Effects of $\beta$-hydroxy-$\beta$-methylbutyrate and creatine monohydrate supplementation on the aerobic and anaerobic capacity of highly trained athletes

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Aim. The aim of this study was to investigate the effects of 6 wks oral supplementation of $\beta$-hydroxy-$\beta$-methylbutyrate (HMB) and a mixture of HMB and creatine monohydrate (HMBCr) on aerobic and anaerobic capacity in highly trained athletes. It was hypothesised that HMB and HMBCr would have positive effects on aerobic and anaerobic power.

Methods. A prospective study involving a repeated measures design was utilised where subjects underwent testing prior to, and immediately after, a 6 wks supplementation period. Elite, male rugby league players (n=27) were divided into 3 groups, a control group (n=6), a HMB group (3 g/d; n=10) and a HMBCr group (3 g/d HMB + 3 g/d Cr; n=11). Testing involved a multistage fitness test to determine aerobic power and a 60 sec maximal cycle test to determine anaerobic capacity. Peak power, total work and peak lactate levels were measured in the anaerobic cycle test.

Results. Two-way repeated measures ANOVA revealed no effect of HMB or HMBCr on any of the measured parameters in comparison to the control group.

Conclusion. Aerobic and anaerobic ability of highly trained male athletes is unaffected by 6 wks oral supplementation with HMB or a combination of HMB and creatine monohydrate.

Key words: Dietary supplements - Creatine - Exercise - Football.

$\beta$-hydroxy-$\beta$-methylbutyrate (HMB) is a metabolic derivative of the amino acid, leucine, that has been proposed to function as an anticitabolic agent and decrease exercise-induced muscle damage.1 Due to this hypothesis, the majority of research on HMB has centred on strength and body composition with a small number of research studies showing ergogenic benefits1-3 and others reporting no effect of HMB.4-7 There have also been a small number of studies investigating the effects of HMB ingestion on aerobic and anaerobic power.8-11

$\text{VO}_{\text{peak}}$ has been reported to be significantly increased in endurance trained cyclists with 2 wks HMB supplementation in comparison to 2 wks leucine or placebo consumption.8 Maximal lactate levels were unaffected by supplementation but tended to be higher following HMB intake (p<0.06).8 In contrast, HMB supplementation during a 12 wks intensive training regime in horses did not significantly improve the distance covered in a 34 min endurance test compared to a control group.9 The findings of the animal study were confirmed in human subjects who consumed HMB (3 g/d) over a 6 wks period and showed no improvement in aerobic power or performance in a 20 km time trial compared to a placebo group.10 However, the consumption of HMB did significantly lower creatine phosphokinase and lactate dehydrogenase in comparison to the placebo following the prolonged run. Although aerobic performance was not enhanced, the authors suggested that decreased levels of these enzymes reflected less muscle damage after consuming HMB.10 Anaerobic capacity follow-
ing HMB supplementation has received very little research attention. One study showed a trend (p=0.06) for improved repeated cycle sprint capacity following ingestion of HMB and HMB combined with creatine monohydrate (Cr) compared to a placebo group in college footballers undergoing both resistance and sprint/agility training. The scant and conflicting evidence regarding HMB supplementation and aerobic and anaerobic performance creates a need for further investigation in this area.

HMB is frequently marketed in conjunction with Cr. Oral supplementation with Cr has been shown to improve performance in short burst activities such as weight lifting and short duration maximal cycling. The ergogenic effect of Cr on short burst activities is a result of an increase in creatine phosphate stores in the muscle which is utilised as an initial fuel during any physical activity. Thus, Cr is of little benefit to the endurance athlete. It was of interest in the current study to determine if Cr combined with HMB would provide further ergogenic benefit to short burst activities compared to HMB supplementation alone.

Rugby League players were recruited for the current study because of the need for athletes that were trained in both endurance and short burst activities. Blood lactate levels of 5-17 mmol/L have been recorded during professional Rugby League games reflecting the anaerobic demands of the sport. It is also important for Rugby League players to have good aerobic fitness as players have been recorded to cover distances of 6.0-8.3 km during a single game and the game duration is 80 min. Thus, the aim of this study was to determine whether aerobic power, blood lactate levels and anaerobic work production could be improved in Rugby League players following supplementation with either HMB or HMBCr. Both aerobic and anaerobic power were hypothesised to increase following HMB and HMBCr supplementation.

**Materials and methods**

**Subjects**

The subjects in this study were 27 professional, male players from an Australian National Rugby League team. The average age and body weight of the subjects was 24.9±0.7 years (range 18.0-32.0 years) and 94.8±1.6 kg (range 74.0-116.8 kg), respectively. All subjects had been playing rugby league, competitive at a national or state level, for at least 2 years prior to the study. The procedures were clearly explained to the subjects before they provided their written informed consent to participate. Ethics approval for the project was granted from the James Cook University Ethics committee.

**Procedure**

Due to ethical and religious reasons, some of the athletes declined to be included in a supplement group and were therefore allocated to the control group (n=6). For this reason, it was not possible to employ a double blind protocol. The remaining subjects were allocated to one of two supplement groups and were unaware of whether they were taking HMB (3 g/d; n=10) or HMBCr (Beta Edge; 3 g/d HMB, 3 g/d Cr; 6 g/d carbohydrates; n=11). The participants were asked to dissolve the HMB or HMBCr powder in 400 mL of 50% diluted sports drink (4% carbohydrate including 3% sucrose and 1% maltodextrin) and consume it in the morning. Control subjects consumed only the diluted sports drink.

The subjects were tested prior to, and immediately after, a 6 wks supplementation period. During the supplementation period, all subjects were involved in team training sessions which minimised differences in training intensity, duration, volume and frequency. The training program involved resistance, aerobic and anaerobic training with 4 skills and/or conditioning sessions, 3 total body, weight training sessions and 1 speed/power session per week. The pre- and post-supplementation testing sessions were performed during preseason training. These testing sessions involved determination of body mass using scales accurate to 50 g (UC-300 Precision Health Scales, A & D Co., Adelaide, Australia) and the multistage aerobic capacity test on day 1, a rest day on day 2 and the 60 sec maximal anaerobic capacity test on day 3.

**Multistage aerobic capacity test**

The multistage aerobic capacity test was used to determine aerobic power. Subjects lined up on a line and ran 20 m shuttles in accordance with an audible ‘beep’ from an audiotape (Australian Sports Commission, Canberra, Australia). Each subject was required to have one foot on or over the line when the ‘beep’ sounded. The time interval between the ‘beeps’ decreased as the test progressed. If the subjects arrived at the line prior to the ‘beep’ they were required to...
wait for the 'beep' before commencing the next shuttle. A subject was considered to have reached exhaustion if they failed to reach the 20 m mark on 2 consecutive 'beeps.' VO_{2max} was predicted from the final stage reached by the subject. The correlation coefficient for test-retest reliability for the multi-stage fitness test has been reported to be 0.95 for adults and validity is also high with a 0.90 correlation with the VO_{2max} attained during a multistage treadmill test.

Sixty second maximal anaerobic capacity test with blood lactate

The subjects performed a warm up on a cycle ergometer at a slow to moderate pace for 3-5 min prior to completing this test. They then cycled maximally for 60 sec without rest during which time they received verbal encouragement to ensure maximal performance. Peak power and total work were measured upon completion of the test using a Repco Supermonitor (Repco Cycle Co., Australia). Upon completion of the test, the subjects performed an active warm-down for 5 min. After completion of the warm down, a 5 min post-test, finger prick blood sample was taken to measure blood lactate using an Acusport tester (Boehringer Mannheim, Sydney, Australia).

Statistical analyses

The SPSS for Windows version 9.0 software package was used for all data analysis. Data were analysed using a 2-way ANOVA (group x time) with repeated measures. There were 3 levels for the group factor (HMB, HMBCr and control) and 2 levels for time (pre- and postsupplementation). The α level was set at p<0.05. All data are presented as mean ± standard error (SE).

Results

Body mass, aerobic power (predicted VO_{2max}), peak anaerobic power, total anaerobic work and blood lactate levels did not differ significantly between the 3 groups prior to supplementation (p>0.05).

HMB and HMBCr had no significant effect on aerobic power compared to presupplementation levels. There was also no significant difference between the HMB or HMBCr groups and the control group in aerobic power at postsupplementation testing (p>0.05).

Discussion and conclusions

The results of this study showed that HMB and HMBCr did not alter the aerobic or anaerobic power of professional Rugby League players after 6 w supplementation in comparison with a control group. These results contrast with those of Vukovich and Adams and Almada et al. but agree with the findings of Miller et al. and Knitter et al. Vukovich and Adams reported an increase in VO_{2peak} after 2 w supplementation with HMB. However, there

Table I. — Mean (±SE) aerobic power and anaerobic peak power, total work and blood lactate for the control, HMBCr and HMB supplemented groups at pre- and postsupplementation.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Control Pre</th>
<th>Control Post</th>
<th>HMBCr Pre</th>
<th>HMBCr Post</th>
<th>HMB Pre</th>
<th>HMB Post</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic power (mlkg^{-1}min^{-1})</td>
<td>52.6 (0.7)</td>
<td>52.0 (0.5)</td>
<td>54.2 (0.6)</td>
<td>55.1 (0.6)</td>
<td>52.1 (0.8)</td>
<td>54.4 (0.6)</td>
</tr>
<tr>
<td>60 sec anaerobic test</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Peak power (Joules/kg)</td>
<td>12.72 (0.52)</td>
<td>13.25 (0.64)</td>
<td>12.59 (0.41)</td>
<td>12.53 (0.42)</td>
<td>11.64 (0.47)</td>
<td>12.32 (0.59)</td>
</tr>
<tr>
<td>Total work (Joules/kg)</td>
<td>19.71 (0.58)</td>
<td>16.70 (0.68)</td>
<td>16.47 (0.83)</td>
<td>13.30 (0.67)</td>
<td>11.01 (1.70)</td>
<td>13.44 (0.38)</td>
</tr>
<tr>
<td>Lactate (mmol.L^{-1})</td>
<td>13.72 (0.58)</td>
<td>13.72 (0.68)</td>
<td>13.72 (0.83)</td>
<td>12.97 (0.67)</td>
<td>13.30 (1.70)</td>
<td>13.44 (0.38)</td>
</tr>
</tbody>
</table>

Table I shows the pre- and postsupplementation values for aerobic power for each group.

Supplementation with HMB or HMBCr did not alter the blood lactate levels after a 60 sec maximal cycling effort compared with the presupplementation values (Table I). There was also no significant difference in blood lactate levels between the HMB or HMBCr groups and the control group at postsupplementation (p>0.05).

Total work produced during the 60 sec maximal effort increased significantly (p=0.017) from the presupplementation testing session to the postsupplementation testing session for all groups indicating a training effect. However, HMB or HMBCr did not display an ergogenic effect in elevating anaerobic capacity beyond that of the control group (p>0.05; Table I). Peak power also improved for all 3 groups following the training period (p=0.037) but there was no group interaction evident (p>0.05; Table I).

There were no adverse reactions or side effects recorded in response to the 6 w supplementation with either HMB or HMBCr.
are differences in the methodology and subject characteristics between the current study and that of Vukovich and Adams. The current study employed the multistage fitness test to estimate VO2max. Although the validity and reliability of this test are high, it does rely on the subjects interpreting their own point of maximal exhaustion. However, this may also have been the case in the Vukovich and Adams study as VO2peak and not VO2max was reported. The use of VO2peak infers that subjects may not necessarily have reached their true maximal potential. The subjects in the Vukovich and Adams study were endurance trained cyclists whereas the current study used highly trained Rugby League players. It may be that subjects trained only for endurance activities respond differently to HMB than subjects trained in both endurance and resistance activities when examining aerobic performance.

The type of subjects utilised is unlikely to be the cause of the different responses to HMB between the current study and that of the Almada et al. study. The latter study employed college footballers who were both resistance and sprint/agility trained. Repeated sprint ability tended to improve after HMB supplementation in this group of subjects whereas in the current study there was no improvement in anaerobic peak power, total work or blood lactate responses after HMB supplementation. The Almada et al. study also investigated HMBCr and found similar improvements in repeated sprint ability as observed with HMB supplementation. Cr supplementation has been shown to increase muscle Cr stores and improve performance in repeated bouts of short burst efforts. Therefore, performance in 12x6 sec sprints with 30 sec rest periods would be expected to improve after Cr supplementation as shown by the Almada et al. study. The current study employed a 60 sec maximal cycle test to assess the effects of HMB and HMBCr on anaerobic performance. The single, 60 sec effort may have been too long, particularly when compared to 12x6 sec sprints, to benefit from Cr supplementation. However, given that HMB has been hypothesised to be an anticitabobolic agent, it was reasonable to believe that HMB should have enhanced performance on the 60 sec test.

The current study is in agreement with the findings of Miller et al. who found no benefit of HMB supplementation on the endurance capacity of horses and also with the findings of Knitter et al. who reported no benefit of HMB on aerobic power or 20 km run times in human subjects. Although these 2 studies did not find a performance benefit from HMB, they did report a smaller increase in blood creatine kinase (CK) levels after HMB supplementation compared to a placebo. Both groups concluded that smaller increases in postexercise CK levels reflected less muscle damage. Other authors have also suggested that HMB reduces muscle damage after resistance exercise with decreased 3-methylhistidine and CK levels in subjects undergoing resistance training and supplementation with HMB. These findings of reduced markers of muscle damage following HMB supplementation support the hypothesis that HMB functions as an anticitabobolic agent. The exact mechanism by which HMB exerts these anticitabobolic effects is unknown. However, Nissen et al. have suggested that HMB may provide an anticitabobolic effect by two possible mechanisms. The first mechanism involves conversion of HMB to β-hydroxy-β-methylglutarate-Co-A which can provide carbon for cholesterol synthesis and thus, support cell membrane integrity. The second hypothesised mechanism is that HMB is polymerised and forms a structural component of the cell membrane. In the case of muscle cells, these effects may reduce exercise-induced muscle damage and lead to quicker recovery from exercise. Thus, supplementation with HMB may lead to decreased muscle degradation and better performance. However, the anticitabobolic effects of HMB on muscle structure needs to be substantiated as blood CK levels are not necessarily good indicators of muscle damage. Muscle ultrastructural studies, in either humans or animals, would provide clearer evidence of the possible anticitabobolic effects of HMB. If current or future research can elucidate the mechanism underlying the HMB response it may well reveal how HMB can decrease exercise-induced muscle damage and thus, clarify the potential of HMB as an ergogenic agent.

The current study did not show an ergogenic effect of Cr supplementation on aerobic power which is consistent with previous studies that have shown little effect of Cr supplementation on endurance performance. However, despite a lack of ergogenic effect of Cr, Bellinger et al. reported a significant decrease in blood ammonia and xanthines after an endurance time trial with Cr loading. The authors suggested that this was reflective of a more efficient maintenance of the ATP:ADP ratio due to a reduced degradation of
The results of this study are limited to highly trained male athletes with experience in resistance, sprint and endurance training. It is necessary to establish these findings in other populations including female athletes with varying training backgrounds. It would also be of interest to establish the findings of the current study by utilising a VO2peak test rather than the multi-stage fitness test and to examine shorter duration sprint performance, particularly with HMBCr.

In conclusion, HMB and HMBCr were found to have no ergogenic effect on aerobic power or anaerobic capacity after 6 wks supplementation in professional Rugby League players undergoing a resistance and endurance program. These findings suggest that HMB may be of little benefit to subjects who are already highly trained. However, until the mechanism of action of HMB is clearly established, it is difficult to surmise how HMB benefits some individuals during sprint and endurance testing and why, in the current study, Rugby League footballers were not affected by this supplement.

References