2000

Does Creatine Supplementation Increase Muscle Strength in Women?

Tricia Cross
Eastern Illinois University

THESIS/FIELD EXPERIENCE PAPER
REPRODUCTION CERTIFICATE

TO: Graduate Degree Candidates (who have written formal theses)

SUBJECT: Permission to Reproduce Theses

The University Library is receiving a number of request from other institutions asking permission to reproduce dissertations for inclusion in their library holdings. Although no copyright laws are involved, we feel that professional courtesy demands that permission be obtained from the author before we allow these to be copied.

PLEASE SIGN ONE OF THE FOLLOWING STATEMENTS:

Booth Library of Eastern Illinois University has my permission to lend my thesis to a reputable college or university for the purpose of copying it for inclusion in that institution's library or research holdings.

Author's Signature

8/8/00
Date

I respectfully request Booth Library of Eastern Illinois University **NOT** allow my thesis to be reproduced because:

____

____

____

Author's Signature

Date

Does Creatine Supplementation Increase Muscle Strength

In Women?

(TITLE)

BY

Tricia Cross

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

Master of Science in Physical Education

IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
CHARLESTON, ILLINOIS

2000

YEAR

I HEREBY RECOMMEND THAT THIS THESIS BE ACCEPTED AS FULFILLING
THIS PART OF THE GRADUATE DEGREE CITED ABOVE

8/8/00

DATE

8/8/00

DATE

ABSTRACT

The purpose of this study was to see if creatine supplementation increased muscular strength in women. Ten females were assigned to either a creatine (CG) or a placebo (PG) group with five subjects in each. The study lasted five weeks with one week of pre-testing, three weeks of creatine use which included one week of loading (12-13 g/day for seven days) and two weeks of maintenance (3-4 g/day for 14 days), and one week of post testing. Pre- and post-test strength were measured with a one repetition maximal lift (1RM) on the bench press and the leg press. All subjects were required to perform a 20-minute warm-up before 1RM measurements to help avoid injury. Each subject then completed two warm-up sets with the bench press or leg press to prepare the working muscle for the 1RM test. After warm-up sets, each subject then completed one repetition lifts until their max lift was attained. Subjects were required to rest a minimum of two minutes in between lifts. No subject performed more than four, one repetition lifts. Over the course of the three-week study, all subjects performed similar workout routines. The results of the post-test 1RM values were not significant between the two groups. The CG increased their mean leg press 1RM (70 ± 47.2 lbs.) and mean bench press 1RM (12 ± 2.2 lbs.). The PG increased their mean leg press 1RM (56 ± 12.7 lbs) and mean bench press 1RM (8 ± 2.8 lbs). Although the PG started and ended with a greater 1RM, the CG displayed a larger mean relative average than did the PG. The CG increased their relative average for the bench press and leg press by 11.3% and 18.6%, respectively compared to the Pl increases of 6.5%, 13.2%, respectively. It is concluded that three weeks of creatine supplementation in women failed to significantly increase leg press and bench press strength greater than a placebo.

ACKNOWLEDGEMENTS

I wish to thank and send gratitude to everyone who helped me with making this thesis possible. The following are the people that I would like to thank and why; Dr. John Emmett for all his help and time in advising me through the whole course of my thesis, Thomas Woodall and the Adult Fitness Program for supplying the creatine and additional research materials for my thesis, and Dr. Richard Kreider for allowing me to incorporate his charts from his creatine presentation into my study.

I would like to send out special thanks and gratitude to the following; Scott Talley for helping with all the editing for this thesis, the Graduate Assistants in the Human Performance Lab for helping distribute the creatine to the subjects, my roommates who helped to take care of my pets during times of long hours spent in the recreation center for subject testing and for all the support given all year long towards the thesis, Melissa Petrucci who not only helped out at home but also in the study as well, and to all the subjects who participated in the study. This study would not have been possible without all those who volunteered to give up their time and efforts during the course of this study.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Creatine has become popular among athletes and non-athletes as a strength enhancement supplement. Despite its popularity, there remains unanswered questions as to its effectiveness, particularly in women.

Creatine's Role In The Body

Creatine's value to physical performance is its ability to maintain energy strores during sprints, resistance training, and other high intensity events lasting approximately 30 seconds or less (Kreider, et al., 1998b). Creatine is stored in the skeletal muscles in one of two forms. One third is present as free creatine, which "floats" freely inside the muscle while two thirds is in phosphocreatine (PC) (Kreider, et al., 1998b; Poortmans, Auquier, Renaut, Durussel, and Brisson, 1997; Mujika and Padilla, 1997). On average, the skeletal muscles store about 125 mmol/kg dm with approximately 150 –160 mmol/kg dm being the maximum amount stored (Greenhaff, 1995). The total concentration of creatine inside the body depends on the amount of muscle mass in the body and the amount of creatine in the diet.

In its raw state, creatine is useless to the body until it is converted into PC by the enzyme creatine kinase. By the addition of a high-energy phosphate group, creatine becomes PC which can react with adenosine diphosphate (ADP) to form adenosine triphosphate (ATP). By producing more ATP, additional energy is available to the cells for stronger muscle contractions (Maughan, 1995).

The Creatine Theory

It is known that creatine is part of the anaerobic metabolism which provides short, intense bursts of energy (Kreider, et al., 1998b). It has also been suggested that creatine may buffer fatigue causing lactic acid, thus increasing the total time to muscle exhaustion (Newsholme and Beis, 1996; Maughan, 1995). Therefore, supplementing the diet with creatine and filling the muscle cells to their maximum could provide additional energy for an individual during anaerobic activities.

Speculations have been made as to why higher PC stores may increase muscular strength gains. Several studies (Hultman, Soderlund, Timmone, Cederblad, and Greenhaff, 1996; Greenhaff, Bodin, Soderlund, and Hultman, 1994; Kreider, et al., 1998b; Maughan, 1995; Volek, Kraemer, Bush Boetes, Incledon, Clark, and Lynch, 1997b) suggest that it may be due to faster PC resynthesis during exercise as PC is used up in the muscle. Once most of the PC is gone ATP can no longer be generated fast enough and fatigue sets in. Furthermore, since PC resynthesis begins immediately after exercise PC stores are nearly full within a few minutes (Greenhaff, et al., 1994). Therefore, higher levels of PC could also allow for faster recovery. Greenhaff, et al.

(1994) were able to demonstrate that after several days of creatine supplementation creatine stores were 30% higher at the end of the recovery period than before supplementation.

Creatine supplementation has been shown to increase muscle size and fat free mass (FFM) due to an increase in water retention (Hultman, et al., 1996). Creatine attracts water as it enters the muscle cell which would increase the actual size of the muscle by means other than protein synthesis. Many individuals experience increased muscle edema during workouts when supplementing their diet with creatine (Volek, 1997b). However, such gains in muscle size may not necessarily lead to increases in muscular strength. Other studies have also theorized that creatine supplementation increases FFM due to an increase in protein synthesis (Clark, 1997; Ingwall, 1976; Volek and Kraemer, 1996; Volek et al., 1997a, 1997b).

Some short-term creatine studies (typically 20 g/day for 5-7 days) have shown a five to eight percent increase in speed or power output in all out sprints in men. During sets of multiple repetitions it has been observed that workloads can be increased by 5-15%. For all out one repepitition power lifts and vertical jumping, improvements of up to five to ten percent have been noted. For long-term creatine studies (typically 20 g/day for 5-7days for loading and 2-25 g/day up to three months for maintenance), gains in single bouts of power and strength are increased by as much as 5-15% (Kreider, 1998a). The majority of studies which investigated the effects of creatine used male recreational bodybuilders, powerlifters, and collegiate athletes. Therefore, it is not surprising that the affects of creatine in women are uncertain at best.

Statement of the Problem

Despite the fact that many women enjoy bodybuilding and power lifting and that many female collegiate athletes possibly supplement their diet with creatine, few studies have investigated the effects of creatine supplementation in women. The purpose of this study was to see if three weeks of creatine supplementation improved maximal strength gains in women.

Hypothesis

The hypothesis of this study is that compared to a placebo, women supplementing with creatine will show greater maximal strength gains in the bench press and leg press.

Delimitations

Only ten female collegiate subjects were used in this study. Initially, collegiate athletes were the desired population, because of the controversy over creatine supplementation, all athletes were not allowed to participate in the study by coaches and athletic training personnel. Therefore all of the subjects used for the study were females from the Eastern Illinois University student body and were not of the same fitness level.

Most subjects were not strength trained and needed to be shown how to perform the main two lifts for the study which added a possible "learning effect" to the results.

It was difficult to provide the subjects with their respective supplement while keeping the study double-blinded.

Limitations

It was assumed that all subjects performed all lifts correctly without direction and guidance from a more highly trained person and that all participants followed all instructions for workouts and supplementation.

Creatine stores were not measured inside the muscles of the subjects. Therefore, it was assumed that all creatine stores were similar for all subjects.

It was assumed that the diets of the subjects remains unchanged throughout the study.

Definitions of Terms

ATP (adenosine triphosphate) – A compound containing adenine, ribose, and three phosphate groups found in cells. The chemical bonds of the phosphate groups store energy needed by the cell for muscle contractions (Bantam Medical Dictionary, 1994).

ADP (adenosine diphosphate) – A compound containing adenine, ribose, and two phosphate groups. ADP occurs in cells and is involved in processes requiring the transfer of energy (Bantam Medical Dictionary, 1994).

Bench-Press – A muscular exercise that stresses and strengthens the muscles of the chest, shoulders, and the upper arm muscles.

Creatine phosphate – Intramuscular substance involved with energy production. The phosphate (creatine phosphate, phosphocreatine (PCr)) acts as a high-energy source in muscle and serves to maintain adequate amounts of ATP, the source of energy for muscular contractions (Bantam Medical Dictionary, 1994).

Creatinine – A waste product derived from creatine and creatine phosphate in the muscle (Bantam Medical Dictionary, 1994).

Creatine kinase – An enzyme involved in the metabolic breakdown of creatine to creatinine (Bantam Medical Dictionary, 1994).

Lactic acid – A fatigue causing compound formed in the cells as a by product of anaerobic glycolysis.

Loading phase – A phase when higher dosages of creatine are consumed to create a fast influx of creatine into the muscles.

Leg press – A muscular exercise that stresses and strengthens the muscles of the hip and knee (e.g. the quadriceps, hamstrings, and gluteus maximus)

Maintenance phase –A phase of creatine which low dosages of creatine are use to maintain creatine levels in the muscles.

Muscle fatigue – A decrease in muscular force production that may be due to the accumulation of waste products in the muscles, dehydration, hyperthermia, neural fatigue, and depletion of energy stores (Bantam Medical Dictionary, 1994).

1RM (one repetition maximum) – The maximal amount of weight an individual can lift one time with a maximal effort.

Placebo – A substance that is ineffective but given to mimic the protocol followed with an experimental drug or supplement (Bantam Medical Dictionary, 1994).

CHAPTER II

REVIEW OF LITERATURE

Introduction

The purpose of this study was to determine if creatine supplementation increased maximal strength in women. Background on the role of creatine in the body, studies looking at strength gains in men taking creatine, and the few studies involving women and creatine supplementation are reviewed here.

A Brief History

A scientist named Chevrevl discovered the existence of creatine in 1835. It was not until 1847 that Liebig discovered creatine was an extract contained in the muscle cells of humans and animals. In the late 1920's, Fiske and Subbarrow discovered that phosphocreatine was an important factor in providing energy for muscle contractions and that the amount of phosphocreatine decreased during muscle contraction and increased during recovery. Fiske and Subbarrow also showed that when creatine was consumed, very little was actually excreted by the body. Collectively, it was determined that creatine plays an important role in energy production of muscle tissue and needs to be replenished (Greenhaff, 1995; Balsom, Soderlund, and Ekblom, 1994).

Creatine and Medical Research for Diseases

Studies have also researched creatine supplementation and PCr administration and its effects on heart disease. Several of the studies showed that intravenous PCr administration improved myocardial metabolism and reduced signs of ventricular fibrillation in patients who have ischemic hearts. (Andrews, Greefaff, Curtis, Pery, Cowley, 1998; Constantin-Teodosiu et al., 1995; Conway and Clark, 1996; Ferraro et al., 1996; Horn et al., 1998; Gordon et al., 1995; Schaufelberger and Swedberg, 1998). It has been suggested that creatine may decrease the injury to ischemic cells by allowing them to work at a higher level without damaging the cell. It is also known that PCr has been administrated intravenously from time to time as a treatment during heart patients' therapy (Saks et al., 1996).

Creatine supplementation was used in patients with chronic heart failure to see how it affected the function of the heart and the ability to exercise. It did not seem to improve any patients with an ejection fraction of 40% or less but did show significant increases in knee extensions (21%), peak torque (5%) and cycle ergometry (10%) (Gordon, et al., 1995).

In an area that is relatively new to creatine studies, researchers found that after creatine supplementation, patients with neuromuscular disease showed significant improvements in anaerobic exercises such as handgrip, dorsiflexion, and knee extension and in high-intensity aerobic exercise (Tarnopolsky, Roy, and MacDonald, 1997; Tarnopolsky and Martin, 1999). There is still much more research to be done in this field.

Spila, Rapola, Simell, and Vannas (1981), demonstrated that patients with gyrate atrophy (an eye disorder) who received 1gram (gm) of creatine a day for one year not only showed a reversal of the atrophy of type II muscle cells but also noticed an improvement in skeletal muscle strength (Balsom et al., 1994; Hultman, et al., 1996). However, it has only been within the last few years that creatine has become popular in the world of bodybuilding and sports in general as a possible strength enhancement supplement.

Creatine Sources

Creatine is naturally found in the body and it is a mixture of three different amino acids, arginie, glycine, and methionine (Balsom, 1994; Greenhaff, et al., 1994). Creatine is either produced by the liver, pancreas, and kidneys or it is taken in through the diet. Creatine is only produced endogenously if the diet is not sufficient enough in creatine consumption, such as with vegans (Walker, 1960). When consumed, creatine must be drawn out of the body's plasma and into the muscle since they are not capable of producing creatine (Clark, 1998). Creatine is taken in to the muscle cell by an active transport against the concentration gradient and once inside it is trapped to ensure creatine concentrations remain elevated (Greenhaff, 1997).

After creatine has been taken up and used by the muscle cells it is broken down into a compound called creatinine, a waste product that is filtered by the kidneys and excreted from the body. However, when ingested in large quantities, the body excretes creatine rather than creatinine in the urine (Harris, Soderlund, and Hultman, 1992). Over a three-day period of creatine supplementation, Harris, et al. (1992) found that the kidneys excreted 40%, 61%, and 68% of the creatine taken per day, respectively. It was assumed that the creatine not excreted entered the muscle cells. Similar findings were found in other studies (Maganaris and Maughan, 1998; Poortmans et al., 1997). Therefore, as creatine supplementation fills creatine levels inside the muscle, the excess amount is excreted from the body.

How To Take Creatine

Initially the recommended doses of creatine consumption were the same for everyone which involved starting with a loading dosage and then switching to a lower maintenance dose. However, it has been suggested that the doses be adjusted according to individual differences such as body weight, frequency of workouts, and the length and intensity of workouts. In their book Creatine: Nature's Muscle Builder, Sahelian and Tuttle (1997) came up with a table for the loading phase and maintenance phase showing their recommendations of creatine consumption. While these recommendations do not have to be followed, (more traditional loading and maintenance dosages can be ingested) by incorporating them into a individual's routine, creatine supplementation may be more efficient than using the standard loading and maintenance dosages.

Studies and Creatine Supplementation

Numerous studies have been conducted since creatine first became popular as a dietary supplement by Experimental and Applied Sciences (EAS) in 1993. Many studies have scientifically shown that creatine supplementation does work while others have not. In this next section, studies supporting both sides of the creatine issue will be summarized and briefly discussed.

When Creatine Does Work In Men

Greenhaff et al. (1993) conducted a study on six subjects divided up into two groups of three. One group took creatine four times daily for five days in doses of five grams per dose. Muscle torque was measured using unilateral knee extensions before and after creatine use. Both groups performed the same test, completing five bouts of 30 reps at maximal velocity. Each subject completed the test three times, once for a preliminary run to base further finding on, then once with the use of a placebo and one last time with the use of creatine. There was a five to seven percent increase in muscle velocity after creatine supplementation but there were no significant differences found in muscle voleocity after use of a placebo.

In another study, Kreider et al. (1998b) looked at strength increases in the bench press, squat, and the power clean. For the study, 28 NCAA division IA football players were divided into two groups, placebo group and a creatine group. The subject's followed a prescribe weight training regimen. Pre- and post-testing lifts consisted of maximal efforts for the bench, squat, and power clean. After 28 days of creatine or placebo supplementation there was a significant difference between the placebo group and the creatine group in the bench press. Conversely, in the squat and power clean movements, no significant differences were found. From the sum total of all the lifts, it was found that the creatine group showed significant increases in the overall total power gained compared to the placebo group. The placebo group had a total of 1,105 ± 429 kg and the creatine group had a total of 1,558 ± 645 kg.

In yet another study, Kamber et al. (1999) divided ten well-trained athletic students into a placebo or creatine group. Each subject performed ten, six second sprints with 30-second bouts of rest in between each trial. This protocol was performed once and then after five days of creatine or placebo use. Subjects in the creatine group ingested 20 grams of creatine a day in four separate dosages for five days. After the five days, there was a significant decrease in sprint times for the creatine group (-3.5 ± 0.5%) while the placebo group showed no significant improvement (-0.07 ± 0.4%).

Volek et al. (1997b) conducted a study on 14 trained athletes. Two groups of seven were assigned to either a creatine or placebo group. Each group performed the bench press and a jump squat on three separate occasions with six days of rest between each testing trial. During the first two trials, no creatine was consumed. Immediately after the second trial, each group was given either a creatine (25 g/day for six days) or a placebo for six days. The creatine group did not demonstrate significant increases between trial one and trial two, however, they did show significant increases between trials two and three. The placebo group, on the other hand, demonstrated no significant results between any of the three trials. How much of a significant increase there was is not known. It was only stated that there were significant increases in the creatine group.

In fact, creatine supplementation has shown an increase in body mass in all types of individuals, including sedentary individuals. Ziegrnfuss et al. (1998) found a 1.8% significant increase in the total body mass of sedentary omnivorous men after five days of creatine supplementation (35 g/kg of body weight).

When Creatine Doesn't Work In Men

Some individuals who have used creatine as a dietary supplement have found little or no beneficial gains. Greenhaff et al. (1994) demonstrated why creatine supplementation might not always be effective. Eight male subjects volunteered to have muscle biopsies taken after 32 seconds (s) of electrical stimulation (1.6 s of stimulation with 1.6 s of rest in between each electrical bout) to the upper thigh before and after creatine supplementation (20 g/day for five days). Biopsies were collected at 20, 60, and 120 seconds respectively. At the conclusion of the study, five of eight subject's total creatine stores were higher. After studying the amounts of creatine stores in the muscle cell before and after supplementation, it was found that the subjects with the most benefits from creatine ingestion were the ones who started out with the lowest creatine concentration stores in their muscles (approximately 120 mmol/kg dm). The subjects showed an average increase of 29 ± 3.0 mmol/kg dm. Three of the eight showed little gain in total creatine stores and no increase in PCr resynthesis. These subjects started out with creatine stores of approximately 125 mmol/kg dm and after five days of creatine ingestion only showed a five percent increase in their total creatine stores.

What causes some individuals to have more or less natural muscle creatine stores is not known. There may be many factors but Greenhaff has noted that women seem to have a higher level of creatine stores and vegetarians have the lowest (Greenhaff, 1995).

Five out of six studies conducted on prolonged swimming activities displayed no ergogenic effects of creatine supplementation (Burk, Pyne, and Telford, 1996; Grindstaff, et al., 1997; Mujika, Charard, Lacoste, Barale, and Geyssant, 1996; Peyrebrune, Nevill, Donaldson, and Cosford, 1998; Thompson, et al., 1996). For these studies, both men and women were used. In fact, most of the swimming studies used women rather than men. The fact still remains, however, that overall there are more creatine studies that used men compared to women.

Cooke, Grandjean, and Barnes, (1995) investigated creatine supplementation in 12 healthy untrained individuals during bicycle sprints. Half the subjects were placed in the creatine group (20 g/day for five days) or placebo group. Each group performed the sprints two times, once before creatine or placebo supplementation and once after. No significant changes were found in sprint performance after five days of creatine supplementation.

Research has demonstrated that caffeine may counter the positive effects of creatine. While the filling of creatine stores was not seem affected by caffeine use, the results did demonstrated that caffeine users produced 10-20% lower torque production. The reasons for this counteraction are not known (Vandenberghe, Van Leemputte, Ban Hecke, Vanstapel, and Hespel, 1996).

While creatine has not shown significant improvements in physical performance, the majority of these studies have used aerobic as opposed to anaerobic protocols. Furthermore, the majority of studies that have shown a significant improvement in anaerobic performance have been conducted on male subjects. Whether the improvements are due to creatine's buffering capacity, PC synthesis or an increase in muscle mass has yet to be determined. However, regardless of the reason, it is logical to assume the same affect would occur in women, yet few studies have looked at creatine affect in women.

When Creatine Does Work In Women

Larson et al. (1998) studied fourteen female soccer players who were divided into two groups, a creatine group (15 g/day for seven days then 5 g/day for 12 weeks) and a placebo group. Subjects performed a series of 300 yard runs during the 12-week study. After the first three to five weeks of the study, subjects displayed significant improvement in their running time but no improvements were seen beyond that.

Mihic, MacDonald, Mckenzie, and Donaldson (1998) found positive effects of five days of creatine supplementation (20 g/day) in both men and women. While both showed increases, the men had greater increases in their total body mass and FFM.

Safety

With the use of creatine supplementation, some people have questioned creatine's safety. This concern was brought about late in 1997 after the deaths of the three collegiate wrestlers. In all three incidences all the athletes were said to have been taking creatine but all autopsies concluded severe dehydration as the cause of death (NCAA News January 5, 1998).

Another concern with creatine use is how it affects the renal system. There have been several studies conducted that looked at creatine and its effects on renal function. As to date, no significant changes or stress on renal function has been found (Poortmans, et al., 1997; Poortmans and Francaux, 1999; Pritchard and Kalra, 1998; Kuehl, Goldberg, and Eliot, 1998)

Not to be misled by these findings, there have been two documented case studies displaying problems with renal function and creatine use. One short article published in The Lancet commented on a 25 year old man admitted into the hospital for renal failure and he stated that he had been using creatine (Pritchard and Kaira 1998). In another case study, a football player with asthma was documented as having elevated serum and urine levels of creatinine and showing signs of renal stress after practicing twice daily (Kuehl, et al. 1998). In either case, none of the complications were irreversible and both patients regained their healthy status after cessation of creatine use.

There are even some 17-year case studies of gyrate atrophy patients taking creatine with no negative side effects being reported. Unfortunately, there are no written case studies of this. However, Vannas-Sulonen, Sipila, Vannas, Simell, and Rapola

(1985) completed a study with these patients who, after five years of creatine use, showed no side effects. Personal contact has been kept with the patients to monitor their health

The only scientifically documented side effect of creatine found through clinical research, has been weight gain. All other side effects associated with the use of creatine have all been undocumented anecdotal reports by the media and non-scientific publications. Most all of the anecdotal reports of negative creatine side effects have been short-term and of minor significance which ceased upon discontinuation of creatine supplementation. Most of the side effects reported by anecdotal reports are as follows: muscle cramping, stiffness, or spasms, and gastrointestitional pain if too much had been taken at one time (William, Kreider, and Branch et al., 1999).

Summary

Studies looking at creatine and its effects on men dominate this field of study. Searching the literature reveals findings on the affect of creatine in male subjects under most any condition. It is possible to search and find the answer to any question concerning creatine affect on physical performance in men. However, with women, the studies are few and far between. Most of these studies, tend to be geared more towards aerobic activities as opposed to anaerobic. Therefore, a need for scientific studies looking at creatine's affect on women is warranted. Furthermore, there is no scientific support for creatine supplement being a health risk, yet little information is available as to creatine's safety in women.

CHAPTER III

METHODS AND PROCEDURES

Methodology

This study's main objective was to compare maximal strength changes among college age females at Eastern Illinois University while supplementing their diet with either creatine or a placebo for three weeks.

Overview of subjects

Twelve female subjects between the ages of 20 and 24 years of age with a mean age of 21.3 ± 1.3 years were recruited from the university student body. All subjects were required to be female and in good health. The study was conducted as a double blind study to reduce the chance of the investigator skewing the results by either encouraging or discouraging the subjects. Six subjects were randomly assigned to either the creatine group (CG) or the placebo group (PG).

Description of Research Design and Procedures

All subjects were required to complete and sign a health history questionnaire and an informed consent form explaining the details, risks and benefits of the study (Appendix A and B).

Testing

Prior to initial strength tests each subject was required to do a ten-minute aerobic warm-up and then approximately ten more minutes of stretching to reduce risk of injury during maximum lifts. The stretches focused on the muscles of the chest, shoulder and upper arms for the upper body and the quadriceps, hamstrings, gluteus maximus for the lower body. After completion of the warm-up the subjects were taken to the free weight area of the Student Recreation Center to perform a 1RM for the bench press and leg press. The subjects performed two very light sets of eight to ten repetitions to prepare the muscles for the movement and range of motion used in the lifts. After the warm-up sets were completed, the subjects were then asked to lift a single resistance determined by the investigator to be near their individual maximal effort. At the completion of each repetition the subject was requested to set the barbell back into it's resting position regardless of if they could perform any further repetitions. The subjects were required to recover at least two to five minutes. After each repetition, the subjects was asked specifically how many repetitions they felt they could have completed if they had been able to finish the set out. Then the weight was increased according to their response.

Responses indicating the possibility of completing ten or more repetitions were increased by ten pounds per side. Responses indicating the possibility of completing between six to ten repetitions were increases by seven and one half pounds per side. Responses consisting of four to six repetitions were increased by five pounds per side and responses consisting of two to four repetitions were increased by two and one half pounds per side. This process was repeated until the subjects felt they could not do a further repetition or they failed their recent repetition. Most subjects reached their 1RMs in two attempts but none of the subjects needed more than four.

After each subjects' pre-test 1RMs was determined, each subject was given a specific strength training program to follow for three weeks (Appendix C). All subjects performed the same exercises for the same number of repetitions and sets. Only the resistance varied based on the subjects' initial strength level.

Supplementation

Subjects underwent were three weeks of supplementation. For the CG the first week was a loading phase and the last two weeks were a maintenance phase. The creatine and the placebo supplements were both distributed to the subjects by a Human Performance Lab Graduate Assistant. Both the creatine and placebo were distributed in two forms, a powder form mixed with sugar free lemonade or in capsule form. The capsules were chosen for the weekends when the lab was closed. This allowed the subjects to take their daily dosages at home. During the week, creatine was consumed in powered form and mixed with sugar free lemonade warmed in a microwave for approximately 30-45 seconds. The placebo consisted of baking soda and sugar mixed with lemonade. Heating the creatine and placebo helped the supplements to dissolve better in the lemonade and minimize noticeable texture differences.

For one week the CG went through an initial loading phase with 12-13 grams of creatine per day. For the following two weeks, subjects consumed either a three to four gram dose per day.

Due to the possibility of stomach upset, the amount of baking soda added to the sugar was just enough to change the flavor of the lemonade. "Take home" doses of the placebo were 12 g/day for two days during the loading phase and two to three grams per day during the maintenance phase.

At the end of the supplementation, the subjects performed post 1RMs following the same procedure as the preliminary 1RM testing.

Other than the addition of creatine or placebo, subjects were asked not to alter or monitored their diet during the course of the study.

<u>Description of Analysis Techniques</u>

A single factor ANOVA with repeated measures was used to calculate the differences between pre and post 1RM of the creatine and placebo groups. Significance was set at the $p = .05$ level. A Macintosh version of Stat View 512+ software was used for statistical analysis.

CHAPTER IV

RESULTS

Some studies have shown significant increases in maximal muscle strength in males (Greenhaff et al., 1993; Kreider et al., 1998b; Kamber et al., 1999; Volek et al., 1997b;) while others have not (Greenhaff, 1994; Cooke et al., 1995; Vandenberghe, 1996). Since the majority of studies have used male subjects the purpose of this study was to compare maximal bench press and leg press strength between subjects given creatine or a placebo.

Findings

Tables 1 and 2 show no significant difference in 1RM for the bench press between CG (107 ± 6.0 lbs.) and PG (108 ± 8.0 lbs.) nor for the 1RM leg press between the CR (362 ± 15.0 lbs.) and PG (432 ± 29.4 lbs.).

Also, as shown in Tables 1 and 2 there was no significant difference between CG and PG in the increase in muscular strength from pre-test to post tests values for the bench press (12 ± 2.2 lbs. and 8 ± 2.8 lbs. respectively) and the leg press (70 ± 47.2 lbs. vs. 56 ± 12.7 lbs., respectively). Although not significantly different, it should be noted that CG showed a larger increase from pre-test to post-test 1RM values than PG for both the bench press and leg press.

Table 1 – Pre- and post-test 1RM values in creatine and placebo groups

Leg Press		
Group	Pre 1RM (lbs.)	Post 1RM (lbs.)
Creatine	292 ± 28.0	362 ±15.0
Placebo	374 ± 44.6	432 ± 29.4

Table 2 – Pre- and post 1RM values in creatine and placebo groups

Bench Press		
Group	Pre 1RM (lbs)	Post 1RM (lbs)
Creatine	95 ± 4.5	107 ± 6.0
Placebo	101 ± 3.5	108 ± 8.0

Tables 3 and 4 provide the raw scores of each subject and their percent of improvement in 1RM for the bench press and leg press, respectively.

Table 3 – Raw scores of the subjects' max lifts and improvements for bench press

Subject	Group	Pre 1RM (lbs)	Post 1RM (lbs)	Difference (lbs)	Increase (%)
		Bench	**Press**		
A	Creatine	95	105	10	9.6
B	Creatine	85	95	10	10.6
C	Creatine	105	115	10	8.7
D	Creatine	105	125	20	16.0
E	Creatine	85	95	10	10.6
Average		95	107	12	11.3
F	Placebo	90	100	10	10.0
G	Placebo	120	120	0	0.0
H	Placebo	100	115	15	13.1
I	Placebo	80	90	10	11.2
J	Placebo	115	120	5	4.2
Average		101	108	8	6.5

Table 4. Raw scores of the subjects' max lifts and improvement for leg press

		Leg	Press		
Subject	Group	Pre 1RM (LBS)	Post 1RM (LBS)	Differences (lbs)	Increase (%)
A	Creatine	230	410	180	44.0
B	Creatine	390	420	30	7.2
C	Creatine	340	410	70	17.1
D	Creatine	290	290	0	0.0
E	Creatine	210	280	70	25.0
Average		292	362	70	18.6
F	Placebo	320	340	20	5.9
G	Placebo	410	500	90	18.0
H	Placebo	430	510	80	15.7
I	Placebo	230	290	60	20.7
J	Placebo	480	510	30	5.9
Average		374	432	56	13.2

Figures 1 and 2 show the overall increases in pounds and percent improvement for each group and the lifts performed. For the bench press the creatine group increased their 1RM weight by an average of 11.3% while the placebo group increased their weight an average of 6.5%. For the leg press, the creatine group improved their 1RM average by 18.6% and the placebo group showed an average improvement of 13.2%.

While the creatine group displayed larger gains in absolute and relative strength, none of the differences were significant.

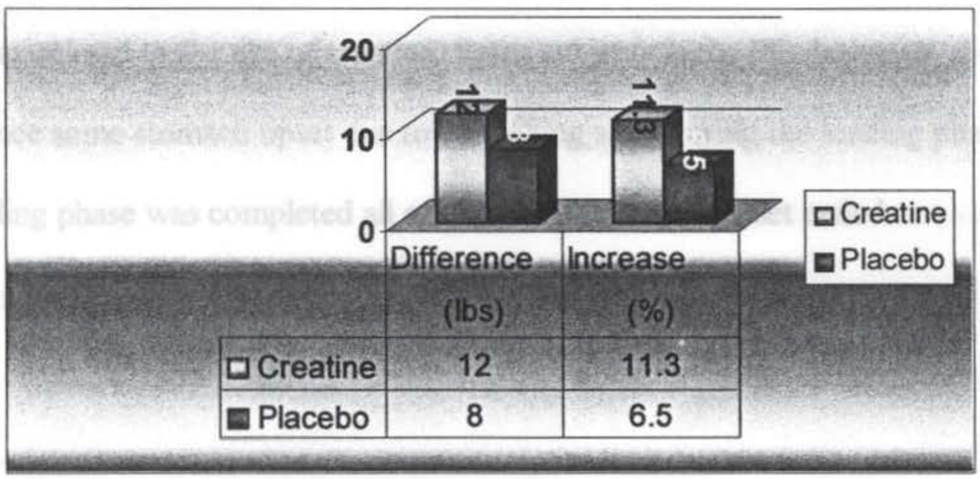


Figure 1. Absolute (lbs) and relative (%) changes between pre and post test for bench press

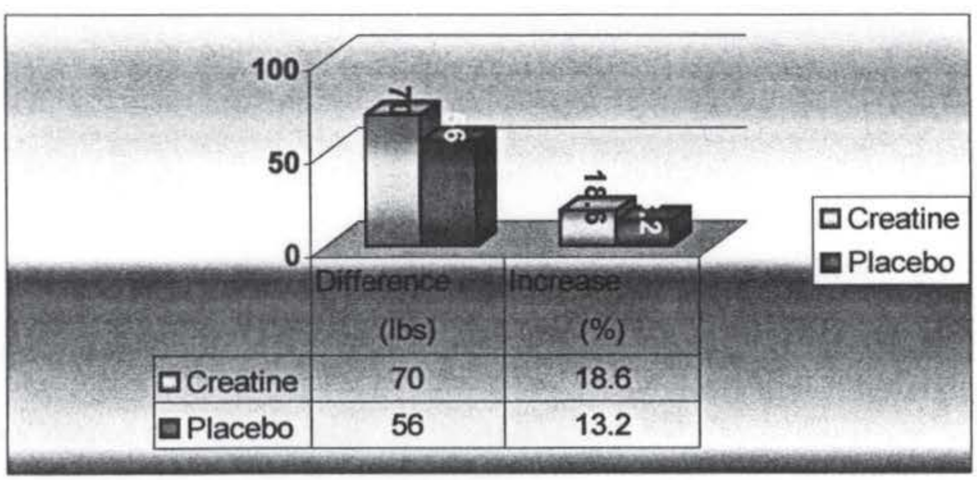


Figure 2. Absolute (lbs) and relative (%) changes between pre and post test for leg press

Side Effects

Due to the concern, some people have with the safety of creatine's it is noteworthy to report that none of the subjects on creatine expressed any problems while supplementing with creatine. During the course of the study two subjects were force to withdraw with the experiment. One of the subjects dropped out due to time constraints and the other drop by doctor's orders because of medical problems that arose during time of creatine supplementation. However, later it was found that the medical problems were in no way related to the use of creatine. Some subjects in the PG, however, did experience some stomach upset due to the baking soda during the loading phase. After the loading phase was completed all symptoms of stomach upset ended.

CHAPTER V

DISCUSSION

Observations of Findings

This study did not show a statistically significant improvement in maximal muscular strength from creatine supplementation. However, in 21 days of use, the CG showed a 12.0 ± 2.2 lbs. (11.3%) increase in the bench press and a 70.0 ± 47.2 lbs (18.6%) increase in the leg press which are comparable to the increases found in men.

There could be many reasons for the lack of significance. One reason could be the small sample size of 10 subjects. A larger sample size would have been a more accurate representation of the chosen population and provide greater statistical power.

Another reason may be that the CG had higher stores of creatinephosphate to begin with. This would cause the muscle cells to recruit less of the creatine, thus in turn, inhibiting a larger gain in strength. As previously mentioned in the review of literature section, Greenhaff (1995) stated that women in general seem to have higher creatine stores than do men. Although are unknown, this could be responsible for the insignificant outcome.

There is a possibility that some of the subjects in the CG did not take the supplement as directed. If the subjects in the CG missed enough of their dosages, they may have altered the effectiveness of the supplement.

There could have been errors in the measurement of the 1RM. If too many sets were performed before their true 1RM was reached the subjects' muscles may have become too fatigued before achieving their true 1RM. Also, some of the subjects could have felt tired or week during that particular 1RM testing and as a result skewed their 1RM. Furthermore, some of the subjects could have figured out which group they were in and thus altering how hard they tried during their post-testing.

It could be that all or some of the subjects were muscularly deconditioned enough that the strength increases for either group were greater than those of a conditioned weight lifter. If conditioned resistance trained females could have been chosen, the results might have been more significant because the lack of a "learning effect". Experienced subjects would have already known how to perform the prescribed lifts and their muscles would have been use to the movement of each lift. In addition, it is theorized that decontitioned muscles respond more rapidly than a conditioned muscle. This could be due to the muscles learning the motion and neural muscular coordination that it takes to teach the muscles how to properly perform each lift. More often than not, novice weight lifters show the greatest gains within the first few months of training due to neural conditioning. After the neural stimulation has been developed, the increase in strength gains slow down or level off.

Another reason for insignificant results could have been due to the design of the workout for the subjects during the study. It may not have been specific enough to produce greater strength gains. The program only consisted of two muscle specific workouts and one day of general training to include all muscle groups that were not the primary muscles being focused on for the study. This could have led to weak secondary and/or stabilizing muscles, over trained primary muscles, or a combination of the two.

Another reason that may have altered the results of the study could be due to the length of time the subjects supplemented with creatine. Twenty-one days of creatine use may not be enough time for women to display significant results. Volek et al. (1999) demonstrated significant power gains in a 12-week study using 19 resistance-trained men. Subjects consumed 25 g/day for seven days and 5 g/day thereafter until the end of the study. To demonstrate power, two lifts were used, the bench press and the squat. After one week of creatine supplementation the subjects increased their squat by 4%. This was not considered a significant gain, but after 12 weeks of creatine supplementation their squat was significantly increased by 32%. For the bench press, the creatine group showed a significant gain of 5% after just one week. At the end of 12 weeks they had significantly improved their bench by 24%. Therefore, one week of supplementation may not be adequate to see any changes in muscle strength, although when used for longer period of times, the muscular gains seem to become more significant.

One last reason why creatine may not have shown any significant gains in the CG is that it just may not work for women. Considering that Greenhaff (1995) stated that women do have higher stores of creatine than that of men supplementing with creatine just may not provide the added benefit for women as in men.

Suggestions For Further Research

For future studies it is recommended to measure muscle creatine levels before and after supplementation. Additional studies on women and the effects of creatine use are still needed. There are some studies on women now but far fewer than those using men as subjects and many of the studies that did use women as subjects, pertained to cardiovascular endurance and not muscular strength.

Conclusion

Supplementing with creatine over a three-week period failed to show significant increases in maximal arm or leg strength in college aged women. While the majority of studies have involved men, this is one of the few to test creatine's affect in women.

The number of studies proving as well as disproving creatine's affects are closely matched. It's hard to tell which studies are more prevalent. However, the majority of studies showing a positive affect looked at anaerobic strength or power while those showing no affect were from aerobic protocols.

Dr. Richard Kreider at the University of Memphis has prepared a presentation on creatine that presents much of his knowledge and findings that he and his two co-authors, Williams and Branch, found while writing their book: Creatine: The Power Supplement (1999). In his presentation, at http://www.hmse.memphis.edu/faculty/kreider/ asep/asep.htm he presents four tables summarizing their findings for creatine and it effectiveness, or lack there of, in all areas (appendix D-G).

Every individual body is different and everyone's body reacts differently to creatine supplementation. There are many reasons why people react differently to the use of creatine. Things to be taken in to consideration are the activity levels of the individual, physical fitness level, amount of an existing creatine store in side the muscles, and whether or not they are an omnivore or a vegetarian.

In regards to long-term use and safety, too many people feel that the long-term side effects of creatine use are not known, therefore, its safety is in question. However, the long-term side effects of creatine are known up to 17 years in a non athletic population. There just have not been any documented studies showing the effects of long-term creatine use in recreational or professional athletes. Studies researching safety should be long-term studies consisting of at least five years or longer.

REFERENCES

Andrews, R., Greenhaff, P., Curtis, S., Perry, A., and Cowley, A.J. (1998). The effect of dietary creatine supplementation on skeletal muscle metabolism in congestive heart failure. European Heart Journal 19, 617-622.

Balsom, P.D., Soderlund, K., and Ekblom, B. (1994). Creatine in humans with special reference to creatine supplementation. Sports Medicine. 18, 232-237.

The Bantam Medical Dictionary. (1994). New York. Bantam Book.

Burk, L.M., Pyne, D.B., and Telford, R.D. (1996). Effect of oral creatine supplementation on single-effort sprint performance in elite swimmers. International Journal of Sport Nutrition. 6, 222-233.

Clark, J.F. (1997). Creatine and phosphocreatine: A review of their use in exercise and sport. Journal of Athletic Training. 32, 45-50.

Clark, J.F. (1998). Creatine: A review of its nutritional applications in sport. Nutrition. 14, 322-324.

Committee asks for anti-dehydration guideline to become rule. (1998). The NCAA News.

Constantin-Teodosiu, D., Geenhaff, P.L., Gardiner, S.M., Randall, M.D. March, J.E., and Bennett, T. (1995). Attenuation by creatine of myocardial metabolic stress in Brattleboro rats caused by chronic inhibition of nitric oxide syntheses. British Journal of Pharmacology. 116, 3288-3292.

Conway, M.A., and Clark, J.F., eds. (1996). Creatine and Creatine Phosphate: Scientific and Clinical Perspectives. San Diego. Academic Press.

Cooke, W.H., Grandjean, P.W., and Barnes, W.S. (1995). Effect of oral creatine supplementation on power output and fatigue during bicycle ergometry. Journal of Applied Physiology. 78, 670-673.

Ferraro, S., Codella, C., Palumbo, F., Desiderio, A., Trimigliozzi, P., Maddalena, G., and Chiariellol, M. (1996). Hemodynamic effects of creatine phosphate in patients with congestive heart failure: A double-blind comparison trial versus placebo. Clinical Cardiology. 19, 699-703.

Gordon, A., Hultman, E., Kaijser, L., Kristjansson, S., Rolf, C.J., Nyquist, O., and Sylven, C., (1995). Creatine supplementation in chronic heart failure increases skeletal muscle creatine phosphate and muscle performance. Cardiovascular Research. 30, 413-438.

Greenhaff, P.L., Bodin, K., Soderlund, K., and Hultman, E. (1994). Effect of oral creatine supplementation on skeletal muscle phosphocreatine. American Journal of Physiology. 5, E725-E230.

Greenhaff, P.L., Casey A., Short A.H., Harris A.C., Soderlund K, and Hultman, E. (1993). Influence of oral creatine supplementation on muscle torque during repeated bouts of maximal voluntary exercise in man. Clinical Science. 84, 565-571.

Greenhaff, P.L. (1995). Creatine and its application as an ergogenic aid. International Journal of Sport Nutrition. 5, S100-S110.

Greenhaff, P.L. (1997). The nutritional biochemistry of creatine. Journal of Nutritional Biochemistry. 11, 610-618.

Grindstaff, P.D., Kreider, R., Bishop, R. Wilson, M. Wood, L., Alexander, C., and Almada, A. (1997). Effects of creatine supplementation on repetitive sprint performance and body composition in competitive swimmers. International Journal of Sport Nutrition. 7, 330-346.

Harris, R.C., Soderlund, K., and Hultman, E. (1992). Elevation of creatine in resting and exercise muscle of normal subjects by creatine supplementation. Clinical Science. 83, 367-374.

Horn, M., Frantz, S., Remkes, H., Laser, A., Urban, B., Mettenleiter, A., Schnackerz, K., and Neubauer, S. (1998). Effects of chronic dietary creatine feeding on cardiac energy metabolism and on creatine content in heart, skeletal muscle, brain liver and kidney. Journal of Molecular and Cellular Cardiology. 30, 277-284.

Hultman, E., Soderlund, K., Timmone, J.A., Cederblad, G., and Greenhaff. P.L. (1996). Creatine loading in men. Journal of applied Physiology. 81, 232-237.

Ingwall, J.S. (1976). Creatine and the control of muscle-specific protein synthesis in cardiac and skeletal muscle. Circulation Research. 38, I-115-I-123.

Kamber, M., Koster, M., Kreis, R., Walker, G. Walker, B.,and Hoppeler, H. (1999). Creatine supplementation- Part I: performance, clinical chemistry, and muscle volume. Medicine & Science in Sports & Exercise. 31: 2, 1763-1768.

Kreider, R. B. (1998). Creatine Supplementation. Journal of Exercise Physiologyonline 1, 1-10.

Kreider, R.B., Fereira, M., Wilson, M., Grendstaff, P., Plisk, S., Reinardy, J., Cantler, E., and Alamada, A.L. (1998b). Effects of creatine supplementation on body composition, strength, and sprint performance. Medicine and Science in Sports and Exercise. 30, 491-496.

Kuehl, K., Goldberg, L., and Eliot, D. (1998). Renal insufficiency after creatine supplementation in a college football athlete. Medicine and Science in Sports and Exercise. 30, S235. (abstract).

Larson, D.E., Hunter, G.R., Trowbridge, C.A., Turk, J.C., Harbin, P.A., Harbin, P.A. and Torman, S.L. (1998). Creatine supplementation and performance during off-season training in female soccer players. Medicine and Science in Sports and Exercise. 30, S264. (abstract).

Maganaris, C.N., and Maughan, R.J. (1998). Creatine supplementation enhances maximum voluntary isometric force and endurance capacity in resistance trained men. Acta Physiologica Scandinavica. 163, 279-287.

Maughan, R. J. (1995). Creatine supplementation and exercise performance. International Journal of Sports Nutrition. 5, 94-101.

Majika, I., Chatard, J.C., Lacoste, L., Barale, F., and Geyssant, A. (1996). Creatine supplementation does not improve sprint performance in competitive swimmers. Medicine and Science in Sport and Exercise. 82, 1435-1441.

Mihic, S., MacDonald, J.R., Mckenzie, S., and Tarnopolsky, M.A. (1998). The effect of creatine supplementation on blood pressure, plasma creatine kinase, and body composition. FASEB Journal 12, A652. (abstract).

Mujika, J.R., and Padilla, S. (1997). Creatine supplementation as an ergogenic aid for sports performance in highly trained athletes: a critical review. International Journal of Sports Medicine. 18, 491-496.

Newsholm, E.A., and Beis, I. (1996). Old and new ideas on the roles of phosphagens and their kinases. [Creatine and creatine phosphate: Scientific and clinical perspectives, ed M.A. Conway and J.F. Clark, pp. 3-15. Dan Diego: Academic Press.]

Peyrebrune, M.C., Nevill, M.E., Donaldson, F.J., and Cosford, D.J. (1998). The effects of oral creatine supplementation on performance in single and repeated sprint swimming. Journal of Sports Sciences. 16, 271-279.

Poortmans, J.R., Auquier, H., Renaut, V., Durussel, S.M., and Brisson, G.R. (1997). Effect of short-term creatine supplementation on renal responses. European Journal of Applied Physiolagy. 18, 566-567.

Poortmans, J.R., and Francuax, M. (1999). Long-term oral creatine supplemntation do not impair renal function in healthy athletes. Medicine and Science in Sports and Exercise. 31, 5. (abstract).

Pritchard, N.R., and Kalra, P.A. (1998). Renal dysfunction accompanying oral creatine supplements. The Lancet. 351, 1252-1253.

Sahelian, R. and Tuttle, D. (1997). Creatine: Nature's Muscle Builder. Avery Publishing Group. Garden City, New York.

Saks, V.A., Stepanov, V. Jaliashvili, I.V., Konerev, E.A., Kryzkanovsky, S.A. and Strumia, E. (1996). Molecular and cellular mechanisms of action for the cardioprotective and therapeutic role of creatine phosphate. [Creatine and Creatine Phosphate: Scientific and Clinical Perspectives, ed. M.A. Conway and J.F. Clark. 91-114. San Diego: Academic Press.]

Schaufelberger, M., and Swedberg, K. (1998). Is creatine supplementation helpful for patients with chronic heart failure? European Heart Journal 19, 533-534.

Sipila, I., Rapola, O., Simell, A., and Vannas. (1981). Supplementary creatine as a treatment for gyrate atrophy of the chorid and retina. New England Journal of Medicine. 867-870.

Tarnopolsky, M. and Martin, J. (1999). Creatine monohydrate increases strength in patients with neuromuscular disease. Neurology. 52, 854-857.

Tarnoplosky, M.A., Roy, B.D., and MacDonald, J.R. (1997). A randomized, controlled trial of creatine monohydrate in patients with mitochondrial cytopathies. Muscle and Nerve. 20, 1502-1509.

Thompson, C.H., Kemp, G.J. Sanderson, A.L., Dixon, R.M. Styles, P., Taylor, D.J. and Radda, G.K. (1996). Effect of creatine on aerobic and anaerobic metabolism in skeletal muscle in swimmers. British Journal of Sports Medicine 30, 222-225.

Vandenberghe, G.N., Van Leemputte, M., Ban Hecke, P., Vanstapel, F., and Hespel, P. (1996). Caffeine counteracts the ergogenic action of muscle creatine loading. Journal of Applied Physiology. 80, 452-457.

Vannas-Sulonen, K., Sipila, I., Vannas, A., Simell, O., and Rapola, J. (1985). Gyrate atrophy of the choroid and retina. Ophthalmology. 92, 1719-1727.

Volek, J.S., Boetes, M., Bush, J.A., Purtukian, M., Sebastianelli, W.J., and Kraemer, W.J. (1997a). Responses of testosterone and cortisol concentrations to high-intensity resistance exercise following creatine supplementation. Journal of strength and Conditioning Research. 11, 182-187.

Volek, J.S., Duncan, N.D., Mazzetti, S.A., Staron, R.S., Putukian, M., Gomez, A.L., Pearson, D.R., Fink, W.J., and Kraemer, W.J. (August 1999). Performance and muscle fiber adaptations to creatine supplementation and heavy resistance training. Medicine & Science In Sports & Exercise. 31: 8, 1147-1155.

Volek, J.S., and Kraemer, W.J. (1997b). Creatine supplementation: Its effect on human muscular performance and body composition. Journal of Strength and Conditioning Research. 10, 200-210.

Volek, J.S., Kraemer, W.J., Bush, J.A., Boetes, M., Incledon, T., Clark, K.L., and Lynch, J.M. (1997b).Creatine Supplementation enhances muscular performance during high-intensity resistance exercise. Journal of American Dietetic Association. 97, 765-770.

Walker, J.B. (1960). Metabolic control of creatine biosynthesis I: Effect of dietary creatine. Journal of Biological Chemistry. 235, 2357-2361.

Williams, M., Kreider, R., and Branch, J. (1999). Creatine: The Power Supplement. Champaign, Il. Human Kinetics.

Ziegenfuss, T., Gales, D., Felix, S., Straehle, S., Klemash, K., Konrath, D., and Lemon, P.W.R. (1998). Performance benefits following a five day creatine loading procedure persist for at least four weeks. Medicine and science in Sports and Exercise. 30, S265. (abstract).

APPENDIX A

Health History Questionnaire

General

Name:______________________________Date:______
Address:_________________________ City:_______________ State:______
Zip:_________ Birth Date:__________ Age:_____ Phone:________________
E-mail:_________________________

Medical History
Check all that apply to either recent or past history to the best of your knowledge

___heart disease
___irregular heart beats
___defective heart valve(s)
___heart murmur
___pulmonary disease
(Bronchitis, emphysema, etc)
___diabetes
___epilepsy
___high cholesterol
___lightheadedness/fainting
___fatigue

___ peripheral vascular disease
___hypertension (high blood pressure)
___cancer
type:_____________
___joint pain (especially knee, hip, ankle, shoulder, or elbow)
list any that apply:______________
___asthma
exercise induced?______
___allergies
___renal problems

Is there any chance that you maybe pregnant? ____yes ___no

List all surgeries that you have had add their dates to the best of your knowledge:_____________

____

____

List all medications that you are currently taking (including birth control)____________________

____

____

APPENDIX A (continued)

Are you allergic to any medical medications?____yes _____no If yes, please list:_________________

____

Physician's name:____________________________ Phone:___________________
Emergency contact:____________________ Relationship:____________________
Phone(home):_________________ Phone(work):______________________

Family history

Has anyone in your immediate family (parents and/or siblings) had heart disease or a heart attack prior to the age of 50?____yes ____no
If yes, please specify:____

Any family history of the following (blood relatives)

___diabetes
___high cholesterol
___hypertension
___ stroke
___renal problems

Exercise History

Do you currently exercise on a regular basis ____yes ____no
If yes, please specify what you do regularly on a weekly basis:______________________________

____

How many total minutes of exercise do you per week:

___<40 minutes
___40-60 minutes
___61-80mintues
___81-100minutes
___>100 minutes

I have read, understood, and completed this questionnaire. Any questions that I had were answered to my full satisfaction.

Name_______________________ Date________________________
Signature___________________________________
Witness_______________________ Date______________________

APPENDIX B

Informed Consent Form

1) The purpose of the experiment-
The purpose of this experiment is too find out if creatine shows strength gains in women as well as in men.

2) Explanation of experiment-
You will be performing two types of weightlifting exercises, the bench press and the leg press. Each test will be performed three times. Once to establish a starting max weight, once half way through the experiment to see how you are progressing and one last time to determine final max weight. For the experiment, you will be randomly placed on one of two groups; a control group or a creatine group. The experiment will be a double blind test so as to help prevent skewing the results. The first week will be a loading phase of approximately 15 grams of creatine a day. The following three weeks there will be a maintenance phase of approximately 5 grams a day. The experiment will last 28 days. However, the experiment will last a total of six weeks. The week preceding the creatine loading will be used to perform the preliminary max lifts to establish your starting strengths. The sixth week following the last week of creatine consumption will be used to perform final max lifts to find final strength gains. During the course of the experiment your diet is to remain the same. No diet changes are necessary and discouraged.

3) Attendant risks and discomforts-
There exists the possibility of certain risks occurring during the experiment. They include abnormal blood pressure and torn muscles during the lifts and the workouts also, during the workout or while taking the supplement here are some possibilities, muscle cramps and spasms for the creatine group. Some of the other possible side affects could be stomach cramps, gastrointestinal problems, bloating, dehydration, and in rare circumstances, renal failure. Every effort will be made to minimize these risks by evaluation of preliminary information relating to your health and fitness and constant updates of your health and fitness through out the experiment.

4) Responsibilities of participant-
Information that you possess about your health status or previous experiences of atypical feelings with physical effort may affect the safety and value of your max lifts. Your prompt reporting of feelings with effort during the max lift itself is also of great importance. You are responsible for fully disclosing such information on your own or when requested by the tester and spotter.

5)Benefits to be expected-
The results to be obtained from this experiment will help to possibly increase the participants muscular strength and further research in the area of creatine and its effects on the human body. Participation in this study will provide subjects with an accurate measurement of maximal strength and a personalized strength program.

6) Inquires-
Any questions about the procedures used or results taken from this experiment are encouraged. If you have any concerns or questions, please feel free to ask for further explanations.

7) Freedom of consent-
Your permission to perform this experiment is voluntary. You are free to drop out of the experiment at any point, if you so desire.

APPENDIX B (continued)

I have read this form, and I understand the procedures involved in the experiment that I will be performing and the attendant risks and discomforts. Knowing these risks and discomforts, and having been able to ask questions and receiving answers to my satisfaction, I consent to participate in this experiment.

__________ ______________________________

Date Signature of participant

__________ ______________________________

Date Signature of Witness

__________ ______________________________

Date Signature of authorized delegate

APPENDIX C

Weekly Workouts

Workout #1 – Chest

Bench Press 3 sets of 8-12 repetitions (3x8-12)
Incline Press 3 x 8-12
Incline Dumbbell Press 3 x 8-12
Flat Bench Flies 3 x 8-12

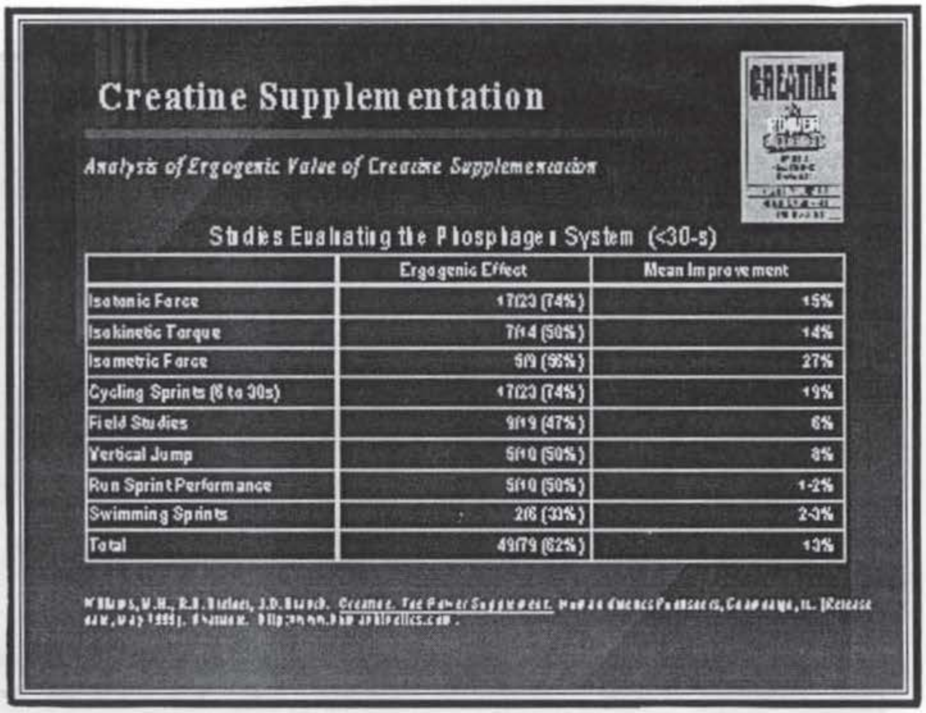
Workout #2 – Legs

Leg Sled 3 x 8-12
Stiff Legged Deadlift 3 x 8-12
Leg Extension 3 x 8-12
Leg Curl 3 x 8-12

Workout #3 – Back, Bicep, Tricep, Shoulders

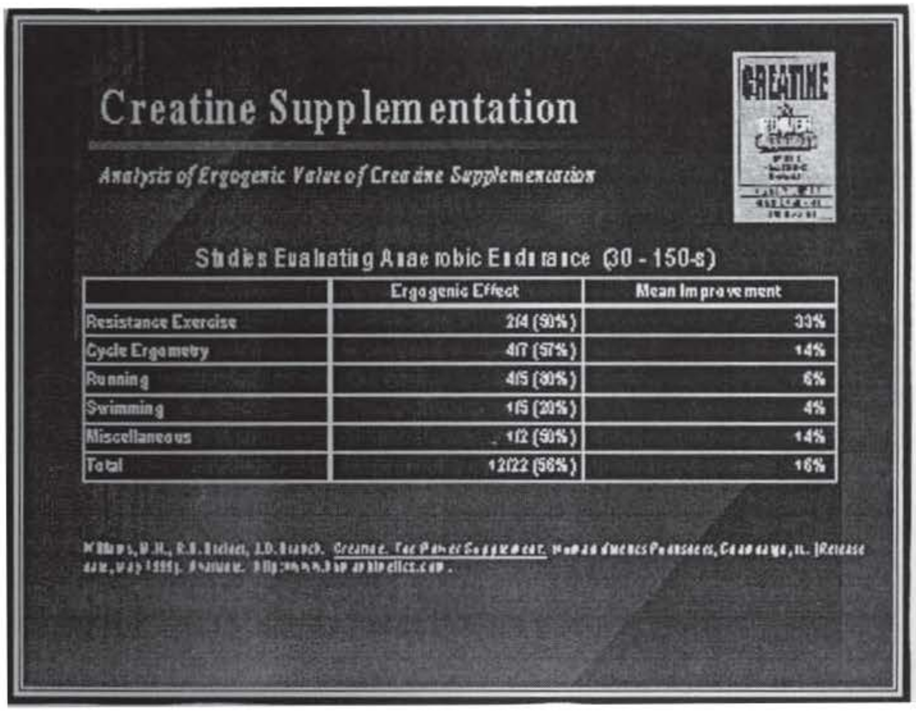
Lat Pulldown 3 x 10
Straight Bar Bicep curl 3 x 10
Tricep Pushdowns 3 x 10
DB Shoulder Press 3 x 10

APPENDIX D



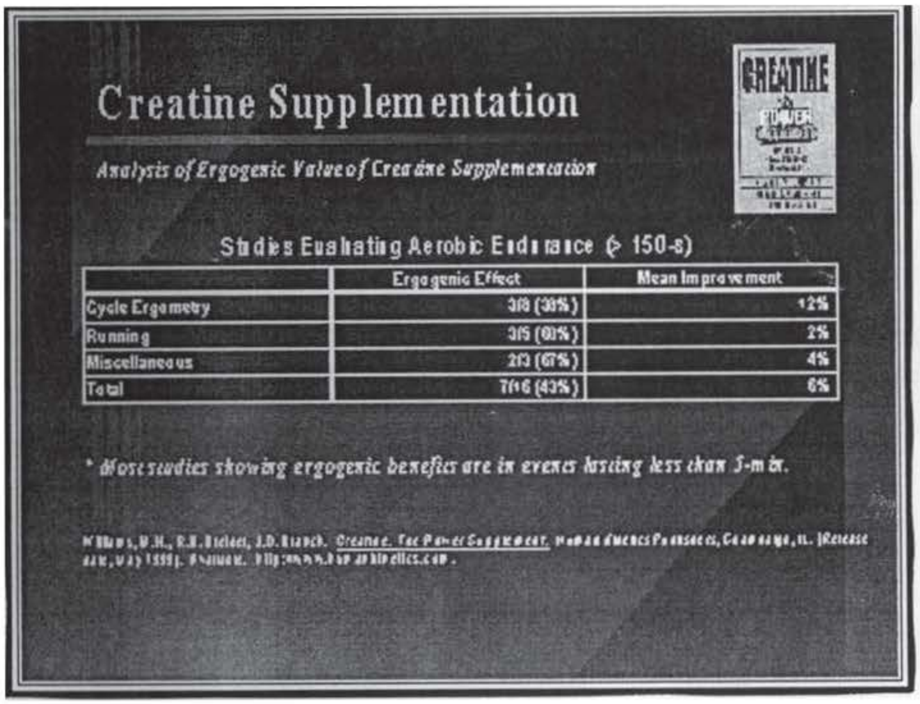
	Ergogenic Effect	Mean Improvement
Isotonic Force	17/23 (74%)	15%
Isokinetic Torque	7/14 (50%)	14%
Isometric Force	5/9 (56%)	27%
Cycling Sprints (6 to 30s)	17/23 (74%)	19%
Field Studies	9/19 (47%)	6%
Vertical Jump	5/10 (50%)	8%
Run Sprint Performance	5/10 (50%)	1-2%
Swimming Sprints	2/6 (33%)	2-3%
Total	49/79 (62%)	13%

APPENDIX E



	Ergogenic Effect	Mean Improvement
Resistance Exercise	2/4 (50%)	33%
Cycle Ergometry	4/7 (57%)	14%
Running	4/5 (80%)	6%
Swimming	1/5 (20%)	4%
Miscellaneous	1/2 (50%)	14%
Total	12/22 (56%)	16%

APPENDIX F


Creatine Supplementation
Analysis of Ergogenic Value of Creatine Supplementation
Studies Evaluating Aerobic Endurance (> 150-s)

	Ergogenic Effect	Mean Improvement
Cycle Ergometry	3/8 (38%)	12%
Running	3/5 (60%)	2%
Miscellaneous	2/3 (67%)	4%
Total	7/16 (43%)	6%

* Most studies showing ergogenic benefits are in events lasting less than 3-min.

APPENDIX G

Written Permission From Dr. Kreider For Charts

Reply | Reply All | Forward | as attachment

Download Attachments

Delete | Prev | Next | Inbox

· Choose Folder · | Move

From: "Richard B. Kreider, PhD" <rkreider@memphis.edu> | **Block address**

Add Addresses

To: "Tricia Cross" <triciacross1@yahoo.com>

Subject: Re: research

Date: Thu, 22 Jun 2000 14:38:17 -0500

Tricia:

I would suggest using the tables in Creatine: The Power Supplement (Human Kinetics). Summaries of these tables are available online at http:www.hmse.memphis.edu/faculty/kreider/index.html (click course/research presentations and the link to SWACSM presentation).

> ----- Original Message -----
> **From:** Tricia Cross
> **To:** kreider.richard@coe.memphis.edu
> **Sent:** Wednesday, June 21, 2000 5:27 PM
> **Subject:** research
>
> Dr. Kreider,
>
> Hello, my name is Tricia Cross and I am a graduate student at Eastern Illinois University and I am completing a thesis using creatine. I noticed in your atricle "Creatine, the Next Ergogenic Supplement?" you have several tables listed that show different outcomes of several studies. These tables would greatly help and support my thesis documenting studies that do show ergogenic effects and studies that don't. I am writing to ask your premission to use your tables in my thesis.
>
> Sincerely,
>
> Tricia Cross