



Official Research Journal of
the American Society of
Exercise Physiologists

ISSN 1097-9751

JEPonline

Effects of 12-Weeks of Supplementation with β -Hydroxy- β -Methylbutyrate-Ca (HMB-Ca) on Athletic Performance

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ABSTRACT

Ferreira HF, Gill P, Fernandes Filho J, Fernandes, LC. Effects of 12-Weeks of Supplementation with β -Hydroxy- β -Methylbutyrate-Ca (HMB-Ca) on athletic performance. **JEPonline** 2015;18(2):85-94. It has recently been suggested that β -hydroxy- β -methylbutyrate-Ca (HMB-Ca) increases fat-free mass (FFM) and strength gains during resistance training in adults. This prospective, randomized, double-blind, placebo-controlled study assessed the effects of HMB-Ca ($37.5 \text{ mg}\cdot\text{day}^{-1}$) on body composition, athletic performance, and inflammatory mediators in 20 elite canoeists (age, 18.7 ± 1.49 yrs; body weight, 78.9 ± 3.3 kg). The athletes were supplemented and followed for a period of 12 wks during strength training. The results indicated that a dose of HMB-Ca could potentiate an increase in lean body mass (peak strength of $76.70 \pm .92$ to 80.95 ± 2.17 N, pre-test and post-test, respectively) commensurate with strength gains associated with endurance training in competitive athletes. The mechanism by which this occurs is still unknown, but the results indicate that supplementation might decrease the damage to skeletal muscle when stressed before training with a significant difference in serum creatinine ($P < 0.05$).

Key Words: Paddlers. HMB, Ergogenic Supplements, Canoeist

INTRODUCTION

β -Hydroxy- β -methylbutyrate (HMB) is a metabolic derivative of the amino acid leucine. Under normal conditions, ~5% of leucine consumed is converted in the body to HMB. It can be found in nature, but it is difficult and impractical to get on a regular basis, for example, 3 g·day⁻¹ (17). Therefore, supplementation may be beneficial for strength training practitioners or those under extreme muscular stress who want to improved athletic performance (31).

Calcium β -hydroxy- β -methylbutyrate (or HMB-Ca) is a nutritional supplement, which represents a calcium salt of HMB is related to decreased protein degradation in humans, suggesting that leucine can serve as a regulator of the protein metabolism (19-21). According to Nissen et al. (20,21) evidence has shown that untrained men and women beginning systematic resistance training have greater strength gains when using doses of 1.5 to 3 g·day⁻¹ of HMB-Ca for 3 to 4 wks. These gains were associated with significant loss of urine excretion of 3-methylhistidine, suggesting that individuals supplemented with HMB-Ca decreased catabolism during training (21).

Vukovich et al. (35) reported that 8 wks of supplementation with HMB-Ca (3 g·day⁻¹) significantly increased lean body mass and promoted 1 RM strength increases in a group of elderly men and women beginning a training program. In agreement, Panton et al. (24) observed that HMB-Ca supplementation during 8 wks of endurance training increased functional capacity in a group of elderly individuals. Similarly, Gallagher et al. (14) analyzed the effects of HMB-Ca supplementation (3 and 6 g·day⁻¹) for 8 wks of resistance training on a group of untrained men and noticed that there was a significant decrease in the excretion of creatine kinase with an increase in lean body mass in the 3 g·day⁻¹ group. Overall, these preliminary results suggest that supplementation with 1.5 to 3 g·day⁻¹ of HMB-Ca can increase fat-free mass (FFM) and strength in untrained individuals in a resistance-training program (21,25,34).

In 2014, Ferreira et al. (11) reported a significant increase in lean body mass and strength gain associated with resistance training in elite kayakers when supplemented with 3 g·day⁻¹ HMB-Ca. In 1997, 17 yrs earlier, Vukovich et al. (35) reported that 2 wks of HMB-Ca supplementation (3 g·day⁻¹) significantly increased time to exhaustion, lactate threshold and VO₂ peak in trained cyclists (35). It was suggested then, which appears to be true today, that HMB-Ca supplementation provides an ergogenic value during intense exercise (27,37). Yet, the mechanism for such increases remains unclear.

Although HMB-Ca supplementation appears to improve adaptations at the beginning of training in untrained subjects, additional investigations are needed regarding HMB-Ca supplementation in athletes as well as the long-term effects. The purpose of this study was to determine whether HMB-Ca supplementation of 37.5 mg·day⁻¹ during intense endurance training affects the markers of catabolism and athletic performance in the elite canoeing athletes over a 12-wk period.

METHODS

Subjects

The subjects consisted of 20 elite canoeing athletes who volunteered to participate in this study. The athletes were analyzed during strength training. All subjects were informed of the objectives and procedures prior to signing a consent form, which was approved by the ethics committee of the Faculty of Medical Sciences of Santa Casa of Sao Paulo, number 518.993 on 29th January 2014. The descriptive characteristics of the subjects were (mean \pm SD): (a) age, 18.7 \pm 1.49 yrs; (b) body weight 78.9 \pm 3.3 kg; and (c) height 178.2 \pm 8.0 cm.

Procedures

All subjects maintained their usual training programs during the study, which was prospective, randomized, double-blind, and placebo-controlled. The subjects were divided randomly and equally into two groups. The w/HMB group consisted of 10 athletes who received HMB-Ca supplementation at a dose of $37.5 \text{ mg}\cdot\text{day}^{-1}$ per body weight. The PLB group consisted of 10 athletes who were supplemented with $37.5 \text{ mg}\cdot\text{day}^{-1}$ per body weight of corn starch. Prior to the start of the study the subjects received an explanation and were familiarized with the study procedures. In order to maintain absolute secrecy (double blind), the Botica Ouro Preto Laboratory (Brazil) that performed the sorting and weighing of doses, created a coded key groups, where no rated or reviewer had access. This encryption key was only revealed to the researchers after the end of treatment.

Supplements were prepared in powder form by the Metabolic Technologies, Inc. laboratory (Iowa - USA). They were prepared according to the body weight for each subject, encapsulated and stored in vials at the Botica Ouro Preto laboratory (Brazil) for double-blind administration. The subjects ingested the daily dose, divided into three parts, with meals (morning, afternoon, and evening). Each vial contained sufficient supplements for 15 days. The daily intake of the supplements was controlled by the technical team, who changed the new full vials and received empty ones every 15 days.

Throughout the study, the athletes participated in all training sessions with individual workloads. The training sessions consisted of an average of $6 \text{ hrs}\cdot\text{wk}^{-1}$ of resistance training (e.g., 1 to 3 sets of 2 to 8 repetitions at intensities ranging from 80 to 95% of 1 RM) that was performed on Monday, Wednesday, and Friday as well as $10 \text{ hrs}\cdot\text{wk}^{-1}$ of sprint-specific training and technical assistance with the boat, averaging two daily sessions for a total of 11 training sessions per week. During the study period, the evaluators performed monthly tests that included venous blood samples and a specific maximum sprint test in the boat (tied stroke).

To determine the variables of the force-time curve, a calibrated extensometer (Kratos, Brazil CZC model 500 with a resolution of 1 N and maximum load of 200 N) was attached to the back of the boat by a steel cable as shown in Figure 1. A single kayak (K1) was used. It was built from carbon fiber of the Nelo® brand. The time was recorded using a Nielsen Kellerman® stopwatch, model Interval® 2000 with a precision of 0.001 sec.

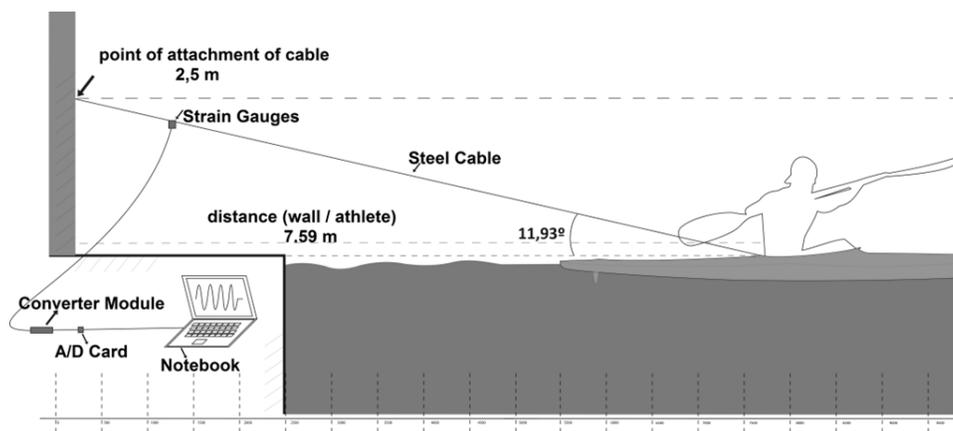


Figure 1. Schematic Representation of the Experimental Arrangement.

All athletes performed a standardized monthly test, which consisted of a warm-up of 10 min paddling at low intensity (~60% FC), after which, the subjects were asked to perform two maximal sprints of 30 sec with an rest interval of 5 min.

The data provided by the extensometer were amplified and transmitted using an analog/digital converter (A/D) (National Instruments, NI6218) with a sampling rate of 1 kHz and, then, analyzed using specific software (Lab View Signal Express 3.0, National Instruments). The data were filtered using a Butterworth 2nd order filter and a cutoff frequency of 20 Hz and processed using the Matlab 7.9 (MATLAB, The Matchworks) program. The variables of the force-time curve were determined by the results of the force components and based on these the following were calculated: the medium force (MF), peak force (PF), rate of force development (RFD), impulse (IMP), and fatigue index (FI).

Figure 2 is a schematic representation of the propellant variables. The MF was established by averaging the power units. The PF was considered to be the greatest value of the propulsive force of a stroke. The RFD was determined by the linear coefficient between 20% and 80% of the peak force. The IMP was defined by the force and time units. The FI was determined from the ratio between the slopes of the peak strength.

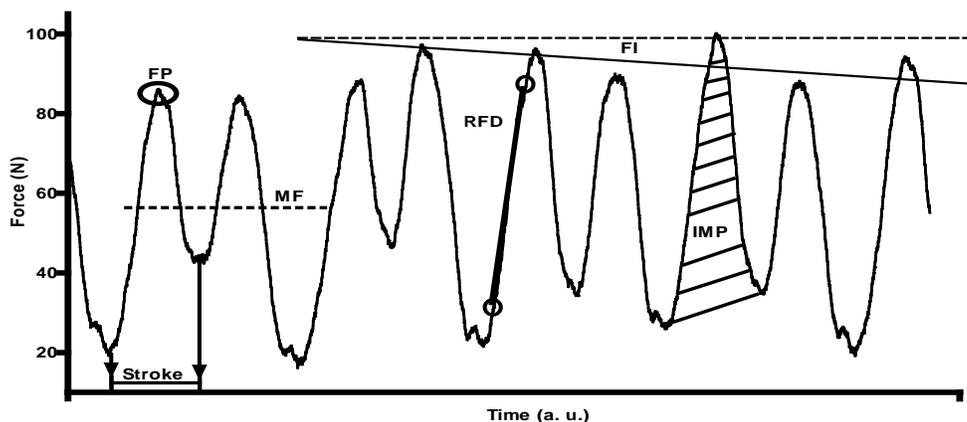


Figure 2. Schematic Representation of the Variables in the Propulsive Force-Time Curve during the Canoe Paddling. FM (Average Force); PF (Peak Force); RFD (Rate of Force Development); FI (fatigue Index) and IMP (Impulse).

Samples of venous blood were obtained after the second sprint by venipuncture of the antecubital vein in the forearm using standard procedures (10,16,29,30). Venous blood was collected in vacuum tubes of 10 mL for serum separation. The samples were centrifuged at $5,000 \text{ rev}\cdot\text{min}^{-1}$ for 10 min using a refrigerated bench top centrifuge Excelsa®, Model 280R. Biochemical parameters were analyzed using kits from Vital Scientific® (Ellitech Group, Spankeren, Netherlands) in a semi-automatic model, Micro Lab 300 brand Vital Scientific® (Ellitech Group, Spankeren, Netherlands) biochemical analyzer.

Statistical Analyses

Data normality was confirmed using the Wilcoxon test and the comparison of means using the Student's *t*-test for paired samples (parametric data) in the statistical package SPSS 13.0 (SPSS Inc., Chicago, IL). The delta variations, together with the magnitude (pre and post), were calculated with the selected variables and analyzed using ANOVA. The results are expressed as mean \pm SD. The findings were considered significantly different when the probability of error was $P \leq 0.05$.

RESULTS

Table 1 presents the results of each biochemical parameters of pre- and post-measurements in the HMB-Ca supplemented group (w/HMB) and the placebo group (PLB), where only the serum creatinine concentration presented a significant difference between pre- and post-training both in the supplemented and placebo groups.

Table 1. Values of Biochemical Parameters Pre- and Post-Supplementation with β -Hydroxy- β -Methylbutyrate (c/HMB, n = 10) and a Placebo (PLB, n = 10) Over the 12-Wk Period.

	c/HMB		PLB	
	Pre	Post	Pre	Post
Body weight (kg)	78.50 \pm 3.04	76.30 \pm 2.82	79.38 \pm 3.56	78.70 \pm 3.46
Serum Creatinine (mg·dL⁻¹)	.84 \pm .15	1.00 \pm .08 *	.94 \pm .15	1.02 \pm .06 *
CK total serum (U·L⁻¹)	299.95 \pm 27.47	188.25 \pm 24.32	263.20 \pm 52.28	268.5 \pm 31.00
CK MM serum (U·L⁻¹)	192.76 \pm 26.95	126.36 \pm 28.81	124.28 \pm 33.98	174.52 \pm 20.15
CK MB serum (U·L⁻¹)	122.25 \pm 28.51	65.88 \pm 15.51	66.92 \pm 18.29	93.97 \pm 10.85
Lactate Dehydrogenase (U·L⁻¹)	367.25 \pm 30.25	290.40 \pm 26.34	336.60 \pm 53.30	332.90 \pm 50.85
Peak Force (N)	76.70 \pm .92	80.95 \pm 2.17 *	75.85 \pm .92	76.30 \pm 1.75
Average Force (N)	59.57 \pm 7.46	76.76 \pm .91	55.73 \pm .24	69.36 \pm 8.40
Rate of Force Dev (N·m⁻¹)	.61 \pm .18	1.42 \pm .23	.79 \pm .15	1.30 \pm .47
Impulse (N·m⁻¹)	21.18 \pm 3.23	32.05 \pm 5.20	22.52 \pm .91	25.31 \pm 5.23
Fatigue Index (%)	1.92 \pm .91	1.4 \pm .88	1.89 \pm .82	1.65 \pm .75

Mean \pm SD, * $P \leq 0.05$

DISCUSSION

Coaches and athletes believe that an increase in lean body mass is very important for many sports (9). Canoeing, in particular, requires a large accumulation of energy reserves. The amount of lean body mass is critical (21) in dealing with the need to increase the intensity of muscular contraction strength and speed, especially the increase in recruitment of Type II muscle fibers (11,12). Thus, there is a consequent mobilization of creatine phosphate for the regeneration of adenosine triphosphate (ATP), resulting in an elevation of serum creatinine (7,15,22). This confirms the findings of the present study where both groups (w/HMB-Ca and PLB) presented an increase, which was higher in the supplemented group.

High intensity resistance training requires excessive force that can cause an overload in the contractile system of muscles with the potential for sarcomeric damage (8,10,16,29,30). The

damage results in an increase in neutrophil infiltration and, consequently, the release of cellular proteins into the circulation (e.g., creatine kinase, CK). Thus, the increase in plasma activity of LDH and CK appears to be a typical physiological response that can be used as markers of muscle injury (13). There was a reduction of LDH in both groups (w/HMB and PLB), but the reduction was more pronounced in the w/HMB group (-20.92%). This finding corroborated the findings by Wilson (36) in which 16 trained men were supplemented with HMB-Ca ($3 \text{ g}\cdot\text{day}^{-1}$) and in the research of Nissen and Rice (21,28).

Although total creatine kinase (CK) levels depend on age, gender, race, lean muscle mass, physical activity, and other factors, the activity of CK enzymes is considered an important marker of muscle damage. Hence, it is important to acknowledge that CK levels in isolation must be viewed in relative terms (29). In addition, the variation in activity differs in accordance to the volume and intensity of training (34). The PLB group presented an increase and the w/HMB group presented a decrease, neither was significant, thus supporting the findings found by Nissen (20).

Muscle damage during exercise is characterized by a decrease in muscle force production, increased inflammation, breakdown of muscle fibers, and increased activity of proteolytic enzymes. The CK elevation may be related to an adaptive microtrauma, which, in highly trained athletes, accelerates the turnover of muscle fibers. If the workload is repeated over time, the muscle damage is reduced and the athlete develops a skeletal muscle adaptation that is characterized by a reduction in the release of CK. This may explain the drop in the levels of total CK from the fourth month of training in this study with a faster recovery of muscle function (23). Lowery et al. (20) observed a reduction in CK levels in both groups supplemented with HMB/ATP and a placebo after 12 wks of training.

The results of the CK-MM activity demonstrated an increase in the PLB group. This release into the bloodstream is more specific to muscle overload when compared with total CK (6,8,16,30). The w/HMB group presented a progressive decline over the months, again suggesting a protective effect of HMB-Ca supplementation against the catabolism imposed by endurance exercise training (34). Several hypotheses have been presented to explain the adaptive microtrauma. Among them, there is the assumption of the occurrence of a metabolic overload in which the need for ATP would become higher than its rate of production. Another assumption is that muscle damage can be caused by mechanical forces (such as those present in the eccentric contraction) capable of breaking the muscle architecture. Another proposes the elevation of mediators of inflammation and oxidative stress (6,8,16,30). CK-MB concentrations exhibited the same behavior as CK-MM for both groups. The increase in serum CK-MB can occur due to atypical CK, for example, macro-CK, which is a complex consisting of CK-BB bound to immunoglobulin's (IgA, IgG), whose presence can cause an apparent increase in the activity of CK-MB.

In canoeing, the main index is the race time where the difference between the competitors in an international championship final is about 1 sec (5,18). Regarding biomechanical analysis, for the average value found for PF, there is a reference to the literature comparing a single stroke of elite Olympic paddling kayakers (26). When appraising the distribution of the units in the force-time curve there was a significant difference between the groups (w/HMB and PLB). The values found in the literature for a single cycle of stroke are lower than those found in this study which could be linked to the evolution of sports equipment in recent years, which has aided performance in the transfer of force with the application of the technique (1,2).

Regarding rate of force developed (RFD), there were no significant differences. Unfortunately, there are no reports in the literature on the analysis of RFD in paddlers of any sporting level. This

makes it difficult to compare the data found in the present study. The impulse (IMP) values found in the literature are superior to those found in the international literature (1,3). This may be due to the evolution of the technique over the last few years. The cycle of stroke technique has become more aggressive with a downward action of the blade at the input stage and shorter length (propulsive phase), thus generating a higher RFD in the first phase and a decrease in IMP during the stroke cycle. It was observed that the values of IMP in a single stroke were higher than those found in the literature (32), this may be related to the type of boat used, as in their study Sperlich (1994) used a double kayak boat (K2), which explains the higher values of IMP due to the use of the stroke for both paddlers at the same time.

Performance in competitions in maximum cyclic sports such as canoeing depends on the ability of the body to regenerate ATP consumption in muscle contraction and in sufficient quantities to perform the external work (3,4,33). In this sense, we noted that the fatigue index (FI) decreased throughout the study, with an average loss of -27.10 and -12.70% in performance (w/HMB and PLB groups, respectively). Although there are no literature reference values for this variable, it is desirable that an athlete reaches the lowest values possible.

Considering the data collected and the average time of an official K1 200 m race (~35 sec) there would be an average decrease of 1.60 sec due to fatigue (FI), bearing in mind that at high levels, 1 sec can represent numerous placements. Monitoring this variable has an important role in planning training, since lower values in this index are related to lower performance losses. The use of only one test is a limitation of this study, restricting the results to only one boat and one official distance. While it cannot be stated that the improvements found in the present study were due to HMB-Ca supplementation, the biochemical parameters and the variables of the force-time curve presented point to this fact (given that an improvement of approximately 1.6 sec in an Olympic boat is very important when considering an international scenario).

CONCLUSIONS

The results of this study indicate that supplementation with HMB-Ca at a dose of $37.5 \text{ mg} \cdot \text{day}^{-1}$ per body weight may potentiate an increase in lean body mass commensurate with strength gains when associated with resistance training in trained, high performance athletes. The mechanism by which this occurs is still unknown, but the results indicate that there might be a decrease in skeletal muscle damage. There was greater improvement in the athletic performance response in the supplemented group. While research to date is encouraging, there is a clear need for more tightly controlled and long-term studies to verify whether HMB-Ca supplementation can be effective in improving the strength and development of muscular hypertrophy associated with resistance training and using the same supplementation in free acid (HMB-FA) form and in different dosages.

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