Body Composition in 70-Year-Old Adults Responds to Dietary β-Hydroxy-β-Methylbutyrate Similarly to That of Young Adults[1]

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ABSTRACT Studies in young adults have demonstrated that β-hydroxy-β-methylbutyrate (HMB) can increase gains in strength and fat-free mass during a progressive resistance-training program. The purpose of this study was to determine whether HMB would similarly benefit 70-y-old adults undergoing a 5 d/wk exercise program. Thirty-one men (n = 15) and women (n = 16) (70 ± 1 y) were randomly assigned in a double-blind study to receive either capsules containing a placebo or Ca-HMB (3 g/d) for the 8-wk study. Skin fold estimations of body composition as well as computerized tomography (CT) and dual X-ray absorptiometry (DXA) scans were measured before the study and immediately after the 8-wk training program. HMB supplementation tended to increase fat-free mass gain (HMB, 0.8 ± 0.4 kg; placebo, −0.2 ± 0.3 kg; treatment × time, P = 0.08). Furthermore, HMB supplementation increased the percentage of body fat loss (skin fold: HMB, −0.66 ± 0.23%; placebo, −0.03 ± 0.21%; P = 0.05) compared with the placebo group. CT scans also indicated a greater decrease in the percentage of body fat with HMB supplementation (P < 0.05). In conclusion, changes in body composition can be accomplished in 70-y-old adults participating in a strength training program, as previously demonstrated in young adults, when HMB is supplemented daily. J. Nutr. 131: 2049–2052, 2001.

KEY WORDS: • older adults • humans • exercise training • body composition • β-hydroxy-β-methylbutyrate (HMB)

An age-associated loss of muscle mass, especially in later years, leads to a loss in strength and functionality and ultimately affects the quality of life. Reasons for this loss may include poor nutrition, lack of exercise or use, a reduction in motor units activated, and/or the loss of contractile or mechanical properties (1). To date, no clear mechanism has been identified whereby muscle is lost during aging.

The factor that seems to be most effective in maintaining body muscle is engaging in regular resistance exercise training. Resistance training in older adults is a viable means of maintaining body muscle mass. It has been shown to result in gains in strength (40–200%) and increases in fat-free mass (4.8–11%) (2–4). However, only a fraction of the elderly population is actively involved in progressive resistance training. The process is slow, time consuming and may ultimately cause a greater amount of muscle damage and exercise-induced proteolysis (5). Clearly, a strategy must be found that would increase the effectiveness of exercise.

One strategy to increase the effectiveness of exercise in the elderly is to attempt to attenuate the exercise-related increase in muscle protein turnover with nutrition. This should result in greater gains per unit of exercise and could lessen the training time and/or intensity. The leucine metabolite β-hydroxy-β-methylbutyrate (HMB)[3] would seem a likely candidate in that it has been shown to decrease muscle proteolysis and muscle damage and increase fat-free mass gain in young adults undergoing resistance training (6–8).

The purpose of the current study was to determine whether dietary HMB supplementation in 70-y-old adults participating in a modest 5 d/wk exercise program would result in greater gains in fat-free mass and strength as well as greater losses in fat mass compared with an age- and fitness-matched group consuming a placebo.

SUBJECTS AND METHODS

Subjects. Thirty-two individuals (16 men and 16 women, mean age 70 ± 1 y) volunteered for this study and signed an informed consent in accordance with the Human Subjects Committee of Wichita State University. Subjects participating in the study had no contraindications to exercise, were taking no medications and had their physicians' approval to participate. Potential subjects were excluded from participating if they had uncontrolled hypertension, a history of cardiovascular disease, diabetes or kidney problems. Before the initiation of the study, subjects had no experience with resistance training.

Study design. Subjects were randomly assigned to one of two groups. Group A received 3 g/d of the leucine metabolite β-hydroxy-β-methylbutyrate (HMB), Group B received 3 g/d of a placebo (rice flour). Both treatments were administered in a double-blind fashion. Capsules were identical in size and appearance. Each HMB capsule contained 250 mg of Ca $(HMB)_2 \cdot H_2O$ and 50 mg of potassium phosphate (monobasic, KH_2PO_4). Subjects were supplied with 10 d worth of supplement at a time. Bottles were labeled with the subjects' name and identification number. When subjects reported for the next bottle or testing, they were asked about compliance. All reported compliance. Subjects consumed 4 capsules, 3 times per day for a total of 12 capsules/d. Diets were not controlled.

Strength testing. The subjects reported to the gym for instruction on use of the exercise equipment. Four training sessions were used to familiarize the subjects with the equipment and proper lifting techniques. Testing procedures were standardized on the basis of specific seat adjustments and body positions according to manufacturer's instructions. Upper and lower body strength was assessed

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[3] Abbreviations used: CT, computerized tomography; DXA, dual X-ray absorptiometry; HMB, β-hydroxy-β-methylbutyrate; 1-RM, one-repetition maximum.

before, at wk 4 and after the 8 wk of training with a one-repetition maximum (1-RM) test. The 1-RM test was defined as the maximal resistance that could be moved through the full range of motion for one repetition. Subjects were allowed five warm-up repetitions before testing and were allowed ~60 s of rest between trials. They completed the same number of trials (average ~3–4) before and after training to reach the 1-RM. Strength measurements were completed on the overhead press, bench press, latissimus pull down, elbow extension and flexion, double leg flexion, double leg extension and leg press.

Exercise program. The exercise program consisted of the above eight lifts using Badger Fitness Equipment (variable resistance machines; Magnum Fitness Systems, South Milwaukee, WI). Each subject trained two nonconsecutive days per week for 8 wk. Subjects completed two sets of 10–12 repetitions. Intensity began at 70% of the 1-RM. Every 2 wk, another 1-RM test was performed and the individual's resistance was changed accordingly. On the other 3 d per week, the subjects reported to an indoor track (6 laps/mile; 3.7 laps/km) for a combination walking and stretching program. Each walking session consisted of 10 min of warm-up and stretching, 40 min of self-paced walking, and 10 min of cool-down and stretching. Four exercise specialists supervised the training sessions. Subjects were required to make up any missed training sessions and subjects complied with the instructions.

Blood collection/analysis. Blood samples were collected from a superficial vein into Vacutainer blood tubes (Vacutainer Systems, Rutherford, NJ) after an overnight fast before supplementation and after 8 wk of training/supplementation. Blood samples were processed and analyzed for plasma HMB levels to ensure compliance.

Skin fold. Skin fold thickness measurements were obtained before and after 4 and 8 wk of training. Skin fold measurements were taken from the subscapular, triceps, biceps, midaxillary, pectoral (men only), suprailiac, umbilical and front thigh. The percentage of body fat was estimated by using the equations of Jackson and Pollock (9).

Computerized tomography (CT scan). CT scans of the right thigh and upper arm were made before the study began and immediately after the 8 wk. The CT measurements were made in a subset of subjects ($n = 20$). The CT scan was performed at these sites, which corresponded to the skin fold measurements (9). To ensure reproducibility, a great deal of care was placed on consistently landmarking and measuring the position of the CT scans. The measurement for the upper arm was made at a point halfway between the acromion and olecranon processes, with the elbow extended and relaxed. The measurement on the thigh was made at a point midway between the greater trochanter and the lateral condyle of the femur. The volunteers (placebo, $n = 11$; HMB, $n = 9$) were examined in the supine position. A pillow was placed underneath the shoulder, hips and calf to prevent the muscles from compressing. The scanner was a Picker PQ 2000 (Marconi Medical Systems, Cleveland, OH) operating at 130 kV peak; slices were 8 mm wide, with a scan time of 2 s, at 150 mA with a field size of 30. Images were scanned using a Hewlett-Packard 4P scanner (Palo Alto, CA). The surface area (pixels) of the fat and muscle regions were measured on the basis of image density using Sigma Scan Pro (SPSS, Chicago, IL).

Dual X-ray absorptiometry (DXA). A total body scan was performed using DXA (model DPX-L, LUNAR Radiation, Madison, WI) and analyzed using the LUNAR Radiation body composition program. Fat mass, lean mass and bone mineral content were determined for the total body and for arm, leg and trunk regions. Statistically, 68% of repeat scans fall within 1 SD. DXA measurements were made before the initiation of the study and immediately after the 8 wk. The measurements were made in a subset of subjects ($n = 23$: placebo, $n = 12$; HMB, $n = 11$).

Statistical design. Absolute and relative changes in strength and body composition were calculated and analyzed by SAS General Linear Model (GLM) procedures (SAS Institute, Cary, NC). The effect of gender and the gender × treatment interaction were not significant and data were pooled; the differences between the two treatment (placebo vs. HMB) effects are presented. The 4- and 8-wk treatment changes in strength and body composition were analyzed by one-way ANOVA. In addition, the effect of treatment by time on body composition measured at 0, 4 and 8 wk was analyzed as a repeated-measures ANOVA. All data are reported as means ± SEM. Significant difference was set at $P < 0.05$; a tendency to differ was set at $P < 0.10$.

RESULTS

One subject dropped out of the study after signing the informed consent, but before pretesting began. Thirty-one men ($n = 15$) and women ($n = 16$) (70 ± 1 y) finished the study without any injury or medical complications. Subjects consuming HMB reported no adverse reactions or medical complications. Plasma HMB levels for the placebo group were 1.69 μmol/L during the 8-wk supplementation period, whereas plasma HMB levels for the HMB group during supplementation were 67.73 μmol/L ($P < 0.05$). The elevated plasma HMB levels for the HMB group suggest compliance with the protocol.

Body composition. During the 8-wk training period, subjects' weight was unaltered by training and supplementation (**Table 1**). However, skin fold analysis showed changes in the percentage of body fat and an alteration in fat-free mass by the combination of resistance training and supplementation. A re-

TABLE 1

Body composition of older men and women consuming 3 g/d β-hydroxy-β-methylbutyrate (HMB) or 3 g/d placebo before and after an 8-wk exercise training program[1]

	Placebo ($n = 17$)			HMB ($n = 14$)		
	Basal	Week 8	Change	Basal	Week 8	Change
Body weight, *kg*	77.9 ± 3.5	77.5 ± 3.5	−0.4 ± 0.3	74.6 ± 3.9	74.5 ± 3.9	−0.1 ± 0.4
Skinfold analysis						
Body fat, %	29.3 ± 1.2	29.5 ± 1.1	0.2 ± 0.4	25.9 ± 1.3	24.8 ± 1.2	−1.1 ± 0.5*
Fat-free mass, *kg*	54.7 ± 2.0	54.5 ± 2.0	−0.2 ± 0.4	55.2 ± 2.2	56.0 ± 2.2	0.8 ± 0.4†
DXA[2] scan						
Body fat, %	34.0 ± 1.4	34.4 ± 1.3	0.4 ± 0.4	33.1 ± 1.4	32.9 ± 1.4	−0.3 ± 0.4
Fat-free mass, *kg*	48.8 ± 1.6	48.9 ± 1.6	0.1 ± 0.4	50.8 ± 1.7	51.1 ± 1.6	0.3 ± 0.4
CT[2] scan (total)						
Fat area, *pixel* $\times 10^3$	49.9 ± 4.3	53.5 ± 4.3	3.7 ± 2.9	56.0 ± 4.8	42.7 ± 4.8	−13.3 ± 3.2*
Muscle area, *pixel* $\times 10^3$	53.0 ± 3.9	54.8 ± 3.9	1.7 ± 1.1	53.8 ± 4.3	55.5 ± 4.3	1.7 ± 1.2

[1] Values are means ± SEM.
* Significantly different change for the HMB-supplemented group compared with the placebo group; $P < 0.05$.
† Trend for a greater increase in fat-free mass for the HMB-supplemented group compared with the placebo group; $P = 0.08$.
[2] DXA, dual x-ray absorptiometry; CT, computerized tomography.

peated-measures ANOVA (time) from 0 to 8 wk indicated that HMB supplementation tended to increase fat-free mass gain ($P = 0.08$; Table 1, **Fig. 1**). Furthermore, HMB supplementation significantly decreased the percentage of body fat compared with the placebo group (**Fig. 2**A). DXA scans on a subset of subjects showed a similar net difference in the percentage of body fat ($P = 0.32$; Fig. 2A) and increase in fat-free mass.

Areas of the upper arm measured by CT were not significantly different between the two groups at pretesting. There was no change in the area of fat [−1495.8 ± 944.5 pixels (−13.3 ± 7.7%)] and muscle [−66.0 ± 402.3 pixels (0.2 ± 2.8%)] of the arm for the placebo group. However, the treatment did significantly reduce the area of fat in the arm for the HMB group [−1650.1 ± 609.5 pixels (−14.8 ± 4.1%)]. There was no change or difference in the area of muscle in the arm for the HMB group [561.1 ± 545.9 pixels (4.4 ± 3.9%)].

The area of muscle in the thigh increased to the same extent in both groups during the 8 wk of training [HMB, 2020.7 ± 1052.9 pixels (4.6 ± 2.2%); placebo, 1767.9 ± 793.0 pixels (4.4 ± 2.1%)]. However, there was a significant reduction in the area of fat for the HMB group [−9172.1 ± 2461.2 pixels (−22.3 ± 4.3%)], whereas the placebo group significantly increased the area of fat for the thigh [5169.9 ± 2090.7 (15.5 ± 5.5%)]. Furthermore, CT scan analysis showed that the HMB supplementation significantly decreased the percentage of fat (pixel area of fat/pixel areas of fat and muscle) for total arm and thigh as well as the thigh alone compared with placebo supplementation (Fig. 2B).

Strength. Upper-body strength was assessed using five different exercises and summing the one repetition maximum (1RM) for each lift to obtain total upper body strength [nonsignificant ($P = 0.99$) 8-wk % change; HMB, 14.9 ± 2.0%; placebo, 14.9 ± 2.9%]. The relative increase in strength in the latissimus pull down after 4 wk of treatment was significantly greater in the HMB group (11.5 ± 3.5%) compared with the placebo group (1.5 ± 3.2%). Lower body strength was assessed using three different exercises and summing the 1RM for each lift to obtain total lower body strength [nonsignificant ($P = 0.45$) 8-wk % change; HMB, 21.8 ± 3.6%; placebo, 18.1 ± 3.4%]. There was a significant difference in the absolute and relative increase in strength between the two groups in the leg curl after wk 4 and 8. For the other exercises, there were no significant differences in strength between the two groups or over time. However, the relative increase in total lower body strength after 4 wk of treatment approached significance ($P = 0.08$), 7.4 and 12.8% for placebo and HMB groups, respectively.

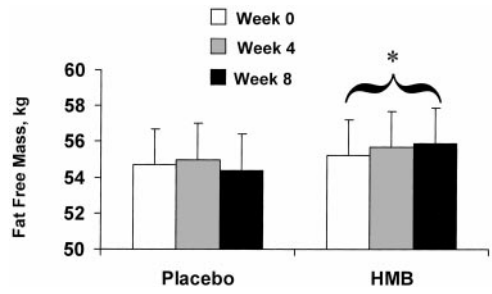

FIGURE 1 Fat-free mass at 0, 4 and 8 wk of a exercise training program in older adults consuming 3 g/d of β-hydroxy-β-methylbutyrate (HMB) or 3 g/d of a placebo as measured by skin fold thickness. Values are means ± SEM, $n = 17$ (placebo) or 14 (HMB), repeated measures ANOVA, treatment × time. *HMB vs. placebo, $P = 0.08$.

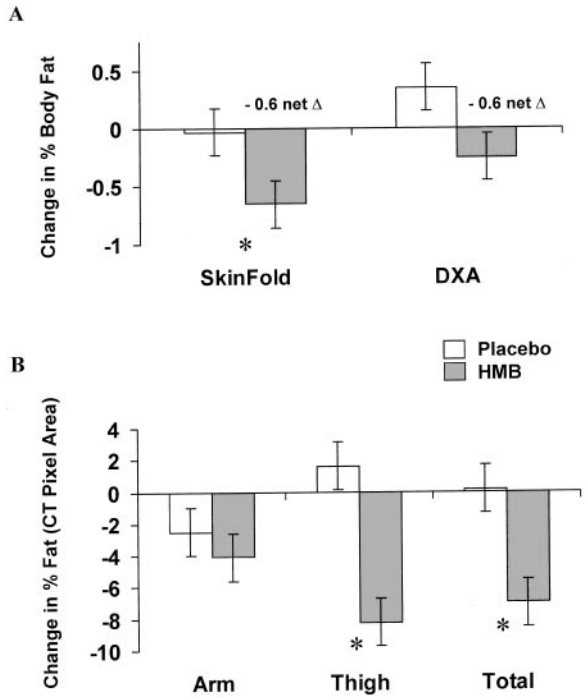

FIGURE 2 Changes in the percentage of body fat after an 8-wk exercise training program in older adults consuming 3 g/d of β-hydroxy-β-methylbutyrate (HMB) or 3 g/d of a placebo. (*A*) Changes in the percentage of body fat as measured by skin fold thickness (placebo, $n = 17$; HMB, $n = 14$) and dual X-ray absorptiometry (DXA) (placebo, $n = 12$; HMB, $n = 11$). (*B*) Changes in the percentage of fat (regional), as measured by computerized tomography (CT) scans (placebo, $n = 11$; HMB, $n = 9$) (CT scan: percentage of fat = pixel area of fat/pixel areas of fat and muscle). Values are means ± SEM; *HMB different from placebo, $P < 0.05$

DISCUSSION

The primary aim of this study was to determine whether HMB could enhance the effect of exercise on body composition. All three measures of body composition performed (skinfold, DXA scan and CT scan) suggest that HMB supplementation decreased the percentage of body fat while increasing fat-free mass. The decrease in the percentage of body fat may be due to both the increase in fat-free mass and/or a decrease in fat mass. However, the data from this study suggest that along with the increase in fat-free mass, there was a decrease in fat mass. We hypothesized that the decrease in fat mass could be a result of a greater energy demand by the fat-free mass gain, which was not met by the diet, resulting in a mobilization of fat stores. However, the exact mechanism for this decrease in fat mass is not known. In contrast to these findings associated with HMB supplementation, resistance training alone (placebo) did not result in an increase in fat-free mass, which is in contrast to others that have reported a 2–3% increase in fat-free mass gains with resistance training (2–4). This lack of a training effect may be due to the relatively short duration of the current study (8 wk) compared with other studies (12–16 wk).

The percentage of increase in fat-free mass seen in this study is consistent with the increase due to HMB supplementation in previous studies of young adults (**Fig. 3**). Data from six studies have been (6–8,10) or will be published concerning HMB supplementation in humans. For the HMB-supplemented group, these studies show a greater increase in the percentage of fat-free mass gained from resistance training

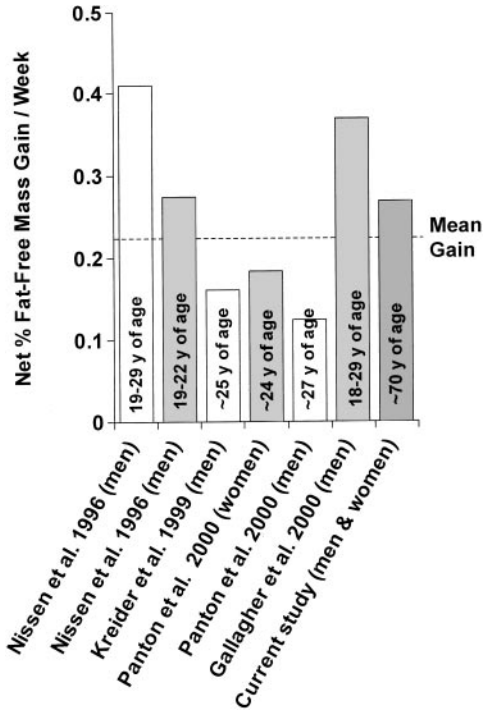

FIGURE 3 Comparison of the net percentage of fat-free mass gain per week with β-hydroxy-β-methylbutyrate (HMB) supplementation observed in this study to that observed in other similar studies. (References in order: 6, 6, 10, 7, 7, 8 and this study.) It should be noted that there are differences in the experimental design of each of these studies. These data suggest that older adults respond similarly to young adults to HMB supplementation. A dashed line represents the mean gain.

compared with the placebo-supplemented subjects. However, HMB supplementation alone, without resistance training, does not affect body composition (11). The findings from the current study suggest that 70-y-old adults respond to HMB supplementation with an increase in fat-free mass from resistance training that is similar to that reported in young adults.

The gain in upper and lower body strength, as measured by the 1RM, was ~11 and 13% for the upper body and 7 and 13% for the lower body for the placebo and HMB groups, respectively. The increase in strength is lower than that reported by others (up to a 40% increase) (2–4,12–14). Again, the study duration was relatively short, and the inconsistencies could be attributed to differences in training intensity (current study, 2 resistance training sessions per week; other studies, 3 resistance training sessions per week) and testing procedures. For example, a 1RM was used as an indicator of strength in the current study, whereas the majority of the other studies used a 3RM as a measure of strength (2,4,13–15).

The safety of HMB was also measured in this study, but the results are reported elsewhere (16). As is the case in young adults, HMB does not appear to have any adverse effects in 70-y-old adults.

Although the definitive mechanism of HMB has not been proven, previously reported decreases in protein breakdown [decreased 3-methylhistidine and creatine phosphokinase activity (6,8)], decreases in in vitro proteolysis in rats and chicks (17), and decreases in muscle calpain and cathespin proteolytic activities in rats (18) all suggest that HMB acts by decreasing muscle proteolysis. The decrease in muscle proteolysis combined with the stimulus of resistance training could then result in greater rates of net muscle protein deposition.

In conclusion, HMB supplementation alters body composition during an 8-wk exercise program in 70-y-old adults in a manner similar to its effect in young adults. This suggests that the underlying mechanism causing the stimulation of fat-free mass gain by HMB is essentially independent of age.

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