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Short-term Effects of Creatine Supplementation on Physical Fitness Measures in Moderately Active College-aged Females: A Randomized Placebo-controlled Pilot Study

Gabriel A. Benavidez[1,*], Nickie Detomasi[1], Peter D. Hart[1,2]

[1]Health Promotion Program, Montana State University - Northern, Havre, MT 59501, USA
[2]Research and Statistical Consultant, Health Demographics, Havre, MT
*Corresponding author: gabe.benavidez72@gmail.com

Abstract Supplementation of oral creatine is a popular practice among strength and power athletes. Little evidence exists, however, on creatine's short-term performance effects in college-aged females. The purpose of this study was to examine the effects of short-term creatine supplementation on physical fitness measures of muscular strength, muscular endurance, and body composition in college aged females. A double-blinded randomized placebo controlled trial was used with n=10 college-aged females assigned to either creatine (n=5) or placebo (n=5) groups. Subjects underwent a 2-week resistance training program with treatments administered during week 2. Fitness measurements were taken at baseline, week 1 (pre-supplementation), and week 2 (post-supplementation). Significant group-by-trial interactions were seen for percent body fat (PBF), 1RM leg press (LP), 1RM bench press (BP), wall sit (WS), push-up (PU), plank, and vertical jump scores, with the creatine group exhibiting significantly (p's<.05) greater improvement over control group on all measures. Results of this study show that short-term creatine supplementation may produce positive effects on physical fitness measures while taken during a resistance training program.

Keywords: *creatine, muscular strength, endurance, body composition, randomized placebo-controlled trial*

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1. Introduction

Creatine is a naturally-occurring amino acid (protein building block) that's found in meat and fish, and also made by the human body in the liver, kidneys, and pancreas [1]. Creatine is converted to creatine phosphate or phosphocreatine and stored in muscle, where it is used for energy production. During high-intensity, short-duration exercise, such as strength training or sprinting, phosphocreatine is converted to ATP, a major source of energy within the human body.

Oral supplementation of synthetic forms of creatine, such as creatine monohydrate, has been shown to increase the amount of creatine available within the muscle by as much as 20 percent [2]. Creatine within the last decade has become one of the most popular and widely used supplements, due to its performance reputation [3]. Creatine has been the subject of over 500 published studies, 300 of which focused solely on its performance enhancing effects [1]. Furthermore, the majority of studies involving creatine have used males as their subjects. Therefore, the performance effects of creatine supplementation among females is less understood.

The primary purpose of this study was to determine if short-term creatine supplementation of minimal dosage can affect fitness measures in moderately active college-aged females.

2. Materials and Methods

2.1 Participants

A convenience sample was used for this study and subjects were recruited by word of mouth. Inclusion criteria included 1) being a college-aged female, 2) willing to commit to a 2-week resistance training program, and 3) willing to take a creatine monohydrate supplement for a 1-week treatment period. Subjects were excluded from the study if they were 1) already supplementing with creatine, 2) already engaged in an ongoing training program, or 3) a highly fit individual or an athlete.

2.2 Study Design

A double-blinded randomized placebo-controlled design was used. A total of n=10 females were randomly assigned to either experiment (n=5) or control (n=5) groups. Both groups were tested at baseline on muscular

strength, endurance, power and body composition measures. Subjects took part in a two week 4-day split resistance strength training program. Both groups trained under the supervision of the researchers in order to assure the resistance training program was being followed in terms of quality and quantity. After week 1 of training, all fitness measures were assessed again to serve as pretest measurements. After week 1, subjects were given marked envelopes which contained their week 2 supplements. Envelope markings indicated which experimental group each subject was in, however, the marking codes were accessible only to a third uninvolved party. The experiment group received 10 pills of 2.5g creatine monohydrate while the control group received 10 pills of vitamin C. Each group was instructed to maintain their same eating habits as usual. For 5 days during week 2, subjects were instructed to consume 2 tablets per day simultaneously. At the conclusion of week 2, fitness measures were re-assessed to serve as posttest measurements.

2.3. Outcome Measures

Upper-body muscular strength was measured by 1 repetition maximum (1RM) bench press (BP) and lower-body strength was assessed by 1RM leg press (LP). American college of sports medicine (ACSM) protocols were used for both tests [4]. Muscular endurance was measured in the upper and lower body as well as the abdominal region. The lower body was endurance tested using a wall-sit (WS) procedure where the total amount of seconds completed served as an endurance score [5]. Upper body endurance was tested using a maximum push-up test (PU) derived from ACSM protocol specifically for females [4]. The abdominal region was tested using a timed plank test (Plank) following a National Health and Nutrition Examination Survey (NHANES) protocol [6]. High speed muscular strength was tested using vertical (Vertical) and broad jump (Broad) tests [7]. These tests were included to differentiate between muscular strength and power of the lower-body. Finally, body composition was assessed using a 3-site skinfold technique and Lange skinfold calipers. Percent body fat (PBF) was estimated from the sum of three skinfold thickness sites using the Jackson and Pollock body density formula as well as the Siri equation [4].

2.4. Statistical Analysis

Data were analyzed using a two-way (3x2) mixed repeated measures factorial analysis of variance (ANOVA) model. The between groups factor was the treatment group (creatine or placebo) and the repeated factor was time (baseline, pretest, and posttest). When interactions were significant, simple effects models were performed. When interactions were not significant, a pooled analysis was performed. Fisher's post hoc tests were used to identify specific group differences. SAS Studio was used for all analyses. All p-values are reported as 2-sided and statistical significance level was set at .05.

3. Results

Results from the interaction tests showed significant group-by-trial interaction for PBF, LP, BP, WS, PU, Plank, and Vertical measures (p's<.05). The Broad model did not show a significant interaction and therefore was analyzed across both groups combined. For PBF, the creatine group showed significant posttest improvement from pretest whereas the control saw no significant changes. For LP, the creatine group showed significant posttest improvement from pretest. The control group also saw significant posttest improvement from pretest in LP, however, the improvement was not as great as the creatine group.

For BP, the creatine group showed significant posttest improvement from pretest. The control group also saw significant posttest improvement from pretest in BP, however, the improvement was not as great as the creatine group. For WS, the creatine group showed significant posttest improvement from pretest. The control group also saw significant posttest improvement from pretest in WS, however, the improvement was not as great as the creatine group.

For PU, the creatine group showed significant posttest improvement from pretest. The control group saw significant posttest improvement from pretest in PU, however, the improvement was not as great as the creatine group. For Plank, the creatine group showed significant posttest improvement from pretest. The control group also saw significant posttest improvement from pretest in Plank, however, the improvement was not as great as the creatine group. For Vertical, the creatine group showed significant posttest improvement from pretest whereas the control saw no significant changes. For Broad, neither group showed improvement from pretest. See Table 1.

Figure 1 displays results for linear tests of trend for time period and fitness improvement by treatment group. Trend line group interactions were significant for PBF, LP, BP, WS, PU, and Vertical. Follow-up linear trend tests of improvement were significant for PBF, LP, BP, WS, PU, and Vertical in the creatine group. However, in the control group, only LP and PU showed significant linear improvement across time periods. Plank and Broad scores significantly improved in linear fashion for both treatment groups.

4. Discussion

The purpose of this study was to investigate the effects of short term creatine supplementation on muscular performance and body composition measures in college aged females. Results from this study found significantly greater increases in 1RM muscular strength measures in the creatine group over the control group. These findings are consistent with other findings such as Brenner et al. (2000) who found significant increases in bench press measures in females who were supplemented with creatine monohydrate during a resistance training program [8]. As well, rugby union football players who supplemented daily with creatine monohydrate performed better in both bench press and leg press tests compared to those in the control group [9].

Results from this study also found that significant improvements in body composition were made in females who supplemented with creatine monohydrate. PBF was reduced by 2.1 percent in the creatine group while the control group showed no reduction. Several studies have shown similar findings of increased fat-free mass in

individuals supplemented with creatine. Both men and women on a resistance training program combined with creatine supplementation showed significant increases in fat-free body mass over 14 weeks [10].

Table 1. Descriptive statistics and two-way mixed design repeated measures analysis of variance results for creatine and performance study

	Baseline				
	Creatine		Control		Between[c]
Measure	*Mean*	*SD*	*Mean*	*SD*	*p*
PBF (%)	33.4	4.1	29.9	5.8	.3127
LP (lb)	328.0	90.4	216.0	117.6	.1298
BP (lp)	105.0	10.0	78.0	17.2	.0161
WS (cm)	94.6	26.6	97.6	26.9	.8635
PU (#)	27.2	6.9	20.4	7.6	.1761
Plank (s)	87.2	37.5	87.1	40.4	.9975
Vertical (in)	14.0	1.8	14.3	2.7	.4090
Broad (in)	78.2	4.2	75.0	7.7	.4357

	Pretest				
	Creatine		Control		Between[c]
	Mean	*SD*	*Mean*	*SD*	*p*
PBF (%)	32.0[a]	4.0	29.5	6.7	.4997
LP (lb)	385.0[a]	120.0	241.0[a]	119.5	.0936
BP (lp)	111.0[a]	11.9	76.0	14.3	.0030
WS (cm)	126.4	60.7	82.2	8.2	.1453
PU (#)	31.2	8.8	24.4	8.9	.2581
Plank (s)	103.2	20.8	97.2	29.0	.7164
Vertical (in)	14.3[a]	1.4	14.3	2.2	1.0000
Broad (in)	80.2[e]	5.0	78.1[e]	7.6	.6199

	Posttest					Overall[d]
	Creatine		Control		Between[c]	g × t
	Mean	*SD*	*Mean*	*SD*	*p*	*p*
PBF (%)	29.9[a,b]	3.9	29.5	6.5	.9209	.0003
LP (lb)	471.0[a,b]	131.5	286.0[a,b]	121.8	.0498	.0227
BP (lp)	127.0[a,b]	8.4	81.0[b]	13.9	.0002	.0020
WS (cm)	155.8[a,b]	60.6	95.8[b]	14.3	.0633	.0307
PU (#)	39.4[a,b]	8.6	27.0[a,b]	9.1	.0583	.0015
Plank (s)	122.4[b]	18.5	104.6[b]	26.0	.2477	.0464
Vertical (in)	15.8[a,b]	1.4	14.4	2.3	.2785	.0008
Broad (in)	84.2[e]	5.4	78.3[e]	5.2	.1163	.3438

Note. [a] indicates significant improvement from baseline. [b] indicates significant improvement from pretest. [c] indicates between groups test. [d] indicates multivariate test of interaction term by Wilk's Lambda. [e] indicates both groups had significant improvement from baseline. [f] indicates both groups had significant improvement from pretest. n = 10, $n_{creatine}$ = 5 and $n_{control}$ = 5. g × t is the group by trial interaction.

There are many strengths associated with the results of this study. First, the results of this research corroborate the findings that have accumulated through numerous years of creatine research but with a specialized population sub-group of non-athletic college-aged females. Therefore, this study shows that the female recreational fitness enthusiast may benefit from creatine supplementation. Another strength of this study is that it incorporated a specialized resistance training program for all study participants, which was administered and monitored by the researchers. The training program was completed with 100 percent compliance from all participants. This additional study component ensured that all participants could receive a training effect and in turn allowed for the examination of creatine's effect on fitness measures over that of a placebo.

This study is not without limitations. One limitation of this study is the small sample size. Although various statistical tests (parametric and nonparametric) were performed to validate the study inferences, a small sample size may still skew the randomization process. For example, the creatine group had a greater mean PBF at baseline, although not significant (p=.313). This small difference, due to randomization, could at least be marginally related to the creatine group's greater improvement in PBF. A second limitation of this study is the form of supplement administration. Although both groups received a pill form of their treatment, the creatine pills had a slightly different look than the vitamin C pills. This difference could lend to various types of bias. One such bias is that subjects themselves could attempt to find out which treatment group they were in.

5. Conclusion

Results from this pilot study show that creatine supplementation improves many fitness measures in college-aged females undergoing a resistance training program. Moreover, a minimal dosage of creatine for a short period of time was shown to be enough to illicit such fitness improvements. Further research is needed to extend these generalizations. One recommendation is the replication of this study using larger samples and longer test periods. Another suggestion is the inclusion of

measurement protocols for adverse effects typically reported from creatine supplementation.

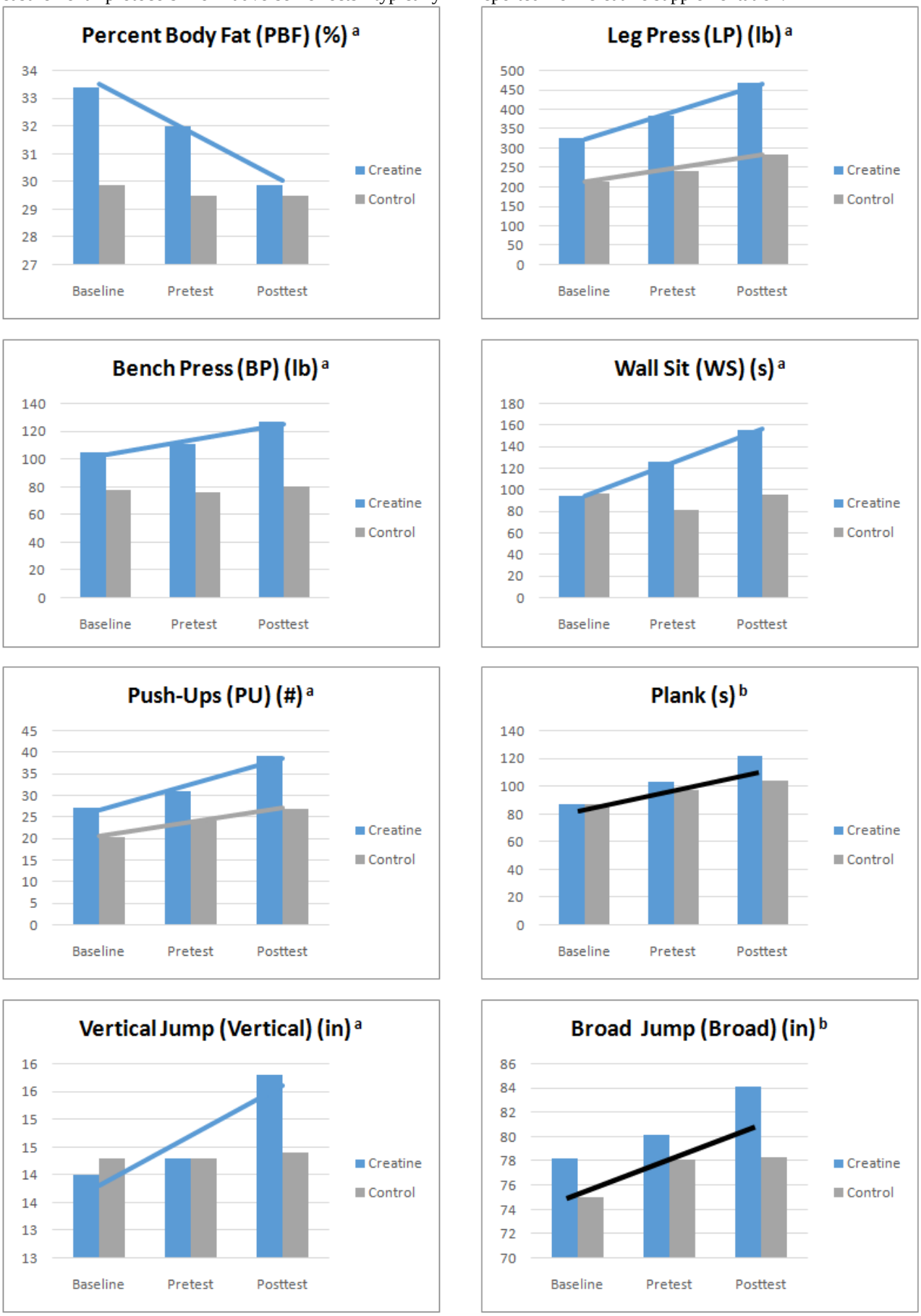

Figure 1. Linear trends analysis across fitness measures by treatment group in creatine study

Note. [a] indicates significant group by trial trend line interaction and in turn group trends were tested seperately. [b] indicates non-significant group by trial trend line interaction and in turn an overall trend was tested. All trend lines shown are significant (p's < .05).

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