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Effect of Creatine Supplementation on Jumping Performance in Elite Volleyball Players

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Jump height is a critical aspect of volleyball players' blocking and attacking performance. Although previous studies demonstrated that creatine monohydrate supplementation (CrMS) improves jumping performance, none have yet evaluated its effect among volleyball players with proficient jumping skills. We examined the effect of 4 wk of CrMS on 1 RM spike jump (SJ) and repeated block jump (BJ) performance among 12 elite males of the Sherbrooke University volleyball team. Using a parallel, randomized, double-blind protocol, participants were supplemented with a placebo or creatine solution for 28 d, at a dose of 20 g/d in days 1–4, 10 g/d on days 5–6, and 5 g/d on days 7–28. Pre- and postsupplementation, subjects performed the 1 RM SJ test, followed by the repeated BJ test (10 series of 10 BJs; 3 s interval between jumps; 2 min recovery between series). Due to injuries (*N* = 2) and outlier data (*N* = 2), results are reported for eight subjects. Following supplementation, both groups improved SJ and repeated BJ performance. The change in performance during the 1 RM SJ test and over the first two repeated BJ series was unclear between groups. For series 3–6 and 7–10, respectively, CrMS further improved repeated BJ performance by 2.8% (likely beneficial change) and 1.9% (possibly beneficial change), compared with the placebo. Percent repeated BJ decline in performance across the 10 series did not differ between groups pre- and postsupplementation. In conclusion, CrMS likely improved repeated BJ height capability without influencing the magnitude of muscular fatigue in these elite, university-level volleyball players.

Keywords: creatine monohydrate, sports supplements, jumping capacity, power, elite athletes

Creatine is widely used by athletes and with success for increasing strength, power and anaerobic capacity.[1] Vertical jump height is a critical aspect of the

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volleyball players blocking and attacking performance.[2] Creatine monohydrate supplementation (CrMS) has been demonstrated to improve jumping performance.[1] However, it has never been previously investigated whether and to what extent CrMS affects jumping performance among highly trained, elite volleyball players, especially in athletes being part of the same team and during the competitive season. In such athletes with proficient jumping skills, the effect of CrMS may be subtle because of a potential ceiling effect, and in the end prove not to provide any meaningful effect. Determining the magnitude of the effect of CrMS on the jumping performance of elite volleyball players is important, as it could provide very useful information for coaches and athletes with potential implications for performance enhancement. The purpose of this study was therefore to examine the effect of 4 wk of CrMS on 1 RM spike jump (SJ) and repeated block jump (BJ) performance among male players of a university-level volleyball team.

Methods

Participants

All 12 subjects of the Sherbrooke University male volleyball team agreed to participate in this study. The mean age, bodyweight, and height of subjects was 22 ± 1.5 y, 84 ± 8 kg, and 190 ± 7 cm, respectively. Before the start of the study, their mean BJ (no step approach) and SJ (3-step approach) height was 58 ± 6 cm and 79 ± 8 cm, respectively. These jumping height results are consistent and in line with those which have been observed in elite national and international male volleyball players.[3] The study was approved by the local Institutional Review Board.

Experimental Design

A parallel, randomized, double-blind, and placebo-controlled protocol was used. Participants were supplemented with a creatine monohydrate powder (Eclipse sport supplements, PA, USA) or a placebo for 28 d. For the first 4 d, subjects ingested four portions of creatine or placebo per day at 3 h intervals; for the next 2 d, two portions per day at 3 h intervals; and for the remaining 22 d, 1 portion per day taken after the hardest training session. Each portion contained 20 g of dextrose, 10 g of sucrose, 300 mL of water, and artificial flavor with (creatine group) or without (placebo group) 5 g of creatine. Both solutions had the same color, texture, and taste. Subjects kept their normal nutritional pattern throughout the study and performed the same training routine each day. Training conditions were controlled for the last 24 h before each testing session. Participants were thoroughly familiarized with both jumping tests. Before and after supplementation, subjects (1) arrived at the laboratory and were weighed; (2) performed a self-selected specific warm-up of 10 min; and (3) underwent the 1 RM SJ test followed by the repeated BJ test. Reach height was measured in all participants before testing as specified in Stanganelli et al.[2] The SJ was measured from a running lead (three-step approach) with subjects jumping off both feet and reaching as high as possible with one arm to touch a 0.5-cm-graduated, 4.5-m high panel. The highest point attained by the tip of the middle finger was taken as the reached height. Each subject performed five attempts interspersed by a 1-min interval. Only the result of the best jump was kept. The BJ started from a standing position with subjects keeping their feet stationary and shoulder width apart. Then, with their hands at shoulder level, subjects rapidly adopted a self-selected squat position immediately followed by an explosive leg and arm extension to reach maximal height and touch the graduated panel. Participants underwent 10 series of 10 repetitions, with a 3 s interval between jumps and a recovery interval between series of 2 min. The average of the maximal height reached by the right and left middle finger was taken as the height score. No markers were placed on the body and all jumps were recorded with a digital high-speed camera for slow motion analysis. The difference between the jumping and reach height was taken as the jump scores. The same individuals analyzed and interpreted all video recordings. Over the course of the study, subjects performed two resistance training sessions per week in addition of completing two plyometric drill sessions aimed at improving jumping height capacity.

Statistics

Two-way repeated-measures ANOVA and independent *t* tests were used to analyze results. Magnitude-based inference statistics[4,5] were utilized to qualify the importance of the change in jumping performance between groups. The threshold for a minimal, worthwhile practical effect of CrMS on jumping performance was set at 0.9%, based on a mean coefficient of variation (CV) for the SJ and BJ of 3%,[2] and a smallest worthwhile enhancement in jumping performance taken as $0.3 \times$ CV of the SJ and BJ.[6] Results of series 1–2, 3–6, and 7–10 for the repeated BJ test were grouped together in an effort to better discriminate and isolate the effect of both the placebo and CrMS upon jumping performance. The percent performance decrement (fatigue index) in repeated BJ height over time during the 10 series was computed for each group before and after supplementation with the following formula: $100 \times$ [sum of all 10 series mean jump heights/(highest 1 series mean jump height $\times$ 10)] – 100. Statistics were performed with SPSS, version 17. Results in text are reported as mean ± SD, with 95% confidence intervals (CI). Those in figures are reported as mean ± SD. Significance was set at $P \leq .05$.

Results

Two participants abandoned the study as a result of injuries and results of two others were discarded as they were ± 3 SD outside the sample mean values.[7] Thus, results are reported for eight subjects (CrMS, $N = 4$; placebo, $N = 4$). Following supplementation, bodyweight increased by 0.5 ± 1.6 kg with CrMS, but decreased by 0.9 ± 1.1 kg with the placebo. The pre- to postsupplementation change in bodyweight between groups was not significant (1.4 ± 1.0 kg, $P = .21$, 95% CI: –1.0 to 3.8 kg).

As shown in Figure 1, both groups increased 1 RM SJ performance following supplementation (CrMS: +4.1 ± 2.2%; placebo: +4.6 ± 4%). The degree of absolute increase in 1 RM SJ height was, however, greater with the placebo, compared with CrMS (+0.13 ± 1.38 mm, $P = .93$, 95% CI: –3.51 to 3.26 mm, unclear change).

Figure 2 shows the pre- to postsupplementation percent change in repeated BJ performance with CrMS and the placebo for series 1–2, 3–6, and 7–10. There was a significant time ($P = .03$), with no treatment or interaction effect. Following

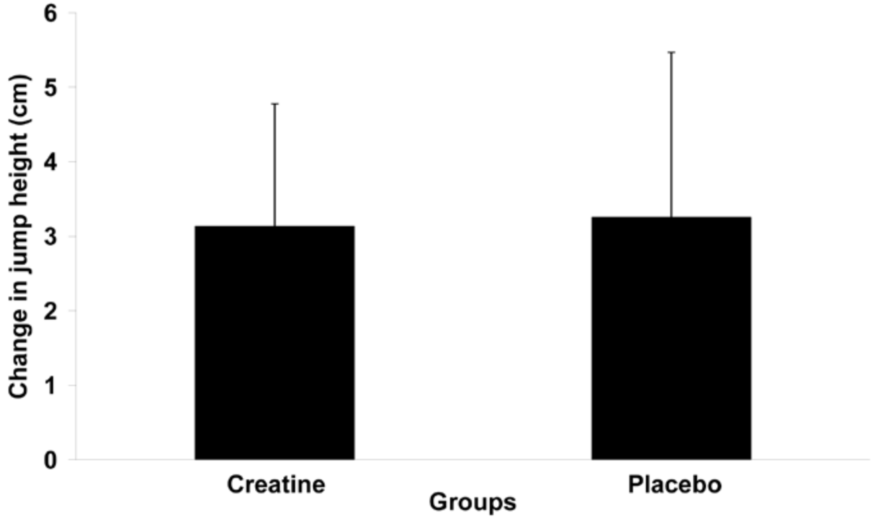

Figure 1 — Effect of creatine monohydrate (CrMS) and placebo on the mean absolute change in 1 RM spike jump (SJ) performance from pre- to postsupplementation. Results are mean ± SD.

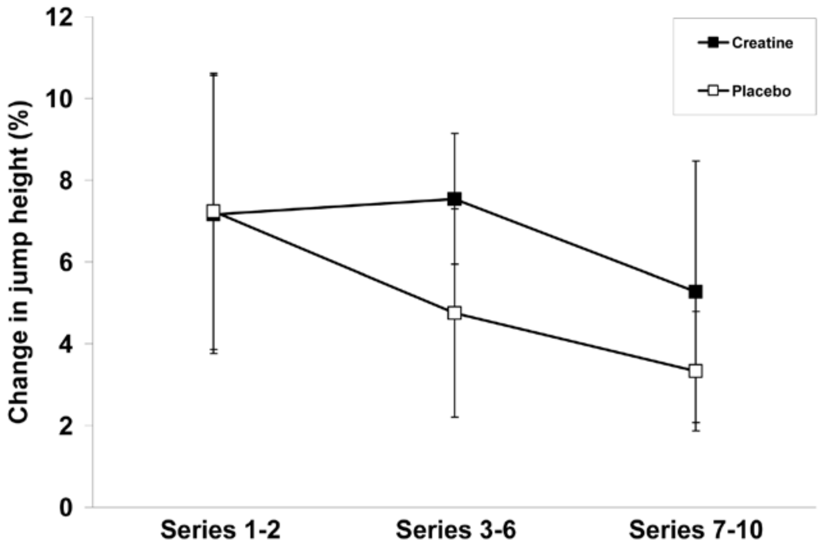

Figure 2 — Effect of creatine monohydrate (CrMS) and placebo on the mean percent change in repeated block jump (BJ) performance from pre- to postsupplementation for series 1–2, 3–6, and 7–10. Results are mean ± SD.

supplementation, both groups increased repeated BJ height by an average of 6.6 ± 2.0% (CrMS) and 4.7 ± 2.3% (placebo) over the 10 series. During the first two BJ series, the improvement in jumping height was lower with CrMS, compared with the placebo (–0.09 ± 2.39%, P = .97, 95% CI: –6.0 to 5.8%, unclear change). However, for series 3 to 6 and 7 to 10, CrMS further improved jumping capacity by respectively 2.8 ± 1.5% (P = .12, 95% CI: –0.9 to 6.5%, likely beneficial change) and 1.9 ± 1.8% (P = .33, 95% CI: –2.9 to 6.8%, possibly beneficial change), compared with the placebo. When results of all 10 series are combined together and contrasted between groups, on average CrMS further increased BJ performance by 1.9 ± 1.5% (P = .27, 95% CI: –1.9 to 5.6%, possibly beneficial change), compared with the placebo.

Figure 3a and b shows the mean absolute repeated BJ height reached during each of the 10 series with CrMS and the placebo before and after supplementation. A statistically significant time (P = .04), with no group or interaction effect was observed for the pre- to postsupplementation change in absolute jump height between groups. Following supplementation, both groups improved their absolute repeated BJ capacity, with CrMS increasing it on average by 3.8 ± 1.3 cm and the placebo by 2.5 ± 0.9 cm over the 10 series. On average, over the 10 series, CrMS further improved absolute repeated BJ capacity by 1.2 ± 0.8 cm, compared with the placebo (P = .16, 95% CI: –0.6 to 3.1 cm, likely beneficial change).

Figure 4 shows the mean percent performance decrement (fatigue index) in repeated BJ height over the 10 series for each group before and after supplementation. No statistically significant treatment, time, or interaction effect was observed. Repeated BJ performance decrement was more important following supplementation than before supplementation for both the placebo and CrMS group. However, the decline in performance was slightly less important with the placebo than with CrMS following supplementation (–0.08 ± 1.11%, P = .94, 95% CI: –2.80 to 2.64).

Discussion

The goal of this study was to compare the effect of 28 d of CrMS to that of a placebo on 1 RM SJ and repeated BJ capacity among highly trained, university-level, elite volleyball players being part of the same team. The study was conducted in the midst of the competitive season and subjects followed the exact same training routine throughout the study period. To the best of our knowledge, this was the first ever study examining the influence of CrMS on jumping ability among volleyball players. Moreover, this was the first study looking at CrMS's effect on repeated BJ height sustainability over 100 repetitions. Given that SJ and BJ capacity is a crucial element in volleyball being responsible for 80% of the points obtained in international games,[2] that it is an important discriminator between higher and lower performers[3] and that during intense exercise of short duration the ATP-phosphocreatine (PCr) system is the predominant energy source supplier,[8] we found it particularly relevant to examine how leaping capacity could be influenced by CrMS in this population. Our results showed that, among volleyball players who already possess good leaping skills, CrMS does not improve 1 RM SJ capacity but is likely to increase repeated BJ height.

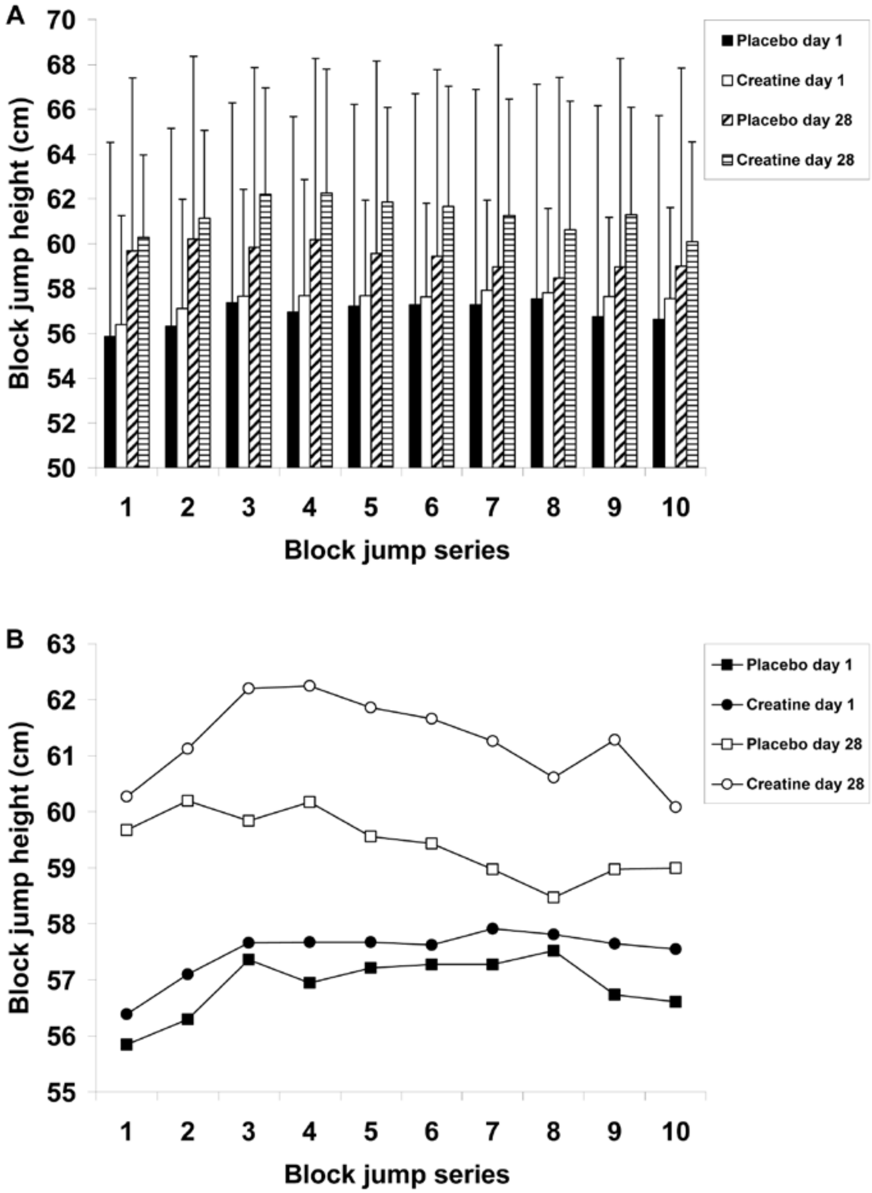

Figure 3 — Effect of creatine monohydrate (CrMS) and placebo on the mean absolute repeated block jump (BJ) height reached during each of the 10 series before and after supplementation. Results are reported as mean ± SD using error bars (panel A) and as mean only using curves for concerns of precision and clarity (panel B).

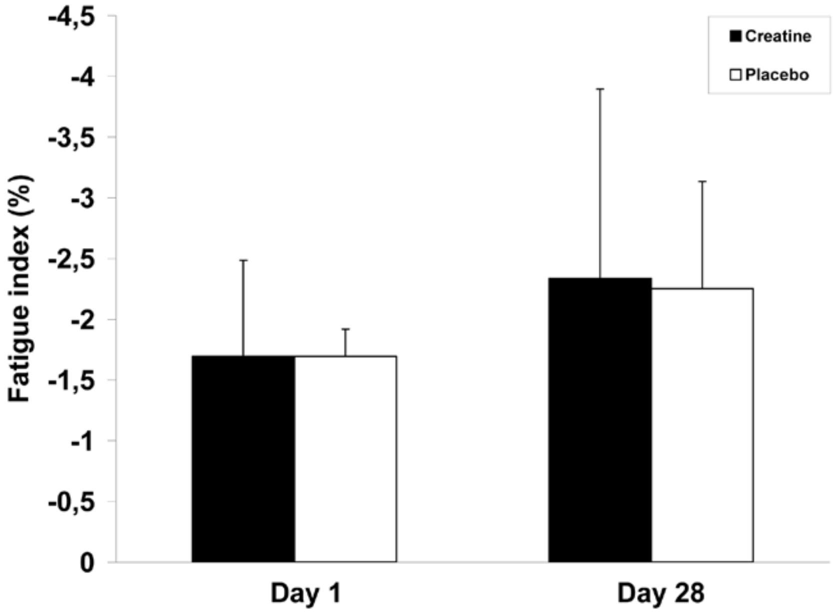

Figure 4 — Mean performance decrement (fatigue index) in repeated block jump (BJ) performance over the 10 series for creatine monohydrate (CrMS) and placebo before and after supplementation.

Albeit not statistically significant likely because of a lack of statistical power, the gain in bodyweight provided by CrMS in comparison with the placebo (+ 1.4 kg) is nevertheless suggestive of a systemic creatine's effect on the body and is in line with results previously reported in the literature.[9] This change in bodyweight is likely a reflection of an increase in total body water, especially in the intracellular compartment due to the increased osmotic load associated with the augmented presence of creatine within the cells.[1]

Following supplementation, both groups improved their vertical jumping capacity in a relatively important manner, ie, 2 to 7%. Some may argue that these training- and competition-induced changes in physical capacity could threaten the validity of our findings. However, it should be noted that such relative improvements in jumping capacity are in the vicinity of those that have been previously noted and observed in elite male and female volleyball players during the competition season.[2,10] Because all subjects in the current study began the experimentation in a well-trained state, followed the exact same training routine over the course of the study and that the fatigue index was similar between groups both before and after the supplementation periods, we propose and feel confident that the increase in jumping performance likely is the reflection of the CrMS effect and not of other confounding factors.

Our results showed that CrMS improved repeated BJ height from series 3 to 10 and that, on average, over the 10 series, by 1.9%. Several studies have demonstrated that CrMS improves muscular performance during repeated vertical jumping exercises in recreational, resistance-trained, sprint and long-jump athletes.[11–13] However, Hoffman et al[14] showed that 10 wk of CrMS did not increase performance over 20 consecutive countermovement jumps in football players. To the best of our knowledge, the present study is the first study to show that CrMS is likely to enhance repeated jump capacity over 100 (ie, 10 series of 10 repetitions) jumps. Our results support the notion that the increased skeletal muscle creatine concentration may have helped accelerate the rate of PCr recovery within the 2-min periods separating each series, thereby allowing subjects to jump higher at each subsequent series.

Interestingly, although on average subjects supplemented with creatine jumped repeatedly higher over the 100 repetitions than the placebo group, the percent decrement in jumping performance across time did not differ between groups. Because CrMS improved repeated BJ height compared with the placebo, and based on the reasonable assumption that this supplementation strategy increased the PCr pool significantly more than the placebo, we interpret this finding to suggest that the relative use of PCr between groups may have been similar and optimal between jumps and series.

Creatine supplementation did not improve 1 RM SJ height in our volleyball players, which contrasts with some,[15–18] but not all,[8,19] results of studies that verified its effect upon 1-RM vertical jump capacity. Along the same line, CrMS did not further improve repeated BJ capacity over the first two series (ie, first 20 jumps), compared with the placebo. Although we cannot provide a definitive explanation for these findings based on the collected data, it is tempting to speculate that, in our elite volleyball players, the baseline PCr stores could already have been sufficiently and optimally elevated such that any additional effect of CrMS could only be detected from and above 20 jumps.

Conclusion and Practical Applications

Our results indicate that, in this elite university-level volleyball team, 28 d of CrMS over the course of the competitive season likely increased repeated BJ height without, however, attenuating the magnitude of muscular fatigue. Hence, the present findings suggest that CrMS could potentially offer a competitive advantage for elite volleyball players during a volleyball match. Larger scale studies must be conducted to confirm or infirm our findings.

Acknowlegments

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