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Research article

Effects of combined creatine plus fenugreek extract vs. creatine plus carbohydrate supplementation on resistance training adaptations

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Abstract
The purpose of this study was to evaluate the effects of combined creatine and fenugreek extract supplementation on strength and body composition. Forty-seven resistance trained men were matched according to body weight to ingest either 70 g of a dextrose placebo (PL), 5 g creatine/70 g of dextrose (CRD) or 3.5 g creatine/900 mg fenugreek extract (CRF) and participate in a 4-d/wk periodized resistance-training program for 8-weeks. At 0, 4, and 8-weeks, subjects were tested on body composition, muscular strength and endurance, and anaerobic capacity. Statistical analyses utilized a separate 3X3 (condition [PL vs. CRD vs. CRF] x time [T1 vs. T2 vs. T3]) ANOVAs with repeated measures for all criterion variables ($p \leq 0.05$). No group x time interaction effects or main effects ($p > 0.05$) were observed for any measures of body composition. CRF group showed significant increases in lean mass at T2 ($p = 0.001$) and T3 ($p = 0.001$). Bench press 1RM increased in PL group ($p = 0.050$) from T1-T3 and in CRD from T1-T2 ($p = 0.001$) while remaining significant at T3 ($p < 0.001$). CRF group showed a significant increase in bench press 1RM from T1-T2 ($p < 0.001$), and also increased from T2-T3 ($p = 0.032$). Leg press 1RM significantly increased at all time points for PL, CRD, and CRF groups ($p < 0.05$). No additional between or within group changes were observed for any performance variables and serum clinical safety profiles ($p > 0.05$). In conclusion, creatine plus fenugreek extract supplementation had a significant impact on upper body strength and body composition as effectively as the combination of 5g of creatine with 70g of dextrose. Thus, the use of fenugreek with creatine supplementation may be an effective means for enhancing creatine uptake while eliminating the need for excessive amounts of simple carbohydrates.

Key words: Fenugreek, creatine, supplementation, performance adaptations.

Introduction

Creatine monohydrate is one of the most commonly ingested and researched sports supplements today and is a popular aspect of sports nutrition and ergogenic aids. Its role as an aid to supply additional substrates for the phosphocreatine system gives creatine a favorable position in the supplementation regimen of many athletes, especially power athletes such as weightlifters and football players. The creatine molecule serves as a phosphate donor during high intensity exercise which allows for the energy restoration and maintenance of high power output for skeletal muscles (Greenhaff and Bodin, 1994). Higher amounts of creatine in skeletal muscle further increase the molecule's effects on high energy demanding endeavors, thus increasing the level of absorption into the skeletal muscle is an important issue when supplementing creatine. Continuing efforts are being made to find various methods that will maximize creatine absorption and retention, thus enhancing creatine's ergogenic benefits in sport-specific applications.

Substantial work has been done on creatine and its effects on performance and anthropomorphic measures. Early work conducted by Volek et al. (1997) reported that the administration of 25 grams of creatine for one week in conjunction with resistance training resulted in significantly greater gains in the areas of jump squat peak power, bench press repetition volume and body mass than changes observed in the placebo group (Volek et al., 1997). Numerous studies, in both acute and chronic settings, have looked at creatine supplementation using a variety of doses and blends. Research on creatine supplementation has repeatedly been supported as a means to enhance resistance training adaptations (Chrusch, et al., 2001; Rawson and Volek, 2003; Volek et al., 1999).

Increasing the uptake of creatine into skeletal muscle would in theory lead to higher amounts of intracellular creatine, and could potentially translate into more substantial effects on performance in anaerobic settings. Creatine is absorbed into skeletal muscle in a similar manner to that of glucose, whose uptake is highly regulated by the hormone insulin. Therefore, insulin and insulin inducing factors, notably high glycemic carbohydrate ingestion, gained interest as mediators of creatine uptake due to insulin's stimulatory actions on GLUT-4 transporters. Green and colleagues (1996a) reported that combination of creatine and large amounts of simple carbohydrates led to a 60% increase in muscle creatine levels, along with a decreased urinary creatine excretion. Further work has shown that ingesting a 100 g carbohydrate dose increased the absorption of creatine via the stimulatory actions of insulin on creatine's sodium-dependent pump (Steenge et al., 1998). The utilization of carbohydrate ingestion to enhance creatine absorption does seem to translate into additional performance adaptations when combined with resistance training. Various reports have indicated that the concurrent ingestion of creatine and carbohydrates produces greater increases in strength and

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body composition (Becque et al., 2000; Bemben et al., 2001; Kreider et al., 1998; Stout et al., 1999a).

Despite the ability of carbohydrate consumption to increase the levels of creatine absorption, the chronic ingestion of such high levels of simple carbohydrates delivers a very high amount of calories and may have detrimental effects such as hyperglycemia as well as negative effects on body composition. While carbohydrate-induced insulin release has been linked to improved creatine uptake, several other factors have been shown to act as “insulin mimickers”. Mimicking the effects of insulin could theoretically improve creatine uptake in ways that reflects insulin’s action on creatine transport mechanisms, however initial reports have not shown any benefit (Kerksick et al., 2009b). Agents that have been shown to have actions similar to insulin include muscular contraction, chromium picolinate (Martin et al., 2006), alpha lipoic acid (Estrada et al., 1996), and D-pinitol (Bates et al., 2000; Kerksick et al., 2009b).

Although there is currently no research that has evaluated the effects of fenugreek extract in combination with creatine, a potential mechanism for mimicking the effects of insulin to increase creatine uptake may be present due to fenugreek’s prominent hypoglycemic effect that has been supported in both human and animal models (Gupta et al., 2001; Madar et al., 1988; Neeraja and Rajyalakshmi, 1996; Ribes et al., 1984). In a report by Sharma et al. (1990), 24 hour urinary excretion of glucose was decreased by 64% in subjects that were administered 100 g of defatted fenugreek seed powder for 10 days. The decreased excretion rate exhibited directly points to an increased glucose absorption rate by the tissues. Despite the lack of research in the population utilized in this current study, the demonstrated insulin-like actions of fenugreek on glucose could theoretically result in increased creatine uptake by skeletal muscle, in much the same way insulin has shown to augment the creatine transport in earlier studies utilizing carbohydrate models.

The role of creatine supplementation both alone and in conjunction with carbohydrate ingestion have been well established, however, the novel combination of fenugreek extract with creatine possesses a theoretical rationale. To our knowledge, no studies have previously investigated the role of combined fenugreek and creatine supplementation, therefore, it was the purpose of this study to investigate the adaptations from the supplementation of a creatine/fenugreek mixture, creatine/carbohydrate mixture or carbohydrate placebo when used in conjunction with resistance training.

Methods

Experimental approach to the problem

This study utilized a randomized, placebo-controlled parallel design. The specific aim of this study was to investigate the role, if any, that fenugreek extract had on training responses when coupled with creatine supplementation over 8 weeks in comparison to the traditional dextrose plus creatine combinations that have been shown to significantly increase adaptations stemming from resistance training. The independent variable of the study was subject placement in parallel supplementation groups that were matched according to total body weight. Following familiarization, subjects were randomly assigned to supplementation groups consisting of a creatine plus fenugreek extract (CRF), creatine plus dextrose (CRD) or dextrose placebo (PL). Assessed dependent variables included: body composition; upper- and lower-body 1RM strength, upper- and lower-body muscle endurance (80% of 1RM), anaerobic sprint power, and fasting clinical blood profiles (substrates, electrolytes, muscle and liver enzymes, red cells, white cells) that were assessed to monitor and ensure subject safety of the supplementation protocol. Testing of the dependent variables of interest occurred at baseline and following 4- and 8-weeks of combined training and supplementation. All participants were instructed to maintain their current dietary habits throughout the duration of the study.

Subjects

Forty-seven resistance trained males (mean ± SD age = 21.2 ± 2.6 y; body mass = 87.7 ± 11.8 kg, height = 1.82 ± 0.07 m) volunteered for this study. Table 1 shows the group-specific demographics. Only participants considered as low risk for cardiovascular disease and with no contraindications to exercise as outlined by the American College of Sports Medicine (ACSM) and/or who had not consumed any nutritional supplements (excluding multivitamins) one month prior to the study were allowed to participate. All eligible subjects were asked to provide oral and written informed consent based on university-approved documents and approval was granted by the Institutional Review Board for the protection of human subjects.

Table 1. Subject demographics. Values are represented as means (±SD).

	Age (yrs)	Height (m)	Weight (kg)	Body Fat %
PL	19.8 (1.0)	1.77 (.06)	86.6 (11.0)	16.0 (6.0)
CRD	21.0 (4.0)	1.81 (.07)	89.5 (12.0)	18.2 (5.0)
CRF	21.0 (2.0)	1.79 (.06)	85.0 (10.0)	15.2 (6.0)

PL = placebo group; CRD = creatine with dextrose group; CRF = creatine with fenugreek group.

Testing sessions

Following the familiarization/practice session, the subjects recorded all food and fluid intake on dietary record forms on four consecutive days preceding each experimental testing session in order to standardize nutritional intake. Subjects were instructed to refrain from exercise for 48 hours and fast for 12-hours prior to baseline testing (T1). Subjects then reported to the Human Performance Lab for body composition and clinical assessments. Subjects reported to the lab, where height was measured using a stadiometer and total body weight was measured using a standard calibrated scale. Heart rate and blood pressure were assessed in the supine position after resting for 5-min using standard procedures. Body composition was then assessed using a QDR® Series Discovery W*i* (Hologic, Bedford, MA) dual energy x-ray absorptiometer (DXA). Prior to each test, the DXA was calibrated for daily quality control and for the body composition analysis software according to the manufacturer’s instruction.

Subjects then donated approximately 20 ml of fasting blood using venipuncture techniques of an antecubital vein in the forearm according to standard and sterile procedures. Acquired blood samples were mixed by inversion, centrifuged 10 minutes, and refrigerated until all samples were shipped to Quest Diagnostics (Dallas, TX) to run clinical chemistry profiles and whole blood cell counts for supplementation safety assessment.

Subjects then performed maximal tests (1RM) on the isotonic bench press and leg press to assess strength and then muscular endurance. All tests were supervised by trained lab assistants experienced in conducting strength/anaerobic exercise tests using standard procedures. Prior to strength testing, subjects warmed-up (2 sets of 8–10 repetitions at approximately 50% of anticipated maximum) on the 45° leg press. Subjects then performed successive 1RM lifts on the leg press starting at about 70% of anticipated 1RM and increased by 25–50 lbs until achieving a 1RM. After a 10-minute rest period, subjects warmed up (2 sets of 8–10 repetitions at approximately 50% of anticipated maximum) on the bench press. Subjects then performed successive 1RM lifts starting at about 70% of anticipated 1RM and increased by 5–10 lbs until the achieving a 1RM. Three minutes of rest were given between each attempt on both the leg and bench press tests. A maximum of 5 1RM attempts were performed for both bench and leg press 1RM exercises to prevent excessive fatigue during testing.

Following the strength assessments and 15 minutes of rest, subjects then performed a 30-second Wingate anaerobic capacity test using an Excalibur Sport V2 computerized cycle ergometer (Lode BV, Groningen, Netherlands). Cycle ergometer measurements (seat height, seat position, handle bar height, and handle bar position) were recorded during the familiarization session and kept identical for each subject across testing sessions to ensure test to test reliability.

Before leaving the lab, subjects were assigned to a supplement group based on their body weight to groups were homogeneous in nature and given the standard and required resistance training program. Subjects repeated all baseline testing after 4 (T2) and 8 (T3) weeks of combined training and supplementation. Subjects were also instructed to report on a weekly basis to a research assistant throughout the study to answer a questionnaire regarding side effects and health status.

Dietary records

Nutritional intake was standardized for each participant with the use of dietary records. Prior to each testing session, subjects recorded four days, including at least one weekend day, of detailed food consumption in standard diet logs. Dietary intake was assessed using the Food Processor Nutrition Software (ESHA Research, Salem, OR) to ensure that the dietary intake of daily total calories, protein, carbohydrates, and fat were not different across the three experimental groups.

Resistance training protocol

Subjects participated in a periodized 4-day per week resistance-training program split into two upper- and two lower-extremity workouts per week for a total of 8 weeks. The resistance training protocol consisted of 3 sets of 10 repetitions with as much weight as subjects could lift per set (typically 65–80% of 1RM) for the first four weeks of the study (T1-T2). The intensity progressed to 3 sets of 8 repetitions with approximately 75-85% of 1RM for the remaining duration of the study (T2-T3). Rest periods between exercises and sets were standardized at 3 minutes and 2 minutes, respectively. Training was conducted at the Mayborn Campus Center on the campus of the University of Mary Hardin-Baylor under the supervision of trained research assistants. Subjects documented all achieved repetitions and loads in training logs and were required to have them signed by research assistants to verify compliance and monitor progress. This training program has been shown to be a sufficient stimulus at inducing positive change in body composition and strength (Kerksick et al., 2009a).

Supplementation protocol

Subjects were randomly matched into one of three groups that were parallel in accordance to body weight. Subjects were randomly assigned to ingest daily either 3.5 g creatine plus 900 mg fenugreek (CRF) in tablet form (N=17, 21 ± 2 y, 179 ± 6 cm, 85 ± 10 kg, 15.2 ± 6 %BF), 5g creatine plus 70g dextrose (CRD) in powder form (N=14, 21 ± 4 y, 181 ± 7.1 cm, 89.5 ± 12 kg, 18.2 ± 5 %BF) or a 70g dextrose placebo (PL) in powder form (N=15, 19.8 ± 1 y, 177 ± 6 cm, 86.6 ± 11 kg, 16 ± 6 %BF). CRD and PL groups were double-blinded in respect to the treatment groups. Supplements were enclosed in generic packaging for administration by Indus Biotech™ (Maharashtra, India). All groups were instructed to ingest their supplement with 12-16 ounces of water. The necessary method of administration of the fenugreek extract did not allow for preparation in powder form, thus did not allow for the study to be totally blinded and thus is a limitation of the study. The dosages used represent the current recommended dosages.

Statistical analyses

Separate 3x3 (condition [PL vs. CRD vs. CRF] x time [T1 vs. T2 vs. T3]) repeated measure ANOVAs were used to assess body composition, bench press and leg press 1RM and endurance measures, Wingate power, clinical safety markers (heart rate, blood pressure, clinical serum markers), and relative dietary consumption of kilocalories and macronutrients. In circumstances where sphericity within groups could not be assumed due to large within group variances, the Hunyhs-Feldt epsilon correction factor was used to adjust within group F-ratios. When significant group × time interactions were found, separate one way ANOVAs were performed to assess which time points yielded statistical significance between groups. Significant main effects for time were further analyzed with within-group repeated measures ANOVA tests. Significance for all statistical analyses were computed using PASW (Version 17.0, SPSS Inc., Chicago, IL) and an alpha level of 0.05 was set for all analyses, and all data are presented as means ± standard deviations.

Results

Dietary analysis

Although a couple cases of gastrointestinal discomfort were reported (2 in CRF), no subjects experienced any major clinical side effects related or unrelated to the study. All subjects completed the training protocol without any complications. No significant between or within group differences ($p > 0.05$) were detected for total daily caloric intake ($kcal \cdot kg^{-1} \cdot d^{-1}$), or macronutrient intake ($g \cdot kg^{-1} \cdot d^{-1}$), including carbohydrates, fat, and protein.

Hematological variables

There were no significant main effects for group ($p > 0.05$) or time ($p > 0.05$) for red blood cell count, white blood cell count, triglycerides, cholesterol variables, liver enzymes or proteins, markers of kidney function or muscle damage.

Body composition

Assessed body composition variables are presented in Table 2. No group x time interaction effects or main effects for group were found for any measured body composition variables ($p > 0.05$). Total body weight significantly increased ($p = 0.037$) from T1 to T2 in the CRF group. CRD experienced a significant increase in lean mass at T3 when compared to baseline ($p = 0.020$). Lean mass was significantly increased at T2 ($p = 0.001$) and T3 ($p < 0.001$) compared to baseline in CRF. Despite mean increases lean mass and body weight and decreases in body fat mass and body fat percent, no significant levels ($p > 0.05$) were obtained in the placebo group. A significant main effect for time ($p = 0.013$) was observed for body fat percent. However, post hoc analyses revealed no significant changes over time for body fat percent in any group ($p > 0.05$). No significant main effects for time were observed for fat mass ($p > 0.05$).

Performance assessment

Performance assessment variables are presented in Table 3. A significant group x time interaction effect ($p = 0.018$) was detected for bench press 1RM, however, further analyses showed no significant differences between groups in bench press 1RM at any measured time points ($p > 0.05$). PL experienced a significant increase in bench press 1RM from T1 to T3 ($p = 0.050$). Bench press 1RM significantly increased from T1 to T2 ($p = 0.001$) in CRD, and it remained significantly increased at T3 compared to T1 ($p < 0.001$). CRF experienced significant increases in bench press 1RM from T1 to T2 ($p < 0.001$) and T2 to T3 ($p = 0.032$). Leg press 1RM significantly increased from T1 to T2 and T2 to T3 in PL, CRD, and CRF. Wingate peak power significantly increased ($p = 0.011$) at T2 compared to baseline in CRF. No additional between or within group changes were observed for any performance variables ($p > 0.05$).

Discussion

The major findings of this study suggest that combining 900 mg of a commercially available fenugreek extract with 3.5 grams of creatine for eight weeks in conjunction with a structured resistance training program can significantly impact strength and body composition in resistance trained males as effectively as combining 5g creatine with 70g dextrose. At the conclusion of the study, both creatine supplementation groups demonstrated significant increases in bench press 1RM, leg press 1RM, and lean mass, while only comparable increases in leg press 1RM were observed in the dextrose placebo group. With only minimal differences existing between the two creatine groups on body composition and performance parameters, our results demonstrate that ingesting fenugreek in combination with creatine monohydrate may be an effective strategy for improving creatine uptake similarly to dextrose without having to ingest large amounts of simple carbohydrates. However, we acknowledge that without direct measures of creatine content in muscle via biopsy or magnetic resonance spectroscopy, we are speculating.

The resistance exercise program used in the current investigation has previously been shown to significantly increase upper and lower body strength over an eight-week period in young adult's void of any nutrient timing or supplementation strategies (Kerksick et al., 2009a). Our results are in agreement with the previously mentioned study as the placebo group significantly increased bench press and leg press 1RM by 3% and 20%, respectively, after eight weeks of resistance exercise. However, despite overall mean increases in lean mass and body mass as well as a decreased mean percent body fat, the placebo group did not observed significant increases in these over time. It's possible that the resistance trained population didn't reach significance in these areas despite the mean increases because of their training status, and the stimulus of creatine in the other two groups elicited

Table 2. Body composition assessments at week 0 (T1) and after week 4 (T2) and week 8 (T3). Values are presented as means (± SD).

Variable	PL	CRD	CRF
Weight T1 (kg)	88.7 (12.1)	89.7 (12.4)	85.2 (11.2)
Weight T2 (kg)	88.7 (12.1	90.6 (10.9)	86.3 (11.5) *
Weight T3 (kg)	89.2 (11.3	90.6 (11.3)	86.3 (10.6)
Fat Mass T1 (kg)	13.3 (5.6)	15.2 (5.6)	12.4 (7.1)
Fat Mass T2 (kg)	13.5 (6.0)	13.4 (6.0)	14.4 (10.5)
Fat Mass T3 (kg)	13.0 (5.4)	14.5 (5.3)	11.9 (6.1)
Lean Mass T1 (kg)	65.7 (8.8)	64.7 (8.8)	64.4 (6.8)
Lean Mass T2 (kg)	65.9 (8.9)	66.0 (7.9)	66.0 (7.9) *
Lean Mass T3 (kg)	66.2 (8.3)	66.6 (8.2) *	66.1 (6.9) *
Body Fat % T1	16.0 (5.7)	18.2 (5.4)	15.2 (6.4)
Body Fat % T2	16.1 (6.3)	17.7 (5.3)	14.6 (5.9)
Body Fat % T3	15.6 (5.6)	17.1 (5.0)	14.5 (5.4)

PL = placebo; CRD = creatine with dextrose group; CRF = creatine with fenugreek group. Values are presented as mean ± SD. * significantly different from T1 ($p < 0.05$)

Table 3. Performance assessments at week 0 (T1) and after week 4 (T2) and week 8 (T3). Values are presented as means (±SD).

Variable	PL	CRD	CRF
BP 1RM T1 (kg)	114.6 (31.4)	108.6 (30.4)	121.8 (18.5)
BP 1RM T2 (kg)	117.0 (30.9)	115.1 (29.6) *	127.0 (20.5) *
BP 1RM T3 (kg)	118.2 (30.5) *	118.0 (30.0) *	128.7 (20.8) *†
BP 80% reps T1	8.4 (2.2)	7.9 (1.9)	8.1 (1.7)
BP 80% reps T2	8.7 (1.9)	8.2 (2.2)	7.5 (1.4)
BP 80% reps T3	8.1 (1.7)	7.2 (1.7)	8.1 (1.5)
LP 1RM T1 (kg)	371.8 (82.9)	382.5 (86.6)	372.7 (67.4)
LP 1RM T2 (kg)	417.9 (98.5) *	423.8 (79.1) *	417.8 (77.3) *
LP 1RM T3 (kg)	446.4 (102.7) *†	454.0 (87.1) *†	434.4 (78.5) *†
LP 80% reps T1	15.1 (5.0)	11.5 (6.4)	13.5 (4.1)
LP 80% reps T2	13.7 (4.7)	12.5 (5.1)	12.7 (4.4)
LP 80% reps T3	12.1 (5.5)	13.1 (7.0)	12.0 (5.1)
Win PP T1 (watts)	1220.3 (185.6)	1211.6 (189.2)	1229.6 (139.9)
Win PP T2 (watts)	1239.1 (175.3)	1223.8 (189.4)	1286.6 (128.4) *
Win PP T3 (watts)	1264.7 (154.8)	1273.1 (174.9)	1272.9 (142.3)
Win MP T1 (watts)	651.9 (125.7)	625.9 (97.2)	629.9 (80.1)
Win MP T2 (watts)	659.2 (122.5)	635.1 (106.2)	644.8 (67.7)
Win MP T3 (watts)	674.3 (133.1)	634.5 (110.0)	650.1 (71.1)

PL = placebo; CRD = creatine with dextrose group; CRF = creatine with fenugreek group; BP = bench press; LP = leg press; Win PP = wingate peak power; Win MP = wingate mean power. * significantly different from T1 ($p < 0.05$). † significantly different from T2 ($p < 0.05$).

the significant adaptations observed. It should be noted that the group differences over time were not drastically different from pre to post testing (PL: 0.5 kg; CRD: 1.9 kg; CRF: 1.7 kg).

The effects that creatine supplementation have on increasing strength, performance measures, and lean mass are well established (Bemben et al., 2001; Earnest et al., 1995; Kreider et al., 1998; Pearson et al., 1999; Stout et al., 1999a; Willoughby and Rosene, 2001). Of particular interest to the current study are previous investigations utilizing a dosing regimen that combined creatine with simple carbohydrates, as this has often shown to augment training adaptations beyond that of creatine alone. The biological mechanism responsible for these additional benefits stems from an increase in creatine accumulation and retention (Green et al., 1996a; 1996b; Steenge et al., 1998) via insulin-driven, sodium-dependent creatine transport into skeletal muscle (Clausen and Kohn, 1977; Koszalka et al., 1972).

This dosing strategy was tested by Stout et al. (1999a), as these researchers found that administering a solution of 5.25 g creatine monohydrate and 33 g carbohydrates to resistance trained athletes led to a 12.9% increase in bench press 1-RM compared to a 7.3% increase stemming from creatine alone and a 4.5% increase in placebo group. The subjects ingesting the creatine plus carbohydrate mixture also gained a statistically significant 4.6 kg of fat-free mass compared to subjects ingesting carbohydrate alone, while the creatine alone group gained a non-significant 3.9 kg of fat-free mass compared to placebo. The results of this study indicate that 33g of carbohydrates ingested with creatine were enough to increase upper body strength and fat-free mass to a greater extent than creatine supplementation alone in conjunction with eight weeks of resistance exercise. The current study used a dosing strategy of 70g of dextrose with creatine, which is a typical quantity of carbohydrates found in over-the-counter creatine-carbohydrate supplements. In line with the Stout et al. (1999a) investigation, our data shows similar increases in bench press 1RM (9%) and lean mass (2 kg) in response to carbohydrate-creatine supplementation and eight weeks of resistance exercise. Other work has demonstrated favorable performance outcomes when supplementing with carbohydrate-creatine combinations on anaerobic working capacity (31% increase) (Stout, et al., 1999b), 1RM of arm flexors (28% increase) (Becque et al., 2000), and bench press lifting volume (Kreider et al., 1998).

However, as mentioned previously, repeatedly ingesting high levels of simple carbohydrates over an extended time span could prove detrimental to an athlete's performance and overall health, especially if caloric restriction is a concern. Therefore, a key facet of this study was to determine if an alternative method to carbohydrates would be able to demonstrate comparable effects to a creatine-dextrose solution. The current study examined a previously uninvestigated ingredient in regards to its effects on creatine uptake and performance. Fenugreek is supported by several studies as having a hypoglycemic effect by mimicking insulin's action of increasing glucose sensitivity (Madar et al., 1988; Neeraja and Rajyalakshmi, 1996; Ribes et al., 1984; Sharma et al., 1990; 1996; Vijayakumar et al., 2005). Although fenugreek's actions on the GLUT-4 pathways are well established in animal and human studies, the theoretical concept that it would also have an impact on creatine uptake had been previously, to our knowledge, unexamined. Our results demonstrated that combining 3.5 g creatine monohydrate with 900 mg commercially available fenugreek extract did in fact have similar increases in upper (9% creatine + dextrose; 6% creatine + fenugreek) and lower body (19% creatine + dextrose; 17% creatine + fenugreek) strength and lean mass (3% creatine + dextrose; 13% creatine + fenugreek) when compared to 5 g creatine monohydrate combined with 70 g of dextrose.

Unexpectedly, subjects ingesting creatine + fenugreek experienced significant increases in bench press 1RM and lean mass after four weeks of resistance training, whereas subjects ingesting creatine + dextrose saw no such changes after four weeks. These results led to the speculation that creatine absorption and retention may have been elevated in the subjects ingesting fenugreek during the initial weeks of the study more so than those supplementing with creatine + carbohydrates, thus the earlier onset of training adaptations. However, the accuracy of this hypothesis is questionable due to the fact that blood glucose, insulin, creatine uptake, and creatine retention were not monitored throughout the study. This limitation brings into question fenugreek's role as a creatine transporter in the current study. However, our results demonstrate that creatine + fenugreek is as effective as commonly used creatine supplementation strategies for improving resistance exercise and body composition adaptations, and therefore provides new evidence that fenugreek may transport creatine into skeletal muscle in a similar fashion as carbohydrates would via increasing insulin sensitivity. Future investigations analyzing the effects of adding fenugreek to traditional creatine supplements should focus on assessing fenugreek's ability to transport and retain creatine within skeletal muscle in comparison with creatine-carbohydrate supplements. Additionally, it has been speculated that fenugreek may have an effect on androgen levels, thus the interaction of this effect must be considered as well in future research since alterations of other hormones could affect training adaptations that occur with resistance training.

Conclusion

In conclusion, combining 900 mg of a commercially available fenugreek extract with 3.5 grams of creatine for eight weeks in conjunction with a structured resistance training program can significantly impact strength and body composition in resistance trained males as effectively as combining 5g creatine with 70g dextrose. This alternative creatine supplementation strategy may prove beneficial to certain populations concerned with the negative implications of consuming large quantities of simple carbohydrates. These findings are novel to the respect that no studies have previously investigated the effects of fenugreek extract in combination with creatine monohydrate on performance measures.

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References

Bates, S.H., Jones, R.B. and Bailey, C.J. (2000) Insulin-like effect of pinitol. *British Journal of Pharmacology* ***130*(8)**, 1944-1948.

Becque, M.D., Lochmann, J.D. and Melrose, D.R. (2000) Effects of oral creatine supplementation on muscular strength and body composition. *Medicine and Science in Sports and Exercise* **32(3)**, 654-658.

Bemben, M. G., Bemben, D.A., Loftiss, D.D. and Knehans, A.W. (2001) Creatine supplementation during resistance training in college football athletes. *Medicine and Science in Sports and Exercise* **33(10)**, 1667-1673.

Brenner, M., Rankin, J.W., and Sebolt, D. (2000) The effect of creatine supplementation during resistance training in women. *Journal of Strength and Conditioning Research* **14(2)**, 207-213.

Chrusch, M.J., Chilibeck, P.D., Chad, K.E., Davison, K.S. and Burke, D.G. (2001) Creatine supplementation combined with resistance training in older men. *Medicine and Science in Sports and Exercise* **33(12)**, 2111-2117.

Clausen, T. and Kohn, P.G. (1977) The effect of insulin on the transport of sodium and potassium in rat soleus muscle. *The Journal of Physiology* **265(1)**, 19-42.

Earnest, C.P., Snell, P.G., Rodriguez, R., Almada, A.L. and Mitchell, T. L. (1995) The effect of creatine monohydrate ingestion on anaerobic power indices, muscular strength and body composition. *Acta Physiologica Scandinavica* **153(2)**, 207-209.

Estrada, D.E., Ewart, H.S., Tsakiridis, T., Volchuk, A., Ramlal, T., Tritschler, H. and Klip, A. (1996) Stimulation of glucose uptake by the natural coenzyme alpha-lipoic acid/thioctic acid: participation of elements of the insulin signaling pathway. *Diabetes* **45(12)**, 1798-1804.

Green, A.L., Hultman, E., Macdonald, I.A., Sewell, D.A. and Greenhaff, P.L. (1996a) Carbohydrate ingestion augments skeletal muscle creatine accumulation during creatine supplementation in humans. *The American Journal of Physiology* **271(5 Pt 1)**, E821-6.

Green, A.L., Simpson, E.J., Littlewood, J.J., Macdonald, I.A. and Greenhaff, P.L. (1996b) Carbohydrate ingestion augments creatine retention during creatine feeding in humans. *Acta Physiologica Scandinavica* **158(2)**, 195-202.

Greenhaff, P.L., Bodin, K., Soderlund, K. and Hultman, E. (1994) *Effect of oral creatine supplementation on skeletal muscle phosphocreatine resynthesis. American Journal of Physiology- Endocrinology and Metabolism* **266,** E725-E730.

Gupta, A., Gupta, R. and Lal, B. (2001) Effect of Trigonella foenumgraecum (fenugreek) seeds on glycaemic control and insulin resistance in type 2 diabetes mellitus: a double blind placebo controlled study. *The Journal of the Association of Physicians of India* **49**, 1057-1061.

Kerksick, C.M., Wilborn, C.D., Campbell, B.I., Roberts, M.D., Rasmussen, C.J., Greenwood, M. and Kreider, R.B. (2009a) Early-phase adaptations to a split-body, linear periodization resistance training program in college-aged and middle-aged men. *Journal of Strength and Conditioning Research* **23(3)**, 962-971.

Kerksick, C.M., Wilborn, C.D., Campbell, W.I., Harvey, T.M., Marcello, B.M., Roberts, M.D., Parker, A.G., Byars, A.G., Greenwood, L.D., Almada, A.L., Kreider, R.B. and Greenwood, M. (2009b) The effects of creatine monohydrate supplementation with and without D-pinitol on resistance training adaptations. *Journal of Strength and Conditioning Research* **23(9)**, 2673-2682.

Koszalka, T.R., Andrew, C.L. and Brent, R.L. (1972) Effect of insulin on the uptake of creatine-1- 14 C by skeletal muscle in normal and x-irradiated rats. *Proceedings of the Society for Experimental Biology and Medicine Society for Experimental Biology and Medicine (New York, N.Y.)* **139(4)**, 1265-1271.

Kreider, R.B., Ferreira, M., Wilson, M., Grindstaff, P., Plisk, S., Reinardy, J., Cantler, E. and Almada, A.L. (1998) Effects of creatine supplementation on body composition, strength, and sprint performance. *Medicine and Science in Sports and Exercise* **30(1)**, 73-82.

Madar, Z., Abel, R., Samish, S. and Arad, J. (1988) Glucose-lowering effect of fenugreek in non-insulin dependent diabetics. *European Journal of Clinical Nutrition* **42(1)**, 51-54.

Martin, J., Wang, Z.Q., Zhang, X.H., Wachtel, D., Volaufova, J., Matthews, D.E. and Cefalu, W.T. (2006) Chromium picolinate supplementation attenuates body weight gain and increases insulin sensitivity in subjects with type 2 diabetes. *Diabetes Care* **29(8)**, 1826-1832.

Neeraja, A. and Rajyalakshmi, P. (1996) Hypoglycemic effect of processed fenugreek seeds in humans. *Journal of Food Science and Technology-Mysore* **33(5)**, 427-430.

Pearson, D.R., Hambx Wade Russel, D.G. and Harris, T. (1999) Long-term effects of creatine monohydrate on strength and power. *Journal of Strength and Conditioning Research* **13(3)**, 187-192.

Rawson, E.S. and Volek, J.S. (2003) Effects of creatine supplementation and resistance training on muscle strength and weightlifting performance. *Journal of Strength and Conditioning Research* **17(4)**, 822-831.

Ribes, G., Sauvaire, Y., Baccou, J.C., Valette, G., Chenon, D., Trimble, E.R. and Loubatieres-Mariani, M.M. (1984) Effects of fenugreek seeds on endocrine pancreatic secretions in dogs. *Annals of Nutrition & Metabolism* **28(1)**, 37-43.

Sharma, R.D., Sarkar, A., Hazara, D.K., Mishra, B., Singh, J.B., Sharma, S.K., Maheshwari, B.B. and Maheshwari, P.K. (1996) Use of Fenugreek seed powder in the management of non-insulin dependent diabetes mellitus. *Nutrition Research* **16(8)**, 1331-1339.

Sharma, R.D., Raghuram, T.C. and Rao, N.S. (1990) Effect of fenugreek seeds on blood glucose and serum lipids in type I diabetes. *European Journal of Clinical Nutrition* **44(4)**, 301-306.

Steenge, G.R., Lambourne, J., Casey, A., Macdonald, I.A. and Greenhaff, P.L. (1998) Stimulatory effect of insulin on creatine accumulation in human skeletal muscle. *The American Journal of Physiology* **275(6 Pt 1)**, E974-9.

Stout, J.R., Eckerson, J., Noonan, D., Moore, G. and Cullen, D. (1999a) Effects of 8 weeks of creatine supplementation on exercise performance and fat-free weight in football players during training. *Nutrition Research* **19(2)**, 217-225.

Stout, J.R., Eckerson, J.M., Housh, T.J. and Ebersole, K.T. (1999b) The effects of creatine supplementation on anaerobic working capacity. *Journal of Strength and Conditioning Research* **13(2)**, 135-138.

Vijayakumar, M.V., Singh, S., Chhipa, R.R. and Bhat, M.K. (2005) The hypoglycemic activity of fenugreek seed extract is mediated through the stimulation of an insulin signaling pathway. *British Journal of Pharmacology* **146(1)**, 41-48.

Volek, J. S., Duncan, N. D., Mazzetti, S. A., Staron, R.S., Putukian, M., Gómez, A.L., Pearson, D.R., Fink, W.J. and Kraemer, W.J. (1999) Performance and muscle fiber adaptations to creatine supplementation and heavy resistance training. *Medicine and Science in Sports and Exercise* **31(8)**, 1147-1156.

Volek, J.S., Kraemer, W.J., Bush, J.A., Boetes, M., Incledon, T., Clark, K.L. and Lynch, J.M. (1997) Creatine supplementation enhances muscular performance during high-intensity resistance exercise. *Journal of the American Dietetic Association* **97(7)**, 765-770.

Willoughby, D.S. and Rosene, J. (2001) Effects of oral creatine and resistance training on myosin heavy chain expression. *Medicine and Science in Sports and Exercise* **33(10)**, 1674-1681.

Key points

- Fenugreek plus creatine supplementation may be a new means of increasing creatine uptake.
- Creatine plus fenugreek seems to be just as effective as the classic creatine plus carbohydrate ingestion in terms of stimulating training adaptations.
- This is the first study to our knowledge that has combined fenugreek with creatine supplementation in conjunction with a resistance training program.

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