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CONCURRENT CREATINE MONOHYDRATE SUPPLEMENTATION AND RESISTANCE TRAINING DOES NOT AFFECT MARKERS OF HEPATIC FUNCTION IN TRAINED WEIGHTLIFTERS

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ABSTRACT

CONCURRENT CREATINE MONOHYDRATE SUPPLEMENTATION AND RESISTANCE TRAINING DOES NOT AFFECT MARKERS OF HEPATIC FUNCTION IN TRAINED WEIGHTLIFTERS. **J.E. Waldron, G.W. Pendlay1, T.G. Kilgore, G.G. Haff, J.S. Reeves, J.L. Kilgore**. **JEPonline**. 2002;5(1):57-64. This study examined five days of creatine loading followed by five weeks of maintenance during weight training and its affect on hepatic enzymes that mark liver stress. Eight subjects participated in 5 weeks of high intensity Olympic-style weight-training that followed one week of enforced rest. Hepatic stress was assessed through measurement of serum concentrations of alanine amino transferase (ALT), aspartate amino transferase (AST) and alkaline phosphatase (AP). Testing occurred weekly, starting after one week of inactivity to establish baseline values and continuing for five training weeks. Blood urea nitrogen (BUN), albumin, creatinine, and direct and total bilirubin (DB and TB) concentrations were monitored as supplemental markers of hepatic stress.

Blood Chemistry	Baseline	Week 6	Enzyme Chemistry	Baseline	Week 6
BUN	4.91±1.72	5.27±2.13	ALT	22.5±10.24	23.13±10.89
DB	3.25±0.68	2.39±1.37	AST	19.88±3.44	22.25±3.85
TB	14.88±3.93	12.83±6.67			
Albumin	0.75±0.07	0.75±0.04			
Creatinine	126.41±15.03	127.30±15.03			
AP	66±12.18	72.75±14.24			

After loading and maintenance, concentrations of analytes did not vary. Final data indicate that the changes noted were not statistically significant and remained within normal clinical ranges.

Key Words: Ergogenic, Phosphagen System, Liver, Resistance Exercise, Creatinine, Serum Chemistry

INTRODUCTION

Creatine was first discovered in 1835, when the French scientist Chevreul found it in meat products. Supplementation of creatine in athletics began before the late 19th century, but its influence on the systems of the human body has only recently been explored (4). A naturally occurring nitrogenous compound, creatine is both synthesized endogenously from three amino acids; arginine, glycine, and methionine; and ingested through normal dietary intake. The average creatine daily intake is around one gram with the body manufacturing an additional gram. This supply is used in the body when the phosphocreatine kinase mediates the transfer of an inorganic phosphate from phosphocreatine (PCr) to adenosine diphosphate (ADP), forming adenosine triphosphate (ATP). It is the potential enhancement of the transformation of ADP to ATP through increasing the availability of PCr and the increase in creatine phosphate synthesis during recovery from exercise that drives athletes to use creatine to improve athletic performance.

Creatine supplementation has been indicted in the popular press as a potential hazard to the internal systems of the human body. During the past few years, little research has been done on creatine and its effect on the organ systems of the human body that filter the blood and remove toxins; specifically, its effect on liver function. This potential relationship has been overshadowed by the increasing scrutiny of creatine's possible effects on renal function. Juhn and Tarnopolsky (12) and Kreider et al., (13) in their research articles relating to renal function stated a direct need for investigations into the effects of creatine on hepatic function. Poortmans and Francaux's (17) review of the health related literature surrounding creatine supplementation found two research abstracts, two research manuscripts, and the authors unpublished data as the only sources of information regarding blood markers of hepatic function in healthy individuals and athletes. One retrospective study examining a wide variety of serum markers of health did include some measures of relevance to hepatic function (20). The researchers in that study found no relationship between creatine monohydrate supplementation and these markers but also proposed that further studies be conducted to add weight to their conclusions. Robinson et al. (19) examined selected hematologic and serum chemistry indices in healthy subjects and found only serum creatinine to be significantly and reversibly affected by supplementation.

The present study specifically investigated the relationship of serum chemistry markers of hepatic stress during strength training while supplementing creatine monohydrate in highly trained weight-lifters during intense resistance training.

METHODS

Subjects and Research Design

The subject pool consisted of eight healthy volunteers (six male, two female; mean age of 26±6.9 yr), with a similar physical activity history in weight lifting (8.4±7.1 yr training experience; six months of continuous training and competition). Each athlete had qualified for a national level event. Subjects completed a health history questionnaire and screening according to the criteria established by the American College of Sports Medicine (ACSM) prior to inclusion in the study (2). The testing methodology and protocol received approval from the Human Subject Research Committee at Midwestern State University.

Table 1. Organization of Training Program.

Week	*Training Days/Week*	*% 1RM*	*Reps/set*	*Weekly Repetitions **
1	0	0	0	0
2	3	75	2	60
3	4	85	2	112
4	5	90+	2 or 1	188
5	5	90+	2 or 1	158
6	4	88	1	56

**Does not include warm-up repetitions; Weeks 4 and 5 had 7 planned training sessions; In Weeks 4 and 5 a relative daily 1RM was attempted twice in each Snatch or Clean & Jerk.*

Body mass was determined weekly and 3-site body composition (16) was measured by skin-fold analysis in

weeks 1 and 5. A repeated measures design was used with measures obtained after one week of inactivity serving as baseline values. The week of inactivity were enforced to obtain authentic baseline or reference values as a control group was not used in this experimental design.

Training Protocol

One week of rest was enforced prior to the beginning of the training protocol. The load imposed during the experiment was a variation of the published research and training programs for competitive weightlifters and athletes proposed by researchers and coaches (7,11,22,24), and is presented in Tables 1 and 2. Performance in the competitive Olympic lifts (Snatch and the Clean & Jerk) and back squat were periodically assessed throughout the study and weights are reported in Table 3. Entry level performance results were derived from the subject's most recent one repetition maximum (1RM) during their most recent official competitive results (must have been completed within 60 days). Verification of entry level 1RM values took place on the last day of week 2 in the training protocol. All training and performance testing was done with International Weightlifting Federation certified and calibrated elite barbells (York Barbell Co., York, PA, USA).

Creatine Dosage Protocol

In order to obtain authentic baseline values, all subjects abstained from any creatine supplementation for one month prior to the beginning of the testing protocol. This duration was chosen as the research of Hultman et al., indicated a return of intracellular creatine levels to baseline after a 30 day period of no supplementation (10). Prior to the beginning of the exercise protocol, baseline blood chemistry values were obtained for each subject. Pure creatine monohydrate (Cr) (Nutrasense, Shawnee, KS) was distributed to all subjects one week prior to the initiation of the study. Following the measurements for baseline, the subjects began the Cr loading phase for five consecutive days, and the maintenance phase followed for the remainder of the study. Subjects were given ample quantities to sustain supplementation throughout the entire study. Dosages were calculated from each subject's body mass. For the loading phase, each subject took 0.3 g Cr/kg body mass/day for five days. For the maintenance phase, the intake was 0.03 g Cr/kg body mass/day for the remaining five weeks (10). The dosages used follow recent studies of Smith et al., (21), Greenhaff et al., (6), and Balsom et al., (3). All daily doses were taken orally in three to four equal parts throughout the day and were monitored by the research coordinator to insure proper supplementation. On training days the subjects were instructed to consume a portion of their daily dose within one hour of completing their training session. Solutions used to aid ingestion of the product were left to the discretion of the subject (the most common vehicle chosen was chocolate milk). None of the subjects were vegetarians and all reported consuming a high protein diet.

Blood Chemistry

A Medical Technologist (*American Society of Clinical Pathologists*) performed all venipuncture on the same hour and day weekly for the duration of the study. Blood samples were obtained in a fasting state (8 hr) and followed one day of rest and recuperation from the training protocol. A standard 10 mL serum tube (Vacutainer SST, Becton-Dickinson, Franklin Lakes, NJ) of blood was acquired from the antecubital vein. Each subject and each sample was assigned a unique identification number and the code key remained confidential until all analyses were completed. Samples were separated into packed cell and serum components. Chemistry and enzyme assays were then completed for blood urea nitrogen, direct bilirubin, total bilirubin, albumin, creatinine, alanine amino transferase (ALT), aspartate amino transferase (AST), and alkaline phosphatase (AP) using a COBAS Mira™ analyzer (Hoffmann-La Roche, Ltd., Basel Switzerland).

Performance in the competitive Olympic lifts (Snatch and the Clean & Jerk) and back squat were periodically assessed throughout the study. Entry levels for the lifts were derived from the subject's most recent one repetition maximum (1RM) during their most recent official competitive results (must have been completed within 60 days). Verification of entry level 1RM values took place on the last day of week 2 in the training protocol. All training and performance testing was done with International Weightlifting Federation certified and calibrated elite barbells (York Barbell Co., York, PA, USA).

Statistics

All serum chemistry and enzyme results are reported as mean±SD, and were analyzed with a repeated measures analysis of variance (ANOVA) ($p<0.05$) using SAS System Software (Cary, North Carolina).

Table 2. A summary of all lifts completed during the six-week training program.

Week	*Monday*	*Tuesday*	*Wednesday*	*Friday*	*Saturday*
1	Off	Off	Off	Off	Off
2	Power Snatch Power Cln & Jerk Back Squat Abdominals	Off	Hang Pwr Snatch Hang Pwr Clean Romanian Deadlift Abdominals	AM Blood Sample Off	Snatch Power Clean Jerk Back Squat Abdominals
3	Power Snatch Clean Push Press Back Squat Back Extension	Off	Snatch Power Clean Jerk Front Squat Abdominals	AM Blood Sample Power Snatch Power Clean Press Romanian Deadlift	Snatch Clean & Jerk Back Squat Abdominals
4	AM Back Squat Snatch Pull Clean Pull PM Snatch Clean & Jerk Abdominals	Snatch Clean & Jerk Back Squat Abdominals	Power Snatch Press Front Squat Abdominals	AM Blood Sample Snatch Push Press Clean PM Back Squat Snatch Pull Clean Pull	Snatch Jerk Front Squat Abdominals
5	AM Back Squat Snatch Pull Clean Pull PM Snatch Clean & Jerk Abdominals	Snatch Clean & jerk Back Squat Abdominals	Power Snatch Press Front Squat Abdominals	AM Blood Sample Snatch Push Press Clean PM Back Squat Snatch Pull Clean Pull Abdominals	Snatch Jerk Front Squat Abdominals
6	Snatch Clean & Jerk Back Squat Abdominals	Off	Snatch Jerk Front Squat Abdominals	AM Blood Sample Power Snatch Power Clean Press Abdominals	Snatch Clean & Jerk Back Squat Romanian Deadlift Abdominals

During weeks 3 and 4 sessions were divided into am and pm sessions. Off days consisted of active rest with minimal activity. The two female subjects performed only one workout on Mondays and Fridays during weeks 4 and 5.

RESULTS

Data obtained from the testing of strength throughout the study are presented in Table 3.

Table 3. The 1RM and peak weights lifted in the Olympic lifts and back squat.

Exercise	*1RM*	*Week 2*	*Week 3*	*Week 4*	*Week 5*	*Week 6*
Snatch	84.4±28.9	67.4±24	79.4±28.1	83.1±27.1	83.8±27	82.8±29.1
Clean & Jerk	105.9±32.8	84.4±28.1	101.9±36.4	100±28.7	102.8±31.2	100.3±29.5
Back Squat	144.7±42.1	90.9±21.8	117.8±32.4	127.8±36.4	149.1±48.7	113.1±28.1

Blood Chemistry

Over the six week period there were no statistically significant changes found in any of the serum chemistry markers for hepatic stress. Normal values, standard deviations, and means for the six week cycle are presented in Table 4. Over the six weeks the only serum value to approach a statistically significant change was total bilirubin (p=0.08). Creatinine, the sole end product of creatine metabolism, deviated eight percent from the baseline (p=0.923) showing no statistical significance. The specific enzyme markers for hepatic stress ALT (p=0.764), AST (p=0.113), and AP (p=0.815) remained constant over the six weeks.

Table 4. Serum chemistry and enzyme results, including laboratory norms.

Chemistry	*Norms*	*Week 1*	*Week 2*	*Week 3*	*Week 4*	*Week 5*	*Week 6*
BUN	2.9-8.9 mmol/L	4.9±1.72	5.2±1.81	4.6±1.65	5.0±1.38	5.7±1.72	5.3±2.1
Bilirubin (Direct)	0-3.4 µmol/L	3.2±0.68	3.2±0.86	2.7±0.68	3.4±1.20	2.7±0.68	2.4±1.4
Bilirubin (Total)	4.3-25.6 µmol/L	14.9±3.93	13.3±3.08	12.6±3.25	18.8±7.87	11.5±3.25	12.8±6.7
Albumin	0.54-0.74 mmol/L	0.7±0.07	0.7±0.04	0.7±0.04	0.8±1.89	0.7±0.04	0.7±0.0
Creatinine	53-150 µmol/L	126.4±15.0	130.8±19.4	127.3±18.6	131.7±19.4	122.9±14.1	127.3±15.0
Enzyme							
ALT	7-56 IU/L	22.5±10.2	24.0±8.8	32.6±25.5	27.4±13.9	27.1±13.8	23.1±10.9
AST	5-40 IU/L	19.9±3.4	24.7±6.5	27.6±8.8	25.5±6.3	21.4±4.8	22.2±3.8
AP	38-126 IU/L	66.0±12.2	70.5±11.6	70.5±16.0	69.1±15.7	75.9±14.5	72.7±14.2

Body Mass and Composition

Data for body mass over the training period are presented in Table 5 and reveal an increase in body mass from the entry mean value, 82.9 kg, to the final mean value of 84.0 kg. The changes noted were not statistically significant (p=1.00). Mean percent body fat was unchanged over the duration of the experiment (p=0.67). Incoming male percent fat was 15.8±6.6 % and during week 5 was measured as 15.9±6.8 % (female subjects did not participate in body composition assessments).

DISCUSSION

In the present study, a battery of blood chemistries used clinically in diagnosing hepatic dysfunction showed very little deviation from normal serum levels (Table 3). Elevated levels of bilirubin and albumin are indicators

Table 5. Body mass changes (kg) for each subject over the duration of the experiment.

Subject	*Week 1*	*Week 2*	*Week 3*	*Week 4*	*Week 5*	*Week 6*
1	64.6	65.2	65.4	64.6	64.8	64.3
2	144.8	146.5	145.1	146.1	147.1	148.0
4	74.6	75.8	75.4	75.7	75.6	75.6
5	81.2	83.1	82.0	82.7	81.9	82.3
6	86.2	89.8	89.0	89.4	88.8	88.6
7	76.7	76.3	76.4	77.8	76.0	76.5
8	70.4	69.5	69.4	68.9	69.3	70.0
9	64.9	66.0	66.0	65.8	66.7	66.9
Mean±SD	82.9±26.1	84.0±26.6	83.6±26.1	83.9±26.5	83.8±26.8	84.0±27.1

of initial liver cirrhosis and various liver diseases (9). Direct and total bilirubin along with albumin deviated little over the training and creatine protocol. Total bilirubin had a near significant change over the six weeks ($p=0.08$), and may be a marker for further study in larger subject pools. These results are consistent with the limited research completed by Poortmans and Francaux (18) and Earnest et al. (5), who found no significant change in serum bilirubin. Albumin, while at the high end of clinical norms, changed very little from entry through week 6. No other studies reviewed here examined albumin levels in the blood following supplementation alone or in concert with exercise. Similarly, blood urea nitrogen, direct bilirubin, and creatinine also did not significantly vary throughout the experiment. Although some chemistries did deviate from baseline, no results were statistically significant, nor did supplementation appear to induce changes outside of clinical norms, indicating that creatine monohydrate supplementation and training do not affect these measures of hepatic stress.

Levels of ALT, AST, and AP listed in Table 5 show no significant change over the six-week protocol. ALT and AST measurements serve as clinical indicators of hepatic, myocardial, or skeletal muscle necrosis. Concentrations of these enzymes must increase 10-200 fold in order to become clinically relevant markers of malfunction or disease (9). AP determinations provide evidence of hepatobiliary disease and 200 to 300% increases in concentrations are required to be of clinical importance. During this study, ALT rose to a maximal level 45% higher than baseline in week three and remained rather constant in other weeks. This rise of 45%, though seemingly large in layman terms, is inconclusive clinically. Enzyme levels of ALT rising 1000% over the normal value is considered a moderate increase and may mark hepatic disease (9). Also, in week three AST rose 40% from baseline yielding the same clinical interpretation and marking no liver disease. AP results revealed no changes statistically or clinically during the protocol. All increases in serum chemistry and enzyme concentrations remained within normal levels during all six weeks of the protocol.

The present study examined the effects of supplementation on high caliber weightlifters during intense Olympic-style resistance training. As a high percentage of this type of athlete supplements with creatine monohydrate routinely, it was important to investigate the potential effects of supplementation on this population. The findings presented here are consistent with findings from other laboratories that demonstrated a lack of significant changes in hepatic function following a course of oral creatine monohydrate supplementation (1,5,13,17,18).

Body mass increases have been noted as one of the constant side effects of creatine supplementation (8,10,14,23). A recent review by Poortmans and Fancaux (17) evaluated the adverse effects of creatine supplementation. When specifically examining the effect of creatine supplementation on body mass, it was noted that during medium term studies (>10 days) 70% of published data shows an increase in total body mass. This increase varies between 1 to 2 kg. Data from the present study is consistent with these findings. Over the six week protocol there was a constant increase in body mass. Mean body mass increased 1.1 kg from entry to

week 6. The cause of this increase can only be speculated upon, but as body composition did not significantly change in the male subjects it is possible that an increase in intracellular water retention may have occurred (25). Statistically, the increase in total body mass was not significant but does follow the overall trend in the current research.

The evidence presented in this study represents the most comprehensive evaluation of hepatic function to date performed on a single group of athletes supplementing with creatine monohydrate. Data from this experiment strengthens the argument that creatine supplementation does not cause adverse effects for hepatic function in healthy trained athletes. The results of the blood tests show that the specific enzymes and chemistries that mark hepatic stress (ALT, AST, AP, Bilirubin) are not significantly affected when creatine monohydrate is supplemented in strength-trained athletes. These data provide similar evidence to the studies of Almada et al. (1), Earnest et al. (5), Mihic et al. (14), Robinson et al. (19), and Schilling et al., (20) who found no significant changes in serum enzyme and/or bilirubin levels. These data are also consistent with Poortmans and Franceaux's (17) review of existing literature that concluded that there were no deleterious effects to an athlete's health from creatine supplementation.

In applying this evidence to the present argument that creatine monohydrate supplementation is dangerous to an athlete's health, given the consistency of findings in all research to date, we find no evidence to support this notion. Our data adds to the existing body of knowledge supporting the safety of creatine monohydrate supplementation over a period of weeks to months, but additional research should be carried out to affirm the safety of long-term use.

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