

Muscle strength and muscle endurance: with and without creatine supplementation

Daniel KEBRIT¹, Sangeeta RANI²

¹Department of Sport Science, Debre Markos University, Debre Markos, Ethiopia.

²Department of Sport Science, Haramaya University, Haramaya, Ethiopia.

Address correspondence to Daniel Kebrıt, dan2007et@gmail.com.

Abstract

Creatine is one of the legal ergogenic aids which are used by athletes here and there. A number of studies assured that it has a positive effect in high intensity short duration intensity exercise performances. This study tried to evaluate the effect of creatine monohydrate supplements on muscle strength and muscle endurance. Twenty subjects (CG= 10 and EG= 10) were participated in three months of exercise training. In this study complete randomized design was used. The EG consumed creatine and the placebo (CG) used water 45 minutes before exercise. The results indicated that Muscle endurance was improved better in the EG. In curl up performance, the CG showed 35% change while the EG improved by 87%. In addition, 44% improvement in CG and 91% improvement in EG were recorded for push up performance. However, muscle strength was highly enhanced in the EG. In one repetition maximum test, the CG and EG shown 18% and 41% change, respectively. Bench press performance of the CG and EG were improved by 11% and 39%, respectively. Barbell squat performance was improved by 22% for the CG and 51% for the EG. Hence, supplementation of creatine is useful to improve both muscular strength and muscular endurance.

Key Words: Creatine supplements, muscle endurance, muscle fitness, muscle strength.

INTRODUCTION

Creatine supplementation for a week or more when combined with strength training may alter muscle protein metabolism directly (via decreasing protein breakdown or increasing synthesis) and/or indirectly as a result of a greater training load made possible by its acute ergogenic effects on strength and power (7). Countless studies assured that creatine supplementation has improves performance in high intensity short duration exercise (4,11). Although a positive result exhibited in anaerobic performance following creatine supplementation, the effect of the supplement on the muscle strength and muscle endurance were not well documented. The following conflicting findings strengthen this statement.

Creatine supplement brought no significant effect on one repetition maximum and Wingate Anaerobic Test. In other words, it shows less effect on muscular strength (13). It does not increase maximal isometric strength, the rate of maximal force production, nor aerobic exercise performance (2). In another study which used resistance training, males who received creatine and creatine + protein in

combination with resistance training had slightly greater increases in lean tissue mass compared to males who trained and received protein or placebo. Two of three muscular strength measurements, bench press and squat, was also increased to a greater extent in males that supplemented with creatine + protein compared to those that received a placebo (9). Creatine supplementation during resistance training is more effective at increasing muscle strength and weightlifting performance than resistance training alone (10).

Creatine supplement improves both bench press and Vertical Jump performances. The creatine group had shown a better improvement than the placebo group (8). In another study, the bench press performance had been significantly changed. The supplemented group (creatine supplement) observed a significantly greater increase in bench press lifting volume. However, no significant differences were observed in changes in squat or power clean lifting volume but, changes in total lifting volume (sum of bench press, squat, and power clean) were significantly greater in the creatine group (6).

Creatine supplementation appears to be effective for maintaining muscular performance during the initial phase of high-volume resistance training over reaching that otherwise result in small performance decrements (12). However, it may not bring change in elder men and women. Creatine supplementation at a rate of 5 g/day is not an effective intervention to enhance physical fitness in men 55 – 75 year of age enrolled in an exercise training program involving both endurance exercise and moderate resistance training (3).

Generally, Creatine Supplements can increase muscle phosphocreatine content, it may improve performance involving short periods of extremely powerful activity, especially during repeated bouts. However, it may not be true in every individual (2). The individual difference in ergogenic benefit is possibly due to differences in subject response to creatine supplement, length of supplementation, exercise criterion evaluated, and/or the amount of recovery observed during repeated bouts of exercise. Creatine supplementation appears to be effective for maintaining muscular performance during the initial phase of high-volume resistance training (12).

MATERIALS AND METHODS

This research was conducted at Haramaya University main campus. All the tests and physical activity trainings were delivered in the University's gymnasium. This study was conducted for 12 weeks.

Study Subjects and Sampling Techniques

Male beginner athletes (100m, 200m and 400m runners) who compete to represent Haramaya University in 6th Ethiopian Higher Education Institutions sport festival were the subjects and their age ranged from 18 to 25.

Purposive sampling was used to select subjects. Thirty volunteer student athletes filled the medical history questionnaire. The questionnaire was prepared with the aim of identifying whether they were free from cancer, heart disease, stroke and kidney problems. Additionally, injury status was used as one selection criteria. Five of the thirty volunteers, rejected due to factors mentioned above and the other five withdrawn with draw. The study was conducted with only twenty subjects.

Inclusion and Exclusion Criteria

Good at basic sport skills, being free from chronic disease, normal range of BMI, healthy body and being free from any drug abuse were the criteria's that needed to be fulfilled to be the subject of this study. Those individuals who fulfilled the above requirements were selected and participated in this study. Out of the eligible population, those who could not come due to rest or sickness were not included in this study. Subjects, who had the possibility to resign in between, were rejected after short interview.

Instrumentation

The following materials were used through the process of the study. Weight machine, stopwatch, whistle, Girth measurement (flexible metal tape measure), and sport equipment's such as Dumbbells, Treadmill, barbells, Weight benches, stationary bikes, Studio 6, etc. was used through the process of the study.

Experimental Design

Complete randomized design with double blind and placebo controlled was used for this study. The study was conducted for 12 weeks of resistance training associated with creatine supplementation. The effects of creatine supplementation on sprinting performance of Haramaya University male beginner athletes were studied. The subjects were divided in to experimental and control groups. These groups were matched in terms of age level. The average age of the experimental group was 20.1 ± 0.9 and the control group was 19.8 ± 1.1 .

Creatine Monohydrate Supplementation Protocol

The control and experimental groups had been engaged in conditioning exercises for the first two weeks of this study. Then, to create physiological adaptation, the experimental group had begun taking low dose (2 to 3 grams) of creatine monohydrate supplement every training day. The control group kept exercise only. After being supplemented with 2 to 3 grams of CM, the dose of experimental group was increased to 5 grams per training day doing it for a week.

Water was used as placebo for the control group. The supplementation was given 45 minutes before exercise. 200ml of water was used to dilute the 5 gram of creatine supplement. Equal amount of water was given to the control group.

Exercise Training Protocol

The selected subjects were divided in to two groups. Both groups were engaged in conditioning exercise for the first 2 weeks. In the 3rd week, the experimental group started creatine monohydrate supplement 2 to 3 grams per training session for physiological adaptation. The safest creatine supplement was used.

After two weeks of conditioning, the groups were begun performing resistance training (both weight bearing and weight free exercises). Weight exercises include deadlift, barbell squat, bench press, etc. Push up, curl up and brisk walking were some of the weight free exercises which were performed by both groups. The duration of exercise was 45 minutes with the frequency of 3 days per week. Efforts were put to control the subjects. They were advised, not to participate in any other physical activity.

Tests

Repetition Maximum

The maximum number of repetitions one could perform during a given exercise at a given weight and intensity while using proper exercise form (one repetition maximum) was used. In this case, the maximum amounts of weight lift by the subjects (both the experimental group and the control group) were measured at PT, DT and PoT. The procedure used Barbells.

Bench Press

The participants were subjected to lie down on the weight bench and the spotter gave them a barbell. The weight of the barbell lifted was different. The common thing applied was that every individual begun lifting from the simplest in terms of his strength. Then, the maximum weight lifted by the individual was recorded. These measures were taken at PT, DT and PoT and the unit was kilogram.

Barbell Squat

The subjects were asked to hold a barbell on their shoulder with the support of their hand. After that the participants slightly bent their knees until they reached semi squat position. They stayed for 2 to 3 seconds in that position. Finally, return to standing position and dropped the barbell. This test was used to check the strength of gastrocnemius, Quadriceps,

hamstring and Gluteal muscles. It was taken three times at PT, DT and PoT and the unit was kilogram.

Curl up

This test was used to assess the muscular endurance of the rectus abdominis muscles. It was done as follows: The subjects were laid flat on a mat with their knees bent 90 degrees and hands in the hollow of the neck. Then, they stand and touched their leg with their front head. It was performed for a minute. The number of curl ups they perform with one minute was recorded. It was done three times at PT, DT and PoT.

Push Up

The rationale for making push up as one part of the tests was to measure the endurance of upper body muscles. The subject being tested on prone lying position putting their palms at the shoulder level on the ground, face-down on the mat. On the signal go they were asked to raise their body upward until the arms were fully extended, then lowered until the elbows bend at 90 degrees. This constitutes one repetition of a pushup and count as one. The subjects performed free push ups as much as they could do until exhaustion. The total number of push up was recorded as their score.

Data Quality Control

To minimize mistakes during data collection, the all data collectors were trained. Only standardized materials were used to keep the quality of data. Additionally, all the aforementioned tests were recorded with video and photograph.

Ethical Issues and Code of Conduct

This study was conducted inline with the rules, policies and research ethics of Haramaya University. The privacy of the participants was protected. Participants were informed earlier with written letter. The ethical clearance protocol was approved by the IRERC (Haramaya University Institutional Research Ethics Review Committee).

Method of Data Analysis

The data were analyzed by SPSS statistical software package Version 15. Paired sample t-test was used to identify significant differences between the scores of the two groups. Statistical significance for all data was set at $p \leq 0.05$.

RESULTS

Table 1. One repetition maximum (kg), bench press (kg) and barbell squat (kg) mean values for male beginner athletes of both control group (CG) and experimental group (EG); at different occasions of training program.

	CG			EG		
	PT	DT	PoT	PT	DT	PoT
ORM (kg)	37.1 + 2.61	41.0 + 2.57	43.6 + 2.78	37.1 + 3.01	45.9 + 3.40	52.4 + 3.20
BP (kg)	44.0 + 2.73	47.1 + 2.71	48.7 + 2.85	40.5 + 2.67	50.6 + 2.38	56.1 + 2.37
BS (kg)	33.5 + 2.55	37.6 + 2.77	40.8 + 2.94	31.0 + 2.44	39.3 + 2.83	46.8 + 2.81

Table 2. Curl up (number per minute) and push up (number) mean values for male beginner athletes of both control group (CG) and experimental group (EG); at different occasions of training program.

	CG			EG		
	PT	DT	PoT	PT	DT	PoT
CU(no)	27.9 + 2.20	32.8 + 2.16	37.6 + 1.88	29.8 + 2.68	46.3 + 3.43	55.7 + 3.13
PU(no/min)	25.0 + 3.68	29.3 + 3.62	35.9 + 0.76	29.6 + 4.38	44.4 + 4.68	56.5 + 3.82

Values are mean + SE, CG= control group, EG= experimental group, PT= pre training test which is taken before training and supplementation, DT= during training test which was measured at the 6th week of training and supplementation, PoT= post training test measured at the 12th week of training and supplementation, ORM= one repetition maximum, BP= benchpress and BS= barbell squat.

A positive mean difference was observed on one repetition maximum test. The rationale behind the increase of both groups was the physical training they took in the gymnasium and in the stadium. Although both groups showed improvement, the change was better in the EG. The CG increased by 17.52% and 41.2% enhancement was revealed in the EG.

Values are mean + SE, CG= control group, EG= experimental group, PT= pre training test which is taken before training and supplementation, DT= during training test which was measured at the 6th week of training and supplementation, PoT= post training test measured at the 12th week of training and supplementation, CU= curl up, PU= push up.

The mean value difference was greatly identified for both groups in curl up test. The reason was the resistance training both groups were engaged in. The CG showed 34.77% increase in curl up performance and 86.91% improvement revealed in the EG.

As indicated in Table 2 the push up performance of both group changed significantly. The reason behind this change is the physical training they engaged in. However, the EG performed better. The

Alike the one repetition maximum test, both groups significantly changed in their bench press performance. However, a better improvement recorded in the experimental group. If we compare the pre and post test results between groups, the mean difference improves more than 3 times in the experimental group. 10.68% and 38.51% improvement was seen in the CG and EG respectively.

In barbell squat performance test, the mean value of both control and experimental group was increased markedly. The mean difference showed that there was a better improvement in the EG. The CG got 25.79% improvement and 50.97% change was recorded for the EG. The creatine supplement gave a better change for the EG.

push up performance of CG and EG changed by 43.6% and 90.88% respectively.

DISCUSSION

In this study, the basic parameters of Muscle strength and Muscle endurance had been measures. The results of pre and post test assured that creatine monohydrate supplement enhances both muscle strength and muscle endurance. To explain it, creatine enhanced performance in single repetition maximum. Nevertheless, the findings of Zuniga and his friends is different. They found that creatine supplementation does not significantly increase performance during one repetition maximum test (13). Creatine supplementation brought positive effect on bench press performance. This result is consistent with the findings of Lim on volley ball players. According to

him the creatine supplemented group more significantly improved in bench press performance (8). Likewise, it had been shown to improve performance during barbell squat. All in all, supplementation of creatine monohydrate enhances muscular strength.

In a double-blind, randomized study conducted on football players by Kreider and his colleagues, the EG (the supplemented group) exhibited a significantly greater increase in bench press lifting volume. The result of this study is comparable with the findings Kreider et al. (5). However, Kreider and his friends couldn't see significant difference in barbell squat and power clean lifting. This study, which is conducted for 90 days, assured that creatine monohydrate supplement improves performance of one repetition maximum, barbell squat and bench press. In other words, creatine monohydrate supplement showed a very positive effect on muscular strength.

Creatine supplement improved curl up performance in male beginner athletes. The improvement in curl up performance means an enhancement in abdominal muscle endurance. Here, it is possible to conclude that a creatine supplement has positive effects in curl up performance, indeed in abdominal muscle endurance. The supplement also has a positive effect on push up performance. In contrary to this, In a study in which Thirty-five healthy, active duty, U.S. Army volunteers participated, they could not show significant change in two minute push up test (1).

All in all, the test results of the selected parameters assured that creatine monohydrate supplement is important to enhance muscle fitness. The findings of this study contradict with some research findings. However, it coincides with a number of latest research results.

Depending on the major findings of this study, the following points are stated as a conclusion:

- Creatine supplementation enhances the muscle strength performance of athletes. Hence, it would be important if sportmens use it to enhance their muscular strength.
- It's well studied that physical activity improves muscular endurance. But, it will be improved better if an athlete combines exercise with creatine supplements.

- Generally, Every athlete who needs to enhance her/his muscular fitness can use creatine supplements for better improvement

The following points are recommended for coaches and others who work with athletes:

- Any athlete who needs to improve his muscle strength and muscle endurance performance could ease the road by using creatine supplements.
- Creatine supplements when used in association with resistance training would enhance muscle fitness. So, Sportmens shall use it along with resistance training to get visible change.
- Coaches shall advice their athletes to use legal and useful diatery supplements like creatine.

ACKNOWLEDGEMENT

We are grateful to the Ethiopian Ministry of Education for their financial support. We are also thankful to Insitute Research Ethics Review Committee of Haramaya University for their constructive comments. Lastly, we declare that this thesis is our bonafide work and that all the sources of the material used for the thesis have been duly acknowledged.

REFERENCES

1. ArmentanoMJ, Brenner AK, Hedman TL, Solomon ZT, Chavez J, Kemper GB, Salzberg D, Battafarano DF, and Christie DS. The effect and safety of short-term creatine supplementation on performance of push-ups. *Mil Med*, 2007; 172(3): 312-7.
2. BirdSP. Creatine supplementation and Exercise Performance. *J Sports Sc. and Med*, 2003; 2:123-132.
3. Eijnde BO, Leemputte MV, Goris M, Labarque V, Taes Y, Verbessem P, Vanhees L, Ramaekers M, Eynde BV, Schuylenbergh RV, Dom R, Richter EA, and Hespel P. Effects of creatine supplementation and exercise training on fitness in men 55– 75 year old. *J appl physiol*, 2003; 95: 818-828.
4. FukudaDH, Smith AE, Kendall KL, Dwyer TR, Kerksick CM, Beck TW, Cramer JT, and Stout JR. The effects of creatine loading and gender on anaerobic running capacity. *J Strength Cond Res*, 2010; 24(7): 1826-1833.
5. Kreider RB, Farris F, Kreider R, Greenwood L, and Byars A. Creatine supplementation patterns and perceived effects in select division I collegiate athletes. *Clin. J. Sport Med*. 1997; 10: 191-194.
6. Kreider RB, Kathleen M, Makani DS, Julie WD, Hootan K, Thomas S, Jane AK, and Morris S. Creatine Fails to Augment the Benefits fromResistance Training in Patients with HIV

- Infection: A Randomized, Double-Blind, Placebo-Controlled Study. *J Int Soc Sports Nutr.* 1998; 4: 2.
7. Lemon PW. Dietary creatine supplementation and exercise performance: why inconsistent results. *Can. J. Appl. Physiol.* 2002; 27: 663-681.
 8. Lim JY. Effectsof Creatine SupplementationonBody Composition, Strength, and Power of Female Volleyball Players. *J Int Soc Sports Nutr.* 2000; 6: 1543-9518.
 9. Rahmani F, Nader R, Yaser G. TheComparative Effectsof Oral Creatine Supplementation and High Protein on Muscular Strength and Body Composition. *Int J Sport Sc and Eng.* 2008; 02(04): 223-230.
 10. Rawson ES, and Volek JS. The effects of creatine supplementation and resistance training on muscle strengthand weight-lifting performance. *J Strength Cond Res.* 2003; 17: 822-831.
 11. Tarnopolsky MA, and MacLennan DP. Creatine monohydrate supplementation enhances high-intensity exercise performance in males and females. *Int J Sport Nutr Exerc Metab.* 2000; 10(4): 452-63.
 12. Volek JS, Ratamess NA, Rubin MR, Gómez AL, French DN, McGuigan MM, Scheett TP, Sharman MJ, Häkkinen K, Kraemer WJ. The effects of creatine supplementation on muscular performance and body composition responses to short-term resistance training overreaching. *European Journal of Applied Physiology.* 2004; 91: 628.
 13. Zuniga JM, Housh TJ, Camic CL, Hendrix CR, Mielke M, Johnson GO, Housh DJ, Schmidt RJ. The effects of creatine monohydrate loading on anaerobic performance and one-repetition maximum strength. *J. Strength Cond. Res.* 2012; 26: 1651-1656.