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The effects of Creatine supplementation on exercise performance

Nellie Carrillo

THE EFFECTS OF CREATINE SUPPLEMENTATION ON EXERCISE PERFORMANCE

A Project

Presented to the

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California State University,

San Bernardino

In Partial Fulfillment

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by

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ABSTRACT

The purpose of this study was to examine the effects of Creatine Monohydrate (CrM) supplementation on exercise performance. The method for this project was a literature review from peer-reviewed articles. The findings suggest that CrM supplementation shows the most valuable effects for exercise performance when the activity involves repeated short bouts of high intensity physical activity which involve actions such as jumping, sprinting, or cycling. The greatest benefits have been reported when strength or maximal force (isotonic or dynamic contractions) are the outcomes measured post CrM supplementation. In conclusion, Creatine monohydrate supplementation does have a measurable effect on force production regardless of age, sex, or sport. Creatine monohydrate supplementation is most effective when used by trained athletes eating a well balanced diet, receiving plenty of rest, and maintaining proper hydration.

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DEDICATION

To my parents, Roberto and Refugio Carrillo, for their vital encouragement, support and unconditional love.

To my brothers and sisters, who always give me their positive energy to continue in life.

To all my friends and extended family, who have always believed in me.

Most especially to God, who made all things possible.

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CHAPTER ONE

INTRODUCTION

Introduction of the Project

Creatine monohydrate is one of the most commonly used dietary supplements among professional, collegiate, high school, and recreational athletes. One of the reasons for its popularity is the growing evidence that suggests that taking CrM supplements will improve athletic performance (Bryant & Green, 2003). The focus of this project will be on the ergogenic effects of CrM rather than the possible health related side effects of long term use. According to Ahmun, Tong and Grimshaw (2005) the Phosphocreatine (Pcr) stores in the muscle significantly influences the amount of energy generated during brief periods of high intensity activity. The Pcr that is present in human muscles may come from two potential sources, dietary (meat or fish) or internally made by the body. Phosphocreatine is an amino acid that is created in the liver and kidneys from three amino acids: glycine, arginine, and methionine (Lombardo, 2004).

In the human body, creatine (Cr) exists in both the free form Cr and the phosphorylated (Pcr) forms, and approximately 95% of all the Cr is contained within skeletal muscle and is carried out to the muscles through the bloodstream (Kraemer & Volek, 1999). Athletes consume CrM supplements because Cr plays an important part in the immediate energy system used for muscle contraction. When a muscle fiber contracts and exerts force, the energy used to drive the contraction comes primarily from a compound in the cell known as adenosine triphosphate or ATP (Bryant & Green 2003). Adenosine triphosphate provides its energy by releasing one phosphate molecule, becoming adenosine diphosphate (ADP). Since there is only enough ATP to last about ten seconds in the immediate energy system, more ATP needs to be produced in order for this immediate energy system to continue. This is where Cr is involved giving up its phosphate molecule to ADP to recreate ATP that is used in muscle contraction. Thus, the greater quantity of Cr in the muscles the more ATP the muscle can remake working to maximal potential for a short period of time.

According to Lombardo (2004), numerous measured dosing regimens have been proposed, one of the most popular is 20 grams (g) of CrM per day (5 g, four times per day) for one week, and then 2 to 5 g of CrM per day for maintenance. This literature review will provide a summary of the scientific literature as it pertains to CrM supplementation and exercise performance.

Purpose of the Project

The purpose of this project was to examine the effects of CrM supplementation on exercise performance and to generate a pamphlet to assist coaches and athletes with the decision to use this supplement or not to use this supplement.

Scope of the Project

The results of this project are intended to assist individuals in deciding whether or not to consume CrM supplementation as an outcome to increase exercise performance. CrM supplementation is the main topic of the project. This project searched for research investigating the effects of CrM supplementation on exercise performance.

Significance of the Project

This project can be used as a reference to inform potential users about the effects of CrM supplementation on exercise performance. Individuals will be able to use this information to decide whether or not to use CrM supplementation for exercise performance.

Limitations of the Project

Some limitations of this project were the selection of articles. The articles were retrieved from Pubmed Central, EBSCOHost, Science Direct, and Illumina. A total of 11 articles specifically related to the topic of CrM supplementation and exercise performance were selected for review. In addition three books were used in the project.

Definition of Terms

A. Creatine monohydrate (CrM): the most popular form or oral Cr supplementation.

B. Phosphocreatine (Pcr): a phosphorylated creatine molecule that is an important energy store in skeletal muscle.

C. Dietary Supplements: are concentrated sources of vitamins, minerals, and energy substances that are taken to "supplement" the nutrients derived from food ("ACSM's Resources or the Personal Trainer", 2007).

D. Adenosine Triphosphate: the immediate source of energy for muscular contraction (Powers & Howley, 2001).

E. Hydrostatic weighing: underwater weighing used to measure body composition and percentage body fat.

F. Cycle ergometer: a stationary exercise bicycle that permits accurate measurements of the amount of work performed (Powers & Howley, 2001).

CHAPTER TWO

METHODS

To identify possible studies examining CrM supplementation, this review was conducted with the use of the Academic Search Premier EBSCOhost to find articles on EBSCOhost, key word searches were required. The following are samples of key words searched: CrM supplementation, CrM combined with the word monohydrate, athletes, sports, sprinters, and tennis. Another electronic database searched was PubMed Central. Similar CrM terms were searched along with "CrM and exercise performance" and "CrM and performance". A third electronic database Direct Science was also used to research the terms " CrM and sport", "CrM and soccer", "CrM and strength" and "the effects of CrM on exercise performance". Titles and available abstracts were scanned and all articles were printed so that the data could later be analyzed. Only relevant articles in the English language were retrieved. Only articles that resulted in randomized or double-blind placebo controlled studies investigating the effects of CrM supplementation on exercise performance or any sport were considered. The subjects of the studies were healthy professional or well trained athletes. Articles related to CrM kinase were excluded from this study. Books were retrieved from personal library and NetLibrary database.

CHAPTER THREE

REVIEW OF LITERATURE

Many studies have examined the effects of CrM supplementation on exercise performance. The following articles were chosen for review because they deal specifically with the ergogenic effects CrM supplementation has on exercise performance. Participants ranged from highly trained athletes of various sports to the effects Creatine supplementation has on muscular performance in older women. All articles reviewed used placebo controlled research designs as the method for evaluating the effects of CrM supplementation on exercise performance. Outcomes of the articles reviewed indicate that the greatest improvements in performance following CrM supplementation were observed during repeated bouts of high intensity exercise.

In the first article reviewed, Strout, Eckerson, Noonan, Moore, and Cullen (1999) examined the effects of eight weeks of CrM supplementation on exercise performance and fat-free weight in football players during training. Participants included 24 male members of a NCAA Division II football team ages 19.6 ± 1.0 years, height 181.0 ± 4.8 cm, and weight 93.3 ± 17.7 kg. Participants were told not to ingest any medications or other supplements during the length of study and they abstained from taking CrM for at least three months prior to the study. Strout et al. (1999) used a double blind design for their study and randomly assigned the football players into a carbohydrate (CHO), CrM, or a CrM + CHO supplementation group. The dosages received were as follows: CHO group received 35g of flavored glucose (GLU); CrM group received 5.25g CrM plus 1 g CHO; and the CrM + CHO group received 5.25g CM, 33g GLU, 633 mg of sodium and potassium phosphates and 1 g taurine in a powdered mix. Supplements were taken for a total of five consecutive days one or two hours before meals four times a day and twice a day thereafter. Participants were tested for 100 yard dash time, vertical jump (VJ), one repetition maximal bench press (1 RM BPS) and measured for fat-free weight (FFW) one week prior to and immediately after supplementation phase. An electronic laser timer was used to accurately capture the participants' three maximal 100 yard dash sprints using the best time for data analyses. The 1RM BPS was performed using an Olympic weightlifting bar. Participants were asked to not bounce the bar while testing and reached a 1RM within three to five attempts. A Vertec apparatus (vertical jump testing devise) was used to determine VJ distance. The participants performed three maximal jumps and the best score was used for data analyses. Fat free weight was obtained by dual energy x-ray absorptiometry (DEXA). Strout et al. (1999) found, in comparison to the CHO group, the CrM + CHO group had significant changes in BPS, VJ, 100 yd dash time, and FFW. Mean delta scores for the CrM group in every variable measured showed greater improvement in comparison to the CHO group, however, these differences were not considered to be statistically different. The dependent t-tests recorded significant improvement in BPS (pre 118.2 ± 5.5 kg, post 133.4 ± 6.8 kg), VJ (pre 66.5 ± 2.3 cm, post 72.1 ± 2.0 cm), 100 yd dash (pre 12.13 ± 0.36 sec, post 11.82 ± 0.37 sec), and FFW(pre 69.6 ± 1.9 kg, post 72.8 ± 1.6 kg) for the CrM + CHO group. In the CrM group significant improvement was only recorded in BPS (pre 121.1 ± 5.8 kg, post 130.0 ± 5.6 kg) and FFW (pre 71.3 ± 2.3 kg, post 74.1 ± 2.3 kg). The only significant improvement recorded in the CHO group was in BPS (pre 132.1 ± 5.0 kg, post 138.1 ± 5.1 kg). The results of this study support the possible ergogenic benefit that CrM supplementation could have on anaerobic performance and FFW in well trained athletes.

Ziegenfuss, Rogers, Lowery, Mullins, Mendel, Antonio, and Lemon (2002) examined the effects of CrM loading on anaerobic performance and thigh muscle volume in NCAA division I athletes. The purpose of this study was to determine whether three days of CrM supplementation in elite power athletes would affect sprint cycle performance and thigh muscle volume. Twenty NCAA athletes were selected from the university population to participate in the study. Of the twenty participants selected, 10 were females (21.3 ± 1.1 years) and 10 were male (20.5 ± 1.9 years). The participants came from a wide variety of sports including: one female track runner, two female basketball players, two female softball players, two female field hockey players, three female gymnast, eight male wrestlers, and two male ice hockey players. The athletes were clear of steroid, tobacco, diuretic or oral contraceptive use. Participants performed two 10 sec cycle sprints 48 hours apart. Based on the average mean power scores of those two sprints, participants were placed into ranked pairs and then randomly placed into a placebo (P) or CrM group. According to Ziegenfuss et al. (2002)

verification of exact residual volume was not necessary because the main purpose of the body composition analyses were to determine the relative CrM dose, so the small error in fat-free mass estimation was considered unimportant. Body density was calculated by dividing body mass by body volume. Body fat was estimated by dividing 4.567 by body density minus 4.142 (Brozek, Grande, Anderson, and Keys, 1963). Fat free mass was then calculated by subtracting body mass from fat mass. Repeated cycle sprints (anaerobic performance) and thigh muscle volume were also assessed prior to actual testing. The CrM loading phase consisted of a three day supply of a drink mixture containing 20 g of CrM (CrM group) or 20 g of melodextrin (placebo group). Participants performed six 10 sec sprints against a load of 0.10 kg/kg of body mass at maximal effort on a cycle ergometer with a 60 sec recovery period against a load of 0.5 kg of body mass. Two indices of anaerobic exercise performance were measured during each sprint including: (a) peak power (the highest power output produced during any second) and (b) total work (the product of the applied resistance and the total distance covered) (Ziegenfuss et. al 2002). Magnetic Resonance imaging (MR) of the thighs was obtained with a 1.5-Tesla Signa whole body imager.

Findings of the study showed an increase in thigh muscle volume as a result of CrM supplementation. Significant improvement in both physical characteristics and anaerobic performance were found in the CrM group. The female athletes had lower peak power, lower body mass, less fat free mass and more body fat than did the males. There was no increase in body mass for the P group, whereas a significant increase was observed in the CrM group (66.7 ± 3.1 kg to 67.6 ± 3.0 kg). In accordance with ANCOVA procedures, significant values for all six sprints varied from 0.31 to 0.82 Watts/kg (peak power) and from 0.21 to 0.86 Joules/kg (total work). The correlations between covariate and dependent variables varied from 0.76 to 0.88 Watts/kg (peak power) and from 0.78 to 0.89 Joules/kg (total work); all of which were statistically significant. During the first sprint, total work values in the CrM group were greater than the P group, and peak power was greater in the CrM group during sprints two through six. During sprints one and two, peak power values were much lower in females but the reverse trend was seen during sprints four through six. The findings of this study suggest that CrM supplementation can enhance cycle sprint performance, as well as, increase thigh muscle volume in elite power athletes.

F. Rossouw, Krüger and J. Rossouw (2000) investigated the effects of CrM monohydrate loading on maximal intermittent exercise and sport specific strength in well trained power lifters. A total of 13 participants were randomly assigned to a CrM or P group. The CrM group consisted of seven males and one female, and the P group consisted of four males and one female. Height and body mass were recorded using a calibrated medical scale and calibrated height gauge. Physical characteristics of the P group (ages 23.8 ± 4.1 years, height 173.3 ± 8.6 cm, and body mass 90.9 ± 16.8 kg) were similar to the CrM group (ages 27.1 ± 5.3 years, height 177.1 ± 7.6 cm, and body mass 100.9 ± 17.0 kg). Right biceps, triceps, umbilicus, thigh, sub-scapula, supra iliac, and calf were measured with a Harpenden skin fold caliper. Also, tensed muscles were measured for circumference (bicep, forearm, waist, wrist, ankle, calf, and upper thigh). The P group received nine grams of sucrose in tablet form and the CrM group received nine grams of CrM in tablet form to be consumed daily for six days. Following four minutes of cycling on a cycle ergometer, a maximal intermittent exercise fatigue test was performed by all participants on an isokinetic dynamometer. The test was comprised of three consecutive bouts of 25 unilateral contractions of the knee extensors at a predetermined velocity, with a rest period of 60 seconds between each bout. The fatigue test measured peak torque (the point during the range of motion tested where the greatest torque or force was produced), explosive power was measured as torque acceleration energy (amount of energy used in the first one eighth of a second of torque output), total work (total energy output done in the first five and last five sample repetitions), and average power (total work completed during the test repetitions divided by the total contraction time) (Rossouw et al., 2000). The day after the isokinetic exercise test, all participants performed a maximal dead lift in accordance with competition rules. The maximal intermittent exercise fatigue and dead lift tests were performed both pre and post supplementation. Outcomes from the F. Rossouw et al. (2000) study showed a significant increase in dead-lifting volume in the CrM group, but no changes in the P group. No differences among the P group or CrM group were recorded in body mass, percentage fat/muscle/residual volume, or lean body mass. Correlation coefficients ranged between 0.84

and 0.92 during the first five sample repetitions for total work, work output, average power, and peak torque in the CrM group increasing at a constant rate. A significant increase in total work was recorded during the third bout of maximal exercise in the CrM group. There were major improvements in both the CrM and P group during exercise bout two of peak torque. During exercise bout three of peak torque, only the CrM group showed greater increases. The results of this study indicate that CrM supplementation can enhance sport-specific strength and maximal intermittent isokinetic power output in well trained power lifters.

Jäger, Metzger, Lautmann, Shushakov, Purpura, Geiss, and Massen (2008) used a double-blind placebo controlled study to investigate the effects of Cr pyruvate (Cr-Pyr) and Cr citrate (Cr-Cit) on performance during high intensity exercise, over a period of five weeks. Forty-nine males were randomly placed in a Cr-Pyr (n= 16, age 26.8 ±3.6 years, height 184.4 ± 4.9 cm, body weight 81.7 ± 10.9 kg, body fat 16.7 ± 4.6 % and forearm circumference 29.0 ± 2.2 cm), Cr-Cit (n=16, age 26.7 ± 4.4 years, height 182.7 ± 6.2 cm, body weight 78.1 ± 9.0 kg, body fat 15. 0 ± 4.3 %, and forearm circumference 28.1 ± 1.5 cm) or P (n=17, age 26.3 ± 4.5 years, height 180.2 ± 5.4 cm, body weight 77.6 ± 7.3 kg, body fat 15.0 ± 5.2 % and forearm circumference 28.3 ± 1.2 cm). The CrM loading phase consisted of the CrM-Pyr group ingesting 60% CrM and 40% Pyr, the CrM-Cit group ingesting 65% CrM and 35% Cit, in the form of lemon flavored effervescent tablets at a dose of 5 g per day (two tablets in the morning, one at noon, and two in the evening), and the P group received equivalent P supplements. During a period of five weeks, participants completed three exercise tests. On day one an incremental test was given, wherein maximum forearm performance was measured by performing a handgrip test. Starting at a weight of 7.5 kg maximal forearm performance was measured increasing the weight by 2.5 kg every three minutes until personal fatigue of the muscle group. On the eighth day, participants performed a pre-test consisting of 10 maximal bouts lasting 15 sec each. Each bout consisted of participants squeezing the handgrip as many times as possible, with a 45 second break in between each bout. On day 35, participants performed the post CrM supplementation test. The post CrM supplementation test consisted of participants performing high intensity intermittent dynamic exercises, at 80% of the maximum weight attained in the incremental test. Participants were required to squeeze the handgrip as many times as possible during a 15 sec exercise bout for 10 intervals, separated by 45 sec breaks. Findings from the Jäger et al. (2008) study suggest positive CrM effects in maximal forearm performance. Body weight and forearm circumferences increased similar amounts in both the CrM-Pyr (body weight 83.2 ± 10.7 kg and forearm circumferences 29.7 ± 2.2 cm) and CrM-Cit (body weight 79.5 ± 9.2 kg and forearm circumferences 28.6 ± 1.2 cm). The placebo group had no increase in mean power, however, both the CrM-Cit and the CrM-Pyr group showed a significant increase in mean power. When compared to the placebo group the CrM-Cit group had a major increase in handgrip force exerted during the first and second intervals but decreased over time. In contrast, the CrM-Pyr group had major improvements in handgrip force exerted during all intervals. The results of this study indicate that CrM-Pyr could improve endurance in athletes due to enhanced activity of the aerobic metabolism, resulting in an increased availability of energy in the form of ATP. It was also found that CrM-Pry and CrM-Cit supplementation significantly enhanced athletic performance in healthy males during intermittent handgrip exercises of maximal intensity.

Skare, Skadberg, and Wisnes (2001) in a single blind experiment evaluated the effects of CrM supplementation in male sprinters during single and intermittent sprints. Eighteen male sprinters with a minimum of three years experience in the 100 m, 200 m, 400 m, 110 m, or 400 m hurdles were recruited for this study. The sprinters physical characteristics prior to testing were 21.1 ± 3.2 years, height 180.4 ± 4.6 cm, and weight (BW) 73.1 ± 5.4 kg. The participants were placed into a CrM or P group based on their pre-trial tests scores. The pre-trial test consisted of one 100 m sprint and six intermittent 60 m sprints starting every 50 sec. Creatine supplementation consisted of the CrM group ingesting 20 g of CrM/glucose per day and the P group ingested 40 g of glucose per day for five consecutive days. The pre and post maximal sprint tests consisted of a 30min warm up followed by a 100 m sprint, a 25 min rest and ending with the six 60 m sprints starting every 50 sec. The sprinters times were recorded electronically. As a result of the Skare et al. (2001) experiment, after five days of high CrM supplementation dosage the sprint performance improved in male sprinters during 100 m sprints and intermittent 6x60 m sprints. Body weight in the CrM group significantly increased 0.6 ± 0.1 kg. In contrast there were no changes in BW or sprint performance for the placebo group. Eight out of nine CrM supplementation sprinters improved their sprint time's five out of six trials (7.30 ± 0.17 s vs. 7.27 ± 0.17 s). Findings of the study concluded that CrM significantly improved sprint performance in well-trained male sprinters.

Mendes, Pires, Oliveira and Tirapegui (2003) conducted a study to evaluate the effects of CrM supplementation on the body composition and performance of competitive swimmers. In this study 18 competitive swimmers were recruited (12 men and six women). Using a double-blind placebo-controlled study, the swimmers were divided randomly into one of two groups, the P group or the CrM group. Physical characteristics of the P group (19.78 ± 2.33 years, height 175.89 ± 8.08 cm, and weight 71.56 ± 8.69 kg) were similar to the CrM group (19.44 ± 2.60 years, height 174.67 ± 6.61 cm, and weight 68.02 ± 13.43 kg). Prior to testing the P group ingested four doses of 20.0 g carbohydrates per day and the CrM group ingested four doses of 5.0 g CrM combined with 20.0 g carbohydrates per day for a total of eight days. Upon completion of the eighth day, post supplementation performance tests were repeated to compare pre and post CrM supplementation findings. Performance testing consisted of 1)three 50-m repetitions (3x3x50), with 30-second intervals between repetitions and 150-second intervals among the three series; 2)one short duration high intensity maximal 50-m swim; 3) one 30-150 second high intensity anaerobic resistance 100-m test swim. A significant increase was recorded for the P group in the 100 m test and repetitive series. Only the CrM group demonstrated a statistically significant increase in lean body mass, body water, and total body weight. According to Mendes et al. (2004) CrM supplementation failed to increase performance and muscle mass gain in swimmers during this study.

Perret, Mueller, and Knecht (2006) conducted a double-blind, placebo controlled study, which involved six competitive wheelchair athletes 2 females and 4 males ages 33.0 ± 9.1 years, height 171.5 ± 7.7 cm, and weight 63.1 ± 6.2 kg. Athletes were randomly assigned into either group A or B. The purpose of this study was to investigate the influence of CrM supplementation on 800 m wheelchair performance. The CrM loading phase consisted of two 6 day treatments with a 28 day washout period in between phases to allow CrM levels back to baseline. Athletes in group A consumed CrM (4 x 5g per day) during the first phase and placebo maltodextrin (4 x 5g per day) during the second phase. Athletes in group B consumed the opposite, placebo maltodextrin (4 x 5g per day) during the first treatment then CrM during the second. Participants weighed in prior to each test session, followed by a 10 minute warm-up at 65% of the velocity of the participants' best time in the 800 m. After the warm up, the athletes rested for 10 minutes followed by a complete 800 m sprint at maximal speed. There were no significant differences found between the placebo or CrM groups during any tests performed in this study. The CrM loading phase showed no effects on the 800 m maximal wheelchair performance in either group nor were there any variations in body weight. Findings of this study failed to support CrM supplementation having any significant benefit in enhancing performance in competitive, spinal cord injured, wheelchair athletes.

Mujika, Padilla, Ibanez, Izquierdo, and Gorostiaga (2000) investigated the effects of Creatine supplementation and sprint performance in soccer players. The purpose of the study was to evaluate the effects CrM supplementation on the performance and recovery of male soccer players engaging in intermittent high-intensity exercise activities specific to competitive soccer. Nineteen male soccer players participated in this study. The soccer player's physical characteristics prior to testing were ages 20.3 ± 1.4 years, height 179.9 ± 5.5 cm, weight 74.8 ± 5.5 kg, and body fat 7.9 ± 1.6 %. The initial baseline control session consisted of the following tests: 1) counter-movement jump test (CMJT): three maximal vertical with a 30 sec rest in between using the best of the three jumps for data analysis 2) repeated sprint test (RST): six maximal 15 m sprints with 30 sec recovery periods 3) intermittent endurance test (IET): forty 15 sec periods of high-intensity exercise (40 m forward, 8.25 m backwards, 95.25 m forward through, 8.25 m sideways leading with right leg, and 8.25 m sideways leading with left leg) and thirty-nine 10 sec periods of low-intensity 4) recovery CMJT: perform a maximal counter-movement jump, recover 3 min, perform another jump, recover 5 min, then perform a final jump. Using a double-blind study to control the CrM and P treatments the CrM group consumed four 5 g doses of CrM per day for six days and the P group 5 g doses of maltodextrin per day for six days. During the supplementation period the CrM group increased body mass from 73.8 ± 5.7 kg to 74.4 ± 6.0 kg ($P<0.05$). The

P group's body mass remained unchanged during the experimental period 75.7 ± 5.4 kg and 75.9 ± 5.8 kg. Neither group had significant changes in the CMJT after the supplementation period. The CrM group's jumps remained at 47.4 ± 6.0 cm and 46.8 ± 6.0 cm, and the P group remained at 47.1 ± 4.5 cm and 47.1 ± 4.8 cm. The CrM group had consistently faster post treatment 5 m and 15 m times in the six sprints. There were significant performance gains at 5 m in sprint one and at 15 m in sprint two. The 5 m distance of sprint two and the 15 m distances in sprints one and three were slightly above statistical significance. Significant gains were also recorded in the sum of times 5.81 ± 0.14 sec vs 5.68 ± 0.17 sec. During all of the six sprints, all but one of the subjects achieved faster times. No significant improvement was shown in the sum of times or the average times of the P group. Performance values were statistically unchanged during the IET and Recovery CMJT for both the CrM and P group. Although CrM supplementation failed to enhance intermittent endurance performance in highly trained soccer players during this study, it was found to have a favorable affect on limiting the decay in jumping ability after the IET, and improving the participants repeated sprint performances.

Ahmun et al. (2005) reported the effects of CrM supplementation on multiple sprint cycling and running performance in rugby players. The purpose of the study was to assess the effects of acute CrM loading using a randomized, double-blind, crossover research design. The participants consisted of 14 highly trained male rugby players. The rugby player's physical characteristics prior to testing were 20.6 ± 1.2 years, height 1.81 ± 0.04 m, weight 88.7 ± 13.1 kg, sum of four skinfolds 43.2 ± 18.5 mm, and body fat 18.6 ± 8.1%. The CrM loading phase consisted of the CrM group ingesting 5 g of CrM and the P group ingesting 5 g of dextrose powder four times a day for five days. The first exercise test was conducted on a cycle ergometer with a pretest warm-up consisting of five min of cycling at 100W, followed with five min of static stretching. Participants then performed two practice starts on the cycle ergometer. The practice starts required the participants to pedal at maximum velocity against a calculated load (7.5% body mass) for 2-3 sec interspersed with cycling for 24 sec. A 4 min recovery period was given before beginning a test. The test began with the participant pedaling constantly at 60 rpm, with the workload applied to the flywheel following a 3 sec countdown. The participant was then required to pedal at maximum velocity for 6 sec. The load was then lifted from the flywheel as the participants performed a 24 sec active recovery. This process was repeated for the remaining sprints. Fatigue index, peak power, and minimum power were calculated for each sprint. The second exercise test consisted of ten 40 m sprints with a warm up consisting of 5 min of light jogging followed by 5 min of static flexibility. No pre or post differences were reported between the CrM and P groups in peak or minimum power, peak or minimum running velocity, or fatigue index. At the conclusion of the first exercise test, the CrM group experienced a 4.9% increase in peak power production and a 4.4% increase in minimum power output, compared to a 0.6% increase in peak power and a 1.2% decrease in minimum power output in the P group. The CrM group exhibited a 0.5% decrease in the fatigue index, compared to a 3.0% increase in the P group. The second exercise test concluded the CrM group had a 1.4% increase in peak running velocity compared to a 1.1% increase in the P group. In regard to minimum running velocity, 85% of the CrM group had a 2.6% increase, while the P group experienced a 2.3% increase. The CrM group's fatigue index was decreased by 7.6% and the P group's was reduced by 6.2%. The CrM group had a 0.4 kg increase in weight and the P group had a 0.2 kg increase. Of the 14 participants, four experienced a reduction in weight, two showed no change, and eight had an increase in weight. The CrM group experienced a 1.1% increase in body fat, while the P group had a 1.6% increase; however, none of these differences were recorded as being significant. Findings of this study failed to support CrM supplementation as providing any statistically significant benefits on multiple sprint cycling and running performance in rugby players.

Glaister, Lockey, Abraham, Staerck, Goodwin, and McInnes (2006) reported the effects short-term CrM supplementation had on multiple sprint running performance using a double-blind, P controlled research design. The participants were comprised of 42 physically active men split into two groups containing 21 participants each. The CrM group's physical characteristics prior to testing were 20 ± 1.0 years, height 1.79 ± 0.07 m, weight 76.1 ± 10.2 kg, and body fat 15.0 ± 5.4 %. The P group's were 20 ± 0.9 years, 1.78 ± 0.06 m, 76.2 ± 9.9 kg, and body fat 14.6 ± 4.1 %. Testing was conducted over four weeks. During the four week period, each participant completed three separate multiple sprint trials. Each sprint was separated by at least 72 hours. Sprint one was a familiarization test, sprint two was a baseline test conducted so that participants could be randomized by fatigue scores, and sprint three was the post supplementation test. After sprint two, the CrM group ingested 5 g of CrM plus 1 g of maltodextrin four times a day for five days, and the P group ingested 6 g of maltodextrins four times a day for five days. Prior to each multiple sprint test, participants performed a 5 min standardized warm-up consisting of 600 m of jogging at their own pace, a series of high-knee and heel-flick sprint drills, and three practice sprints. After the warm-up, participants where allowed 5 min to stretch prior to the multiple sprint test, which was comprised of fifteen 30 m straight-line sprints repeated at 35 sec intervals. Results of the study found that CrM supplementation was responsible for a 0.4 % reduction in body fat and a 0.7 kg increase in body mass. The P group failed to produce any significant changes. Furthermore, compared to the P group CrM supplementation produced a 0.04 sec increase in mean sprint time, a 0.01 sec reduction in fastest sprint time, and a 1.0 % increase in fatigue. Results of this study found that CrM supplementation produced no significant changes in fastest time, mean time, or fatigue scores in healthy male sprinters.

Gotshalk, Kraemer, Mendonca, Vingren, Kenny, Spiering, Hatfield, Fragala, and Volek (2008) reported the effects CrM supplementation had in improving muscular performance in older women. A double-blind placebo controlled design was used for this study. The purpose of this study was to observe the effects of CrM supplementation on body composition, muscular strength, and lower-body motor function in older women. Thirty healthy women participated in this research and were randomly placed into a CrM or P group. The CrM groups physical characteristics prior to testing were ages 63.31 ± 1.22 years, height 160.00 ± 1.58 cm, weight 67.11 ± 4.38 kg, fat-free weight 45.77 ± 3.78 kg, and body fat 31.80 ± 2.40 %, which were similar to the P groups ages 62.98 ± 1.11 years, height 162.25 ± 2.09 cm, weight 67.84 ± 3.90 kg, fat-free weight 48.66 ± 3.32 kg, and body fat 28.27 ± 2.24 %. CrM supplementation phase consisted of the CrM group ingesting CrM (0.3 g kg body mass^{-1}) in capsule form for seven days, and the P group ingesting a cellulose placebo in capsule form for 7 days as well. All tests were performed three times (T1, T2, and T3) seven days apart. The CrM supplementation phase was conducted immediately after T2 for seven days. During T3, participants were tested for (a)sit and stand test (with arms folded across the chest participants were instructed to rise from a seated position and sit and stand for a total of five stands) (b) 1 RM BPS (using a Universal bench press stack apparatus maximal lifts were determined in 1.25 kg increments) (c) 1 RM leg press (using a Universal leg press stack apparatus maximal lifts were determined in 2.5 kg increments) (d)isometric hand grip test (using a hydraulic hand dynamometer the best of three trials were recorded) (e) tandem gait test (participants walked as fast as possible along a 6 m line with heel of one foot directly in front of and in contact with the toe of the opposite foot and the best of six trails were recorded) and (f)upper/lower body cycle ergometer test (five 10 sec bouts were performed against a resistance equal to 0.05 and 0.075 kg/kg body mass^{-1} with 2 min rest intervals). Results of the study found that after supplementation, the P group had no significant differences in any tests performed or in body composition. However, the CrM group had significant improvements in the leg press (5.2 ± 1.8 kg), bench press (1.7 ± 0.4 kg), as well as upper and lower-body mean power. Yet, no significant differences were recorded in upper and lower-body peak power. The CrM group also recorded significant improvement by way of decreased time, in the sit-stand and tandem gait tests. There was no significant change in body fat percentages for either group. The CrM group did however gain a significant amount of body mass (0.49 ± 0.04 kg) and fat-free mass (0.52 ± 0.005 kg) in comparison to the P group. Results of this study concluded that CrM supplementation did result in small, yet significant, increases in lower extremity functional capacity, upper and lower-body dynamic strength, and mean explosive power in older woman.

CHAPTER FOUR

CONCLUSION

The purpose of this project was to summarize scientific literature regarding possible benefits of CrM supplementation, and to present information for athletes considering taking CrM. Research suggests athletes may benefit from consuming CrM supplements because Cr plays an important part in the immediate energy system used for muscle contraction. To summarize, when a muscle fiber contracts and exerts force, the energy used to drive the contraction comes primarily from a compound in the cell known as adenosine triphosphate or ATP (Bryant & Green 2003). Adenosine triphosphate provides its energy by releasing one phosphate molecule, becoming adenosine diphosphate (ADP). Since there is only enough ATP to last about ten seconds in the immediate energy system, more ATP needs to be produced in order for this immediate energy system to continue. This is where Cr is involved by giving up its phosphate molecule to ADP to recreate ATP that is used in muscle contraction. Thus, the greater quantity of Cr in the muscles the more ATP the muscle can remake and continue working to maximal potential for short periods of time. Research supports that CrM supplementation seems to show the most valuable effects for exercise performance in trained athletes when the activity involves repeated, short bouts of high intensity physical activity which involve actions such as jumping, sprinting, or cycling (Bemben & Lamont, 2005).

The results of CrM supplementation have been studied in a variety of physically demanding exercises. Generally speaking, the greatest benefit has been reported when strength or maximal force (isotonic or dynamic contractions) are the outcomes measured post CrM supplementation. Research shows, that CrM supplementation does have a measurable effect on force production regardless of age, sex, or sport studied. Evidence is unclear though regarding the benefits of CrM supplementation as it effects isokinetic force production or isometric muscular performance. Furthermore, there is conflicting evidence relative to both intermittent and continuous endurance activities when performance is assessed based on length and intensity of the exercises. To date, little evidence exists in support of the benefits of CrM supplementation for the prevention or inhibition of muscle soreness or damage following muscular activity.

The key to understanding CrM supplementation is to appreciate that it only helps with certain exercises or sports. Some of the more common sports and exercises that benefit from CrM supplementation are football, lacrosse, squash, soccer, bench press, and the 100 m sprint. Proper dosing is essential for maximizing the potential benefits of CrM supplementation. The most commonly suggested dosage is 20 g of CrM per day (5 g, four times per day) for one week, and then 2 to 5 g of CrM per day for maintenance (Lombardo, 2004). Finally, it is important to remember that every person's body reacts differently and that this may impact the potential ergogenic effects of CrM supplementation. Creatine supplementation has been shown to be most beneficial when used by trained athletes.

In conclusion, the results of the studies reviewed varied depending on the population tested, the methods utilized, and the specific outcomes they examined; however, all articles included in this project did indicate that CrM supplementation showed the greatest improvements in exercise performance during repeated bouts of high intensity exercise.

APPENDIX A

BROCHURE

"The power of the human will to compete and the drive to excel beyond the body's normal capabilities is most beautifully demonstrated in the arena of sport."

Aimee Mullins, Women's Sports Foundation President

Creatine and Athletic Performance

...ject presented to the faculty of California State University, San Bernardino.

...rtial fulfillment of the requirements of the ...ee: Master of Arts in Education: Kinesiology

By

Nellie Carrillo

...creatine right for you?

What Is Creatine?

In the human body, creatine exists in both the free form creatine and the phosphorylated forms, and approximately 95% of all the creatine is contained within skeletal muscle and is carried out to the muscles through the bloodstream (Kraemer & Volek, 1999). Athletes consume creatine monohydrate supplements because creatine plays an important part in the immediate energy system used for muscle contraction. When a muscle fiber contracts and exerts force, the energy used to drive the contraction comes primarily from a compound in the cell known as adenosine triphosphate or ATP (Bryant & Green 2003). Adenosine triphosphate provides its energy by releasing one phosphate molecule, becoming adenosine diphosphate or ADP. Since there is only enough ATP to last about ten seconds in the immediate energy system, more ATP needs to be produced in order for this immediate energy system to continue. This is where creatine is involved giving up its phosphate molecule to ADP to recreate ATP that is used in muscle contraction. Thus, the greater quantity of creatine in the muscles the more ATP the muscle can remake working to maximal potential for a short period of time.

Creatine monohydrate is one of the most commonly used dietary supplements among professional, collegiate, high school, and recreational athletes. One of the reasons for its popularity is the growing evidence that suggests that taking creatine monohydrate supplements will improve athletic performance (Bryant & Green, 2003). According to Ahmun, Tong and Grimshaw (2005) the Phosphocreatine stores in the muscle significantly influences the amount of energy generated during brief periods of high intensity activity. The phosphocreatine that is present in human muscles may come from two potential sources, dietary (meat or fish) or internally made by the body. Phosphocreatine is an amino acid that is created in the liver and kidneys from three amino acids: glycine, arginine, and methionine (Lombardo, 2004).

Who can benefit from creatine supplementation?

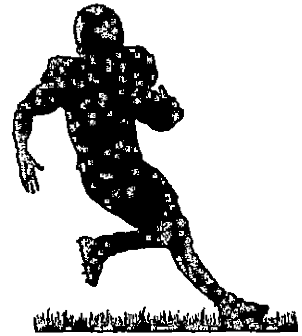
Creatine supplementation has been shown to be most beneficial when used by trained athletes. The key to understanding creatine monohydrate supplementation is to appreciate that it only helps with certain exercises or sports. Creatine monohydrate supplementation seems to show the most valuable effects for exercise performance when the activity involves repeated, short bouts of high intensity physical activity which involve actions such as jumping, sprinting, or cycling (Bemben & Lamont, 2005). Some of the more common sports and exercises that benefit from creatine monohydrate supplementation are football, lacrosse, squash, soccer, bench press, and the 100 m sprint.

Recommended dosing

Proper dosing is essential to maximizing the potential benefits of creatine monohydrate supplementation. The most popularly suggested dosage is 20 g of creatine monohydrate per day (5 g, four times per day) for one week, and then 2 to 5 g of creatine monohydrate per day for maintenance (Lombardo, 2004). While taking creatine monohydrate supplementation it is important to maintain a healthy diet, get plenty of rest, and stay properly hydrated.

Conclusion

Finally, it should be remembered that every person's body reacts differently and that this can impact the potential ergogenic effects of creatine monohydrate supplementation. As always, consult a physician prior to beginning any exercise or supplementation program.



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