trained athletes undergoing intense resistance/agility training. Second, it is possible that HMB supplementation may be more effective in untrained subjects initiating training than in trained subjects (12). Third, although previous studies reported significant benefits of HMB supplementation within 3 to 4-wks of supplementation, it is possible that athletes involved in intense training may require a longer period of time in order to obtain an ergogenic effect from HMB supplementation. Finally, it is possible that differences in experimental design (e.g., types of subjects evaluated, dietary controls, type of training, etc.), methods employed (e.g., placebos used, supplement formulations investigated, methods of assessing body composition and strength), and/or statistical analysis procedures employed among studies may account for some of the differences observed.

CONCLUSIONS

The findings in this investigation do not support contentions that HMB supplementation (3 g/d) reduces markers of catabolism or promotes lean tissue accretion, fat loss, and/or gains in isotonic lifting volume in well-trained athletes undergoing resistance/agility training. These findings also indicate that HMB supplementation provides no ergogenic value to well-trained athletes involved in intermittent high intensity exercise. Whether longer periods of supplementation and/or higher doses of HMB are necessary to reduce whole body catabolism, promote lean tissue accretion, fat loss, and/or gains in strength during intense-training in well-trained athletes remains to be determined. Further, whether HMB supplementation provides greater benefit to untrained men and women initiating resistance training compared to well-trained athletes also remains to be determined. Additional research should evaluate the effects of HMB supplementation at varying doses on anabolic/catabolic status, body composition, and strength in untrained male and female subjects initiating training as well as in well-trained athletes involved in intense periods of training.

REFERENCES

1. Nair KS, Schwartz RG, Welle S. Leucine as a regulator of whole body and skeletal muscle protein metabolism in humans. *Am J Physiol* 1992;263: E928-934.
2. Nissen S, Sharp R, Ray M, Rathmacher JA, Rice D, Fuller JC Jr, et al. Effect of leucine metabolite beta-hydroxy-beta-methylbutyrate on muscle metabolism during resistance-exercise training. *J Appl Physiol* 1996;81:2095-2104.
3. Van Koeveering MT, Nissen S. Oxidation of leucine and α -ketoisocaproate to β -hydroxy- β -methylbutyrate in vivo. *Am J Physiol*. 1992;262: (Endocrinol. Metab. 25): E27.
4. Nissen S, Faidley TD, Zimmerman DR, Izard R, Fisher CT. Colostral milk fat and pig performance are enhanced by feeding the leucine metabolite β -hydroxy- β -methylbutyrate to sows. *J Anim Sci* 1994; 72: 2331-7.

5. Van Koevering MT, Dolezal HG, Gill DR, Owens FN, Strasia CA, Bucahnan DS, et al. Effects of β -hydroxy- β -methyl butyrate on performance and carcass quality of feedlot steers. **J Anim Sci** 1994;72:1927-1935.
6. Miller P, Sandberg L, Fuller JC. The effect of intensive training and β -hydroxy- β -methylbutyrate (HMB) on the physiological response to exercise in horses. **FASEB J** 1997; 11:A1683.
7. Peterson AL, Qureshi MA, Ferket PR, Fuller JC Jr. Enhancement of cellular and humoral immunity in young broilers by dietary supplementation of beta-hydroxy-beta-methylbutyrate. **Immunopharmacol Immunotoxicol.** 1999;21:307-30.
8. Peterson AL, Qureshi MA, Ferket PR, Fuller JC Jr. In vitro exposure with beta-hydroxy-beta-methylbutyrate enhances chicken macrophage growth and function. **Vet Immunol Immunopathol** 1999;4:67:67-78.
9. Nissen S, Panton L, Fuller J, Rice D, Ray M, Sharp R. Effect of feeding β -hydroxy- β -methylbutyrate (HMB) on body composition and strength of women. **FASEB J** 1997;11:A150. (Abstract)
10. Vukovich MD, Adams GD. Effect of β -hydroxy- β -methylbutyrate (HMB) on VO₂peak and maximal lactate in endurance trained cyclists. **Med Sci Sports Exerc** 1997;29:S252. (Abstract)
11. Panton L, Rathmacher J, Fuller J, Gammon J, Cannon L, Stettler S, et al. Effect of β -hydroxy- β -methylbutyrate and resistance training on strength and functional ability in the elderly. **Med Sci Sports Exerc** 1998;30:S194.
12. Gallagher PM, Carrithers JA, Godard MP, Schulze KE, Trappe SW. β -hydroxy- β -methylbutyrate: supplementation during resistance-training. **Med Sci Sports Exerc** 1999;31:S402.
13. Vukovich MD, Stubbs NB, Bohlken RM, Desch MF, Fuller JC, Rathmacher JA. The effect of dietary β -hydroxy- β -methylbutyrate (HMB) on strength gains and body composition changes in older adults. **FASEB J** 1997;11:A376. (Abstract)
14. Kreider RB, Ferreira M, Wilson M, Almada AL. Effects of calcium β -hydroxy- β -methylbutyrate (HMB) supplementation during resistance-training on markers of catabolism, body composition and strength. **Int J Sports Med** 1999;20:503-9.
15. Van Loan MD. Bioelectrical impedance analysis to determine fat-free mass, total body water and body fat. **Sports Med** 1990;10:205-217.
16. Klesges RC, Ward KD, Shelton ML, Applegate WB, Cantler ED, Palmeiri GMA et al. Changes in bone mineral content in male athletes: Mechanisms of action and intervention effects. **J Am Med Assoc** 1996;276:226-30.
17. Kreider R, Ferreira M, Wilson M, Almada A. Effects of creatine supplementation on body composition, strength and sprint performance. **Med Sci Sport Exerc** 1998;30: 73-82.
18. Fuller NJ, Jebb SA, Laskey MA, Coward WA, Elia M. Four-compartment model for assessment of body composition in humans: comparison with alternative methods and evaluation of the density and hydration of fat-free mass. **Clin Sci.** 1992; 82:687-693.
19. Horbes FF, Thomi F, Casez HP, Fonteielle J, Jaeger P. Impact of hydration status on body composition as measured by dual energy X-ray absorptiometry in normal volunteers and patients on haemodialysis. **Br J Radiol.** 1992;65:895-900.
20. Kellie EE. Measurement of bone density with dual-energy x-ray absorptiometry (DEXA). **J Am Med Assoc** 1992;267:286-294.
21. Mazess RB, Barden HS, Biseck JP, Hanson J. Dual-energy x-ray absorptiometry for total-body and regional bone-mineral and soft-tissue composition. **Am J Clin Nutr** 1990;51:1106-111.
22. Kreider, RB, Klesges R, Harmon K, Grindstaff P, Ramsey L, Bullen D et al. Effects of ingesting supplements designed to promote lean tissue accretion on body composition during resistance exercise. **Int J Sport Nutri** 1996;6:234-246.
23. Fleck SJ, Kraemer WJ. *Designing resistance training programs (2nd ed.)*. Champaign, IL: Human

Kinetics, 1997.

24. Kraemer, WJ. General adaptations to resistance and endurance training. In: Baechle T, editor. **Essentials of Strength Training and Conditioning**. Champaign, IL: Human Kinetics, 1994:127-150.

25. Wathen D. Load assignment. In: Baechle T, editor. *Essentials of Strength Training and Conditioning (2nd ed)*. Champaign, IL: Human Kinetics, 1994, 435-446.

ACKNOWLEDGMENTS

We would like to thank the subjects who participated in this study and the laboratory assistants in Exercise & Sport Nutrition Laboratory, the Universities Prevention Center, and in the Department of Athletics at The University of Memphis who assisted in data acquisition and analysis. This study was funded in part through a research grant provided to The University of Memphis from Experimental and Applied Sciences, Golden, CO (EAS). Investigators from The University of Memphis collected, analyzed and interpreted data from this study and have no financial interest in the outcome of results reported. Presentation of results in this study does not constitute endorsement by The University of Memphis of the nutrients investigated.

Current address for M. Ferreira, MS, RD is School of Dietetics and Human Nutrition, McGill University - MacDonald Campus, 21,111 Lakeshore Road, Ste. Anne de Bellevue, Quebec. Current address for M. Greenwood, PhD, CSCS * D is Department of Health, Physical Education, and Sport Sciences, Arkansas State University, P.O. Box 240, State University, AR 72467. Current address for S. Plisk, MS, CSCS, is Department of Athletics and Physical Education, Yale University, P.O. Box 208216, New Haven, CT. 06520-8216. Current address for J. Reinardy, MS, CSCS is Department of Athletics, 1800 S. Fourth, Jabcobson Building, Iowa State University, Ames, IO 50011. Current address for A.L. Almada, MSC is MetaResponse Sciences, Inc., 9053 Soquel Dr., Suite 202, Aptos, CA 90053.

Address for correspondence:

Richard B. Kreider, PhD, Exercise & Sport Nutrition Laboratory, Department of Human Movement Sciences & Education, The University of Memphis, FH 106C, Memphis, TN 38152.
