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Original Research Article

The Effects of Pre/Post Dietary Supplementation on Power Output in Collegiate Female Soccer Players

Brandon D. Rodewald[1], Lance C. Dalleck[1], Christina A. Buchanan[1]

[1]High Altitude Exercise Physiology Program, Western Colorado University, Gunnison, CO, USA

ABSTRACT

Introduction: Creatine and leucine have been extensively studied with recommended dosages showing significant benefits on athletic performance. The timing of these supplements has been less researched. The purpose of this study is to determine if the timing of creatine and leucine supplementation effects strength and power output in collegiate female soccer players. **Methods:** 17 Female NCAA soccer players were randomly assigned to two groups. (Pre-supplementation and Post-supplementation) Training lasted nine weeks with two testing weeks (one pre, one post). Subjects trained four times per week and were tested on various strength, power and speed variables. During each visit each subject received one scoop of Muscle Pharm ReCon containing five grams of creatine monohydrate and three grams of leucine. **Results:** Both pre and post supplementation groups saw significant changes ($p<0.05$) in the Bench Press, Back Squat, Deadlift, Total, pound for pound ratio, Wingate peak power and the t-test. The pre-group saw significant changes in vertical jump as opposed to the post group. On the other end the post group saw significant changes ($p<0.05$) in weight change whereas the pre group did not. Neither group significantly changed their pro-agility time from pre to post testing. **Conclusion:** Using recommended dosages from previous literature this study was to determine if nutrient timing had any effect on power output. Results showed that both groups benefitted significantly over the course of nine weeks of off-season strength and conditioning training. It would appear that dosaging plays more of a role in performance enhancement than timing. Further research should experiment with different dosages as well as timing to determine the optimal dose and time of supplementation.

KEYWORDS: Creatine, Leucine, Power Output, Dosage, Strength and Conditioning.

Introduction

The world of collegiate athletics is competitive in all facets and athletes are constantly looking for an edge to put them ahead of their competition. One of these avenues athletes have begun using is the use of sport and nutrition supplements to help take their bodies to the next level. Supplementation has been used for several decades but has increased steadily across the world including the United States. In fact the global sports nutrition market has experienced a 9% growth rate over the past six years[12]. The use of these supplements can benefit performance pre-competition, during competition as well as post-competition. Some of the most popular supplements currently are protein, creatine and branch chain amino acids[12]. These supplements are designed to increase recovery from high intensity bouts of exercise allowing athletes to prepare for the next training session or game faster.

Supplements containing creatine have been heavily studied and have shown great results with increasing lean muscle mass and providing increases in strength. One study conducted by Ramirez-Campillo et al. (2016) observed the effects of creatine use post exercise in female soccer players. After six weeks of plyometric and resistance training the creatine group saw increases over the control group in peak jump power, 40cm reactive jump index as well as all speed and agility tests. Another study also looking at female athletes and creatine supplementation analyzed creatine effects on athlete's performance during different times of the year (in-season, off-season) and analyzed that creatine use in both groups resulted in better increases in lean muscle mass[6].

BCAA supplementation has been less researched but it has been studied that serum levels of amino acids are significantly lowered after 90 minutes of resistance training[2]. This would suggest that supplementing a BCAA supplement could elevate levels of amino acids during resistance training and enhance protein synthesis. The amino acid leucine is more researched and has been shown to prevent the decrease of serum amino acids during intense exercise[14]. BCAA supplementation has also been shown to help promote anabolic effects in relation to hormones. A study looking at resistance training and BCAA supplementation noted that after 28 days of supplementation, testosterone levels increased and cortisol levels decreased in the supplementation group[14]. Although creatine and BCAA have shown benefits in athletic performance and there are recommendations on proper dosing for these supplements there is less research on the timing to optimize the performance benefits associated with these supplements. Therefore, the purpose of this study was to look at the effects of a creatine and BCAA supplement in collegiate female athletes and analyze the performance benefits as they relate to time of consumption. It can be hypothesized that the post-exercise group will see greater benefits in body composition

and strength gains due to increased blood flow during exercise that can lead to creatine and amino acid uptake in the skeletal muscle.

Methods

Subjects

In this study 17 female collegiate soccer players volunteered to participate. Subjects ages ranged from 18-22 years of age and were included if they were a current member of the Western Colorado University's Soccer team. Subjects were excluded from the study if they had any dietary limitations or physical limitations that would not allow them to participate in off-season training or take the supplement Re-con. Subjects were also excluded if they were not considered low-risk. Subjects were randomly assigned to either a pre-workout (pre-RecCon) or post-workout (post-ReCon) group with a total of eight subjects in the pre group and nine in the post group (Table 1).

Table 1. Subject characteristics.

Characteristic	Pre	Post
N	8	9
Height (cm)	63.5±11.8	59.1±6.1
Weight (kg)	162.9±6.2	162.9±5.5

Height and Weight presented in mean±SD

Prior to any data collection informed consent was completed. Study protocols were provided in both writing and verbally to each subject.

Experimental Design

The randomized comparative study was designed to look at the benefits of taking a supplement designed to promote recovery from intense exercise. The primary ingredients in the product Re-Con by Musclepharm are five grams of creatine monohydrate and branched chain amino acids specifically three grams of leucine. The purpose of this study was to analyze if taking these ingredients either prior or post exercise is most beneficial. Therefore, nine subjects were randomly placed in a pre-workout ingestion group while the other nine were placed in a post-workout group. The Re-Con was mixed with 6 ounces of water and was ingested either 10 minutes prior or after training. Subjects supplemented during every training session four times per week.

All subjects were on the same protocol as far as off-season workouts. Workouts were held at the NCAA strength and conditioning facility inside Paul Wright Gym at Western State Colorado University. Subjects trained Tuesday-Friday at 6 a.m. The training program during the off-season was formatted utilizing block periodization (undulating) and lasted approximately 9 weeks. 3 blocks were utilized during the course of the program. The schedule for training included 2 weeks of testing, 2 weeks of eccentric focused training, 2 weeks of isometric training, 2 weeks of concentric training and finally 1 deload week right before the post testing period. See figure 1.

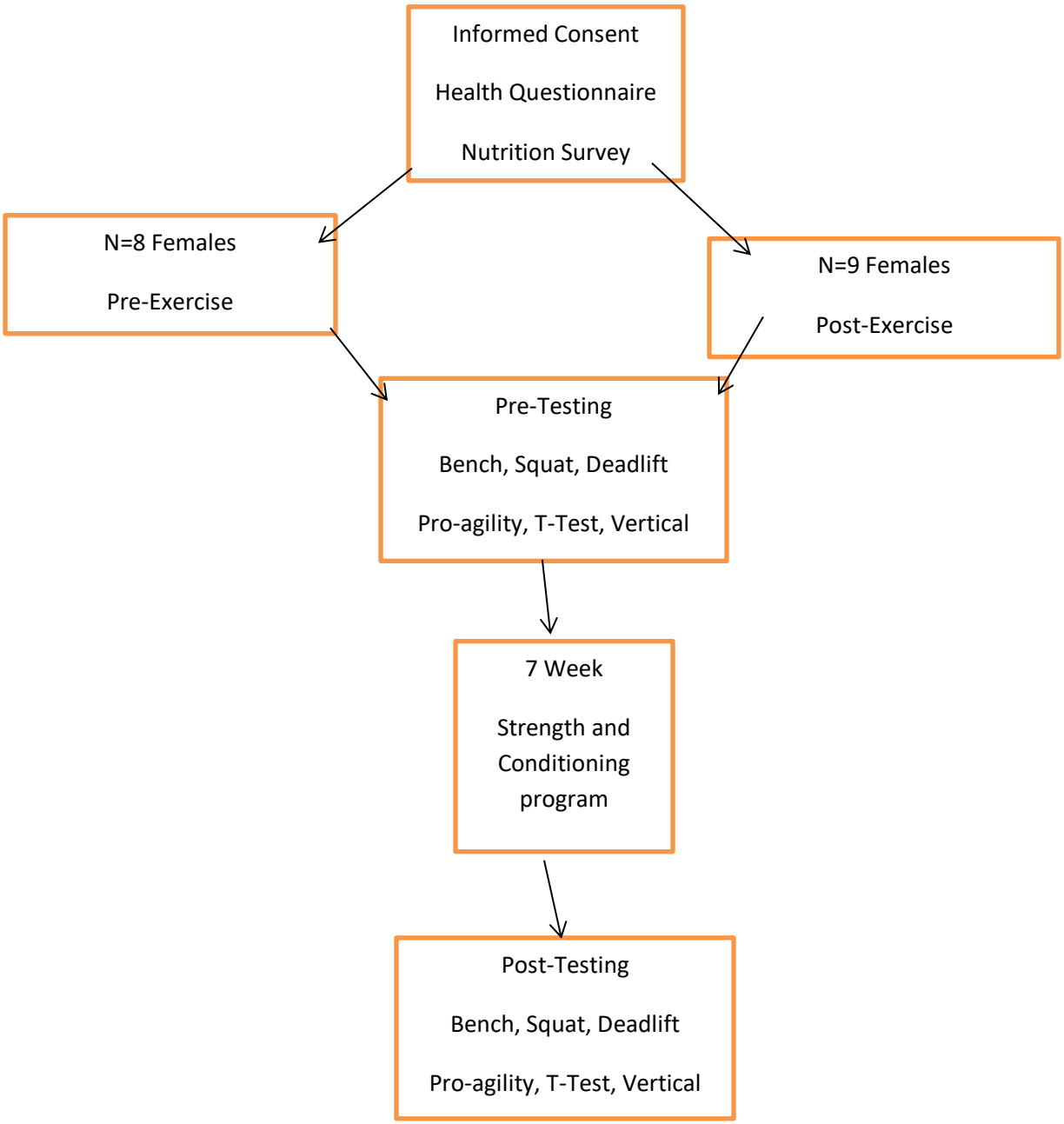

Figure.1 Experimental flowchart.

Procedures:

Supplementation

1. For all training sessions 1 scoop of Re-con was administered to the subjects either 10 minutes prior to training or 10 minutes post training. Each testing day was scheduled for 1 hour in duration.

Monday-Anthropometric Measures

1. Height and Weight for all 18 subjects will be collected at the Paul Wight Gym Strength and Conditioning Facility. Upon completion the subjects began warming up for the speed and agility tests. All tests were completed within an hour to an hour and a half.

Tuesday-Wingate Testing

1. Wingate testing was performed inside the Western State Colorado University's High Altitude Performance Lab (HAPLAB). The bike used was a Monark bike that utilized Monark Wingate software to analyze all statistics. The testing for the Wingate was the following.

a. Bike was set up to drop 7.5% of subject's body weight in kg.
b. Subjects warmed up at 50 watts for 3 minutes
c. After 3 minutes the subject pedaled as fast as they can and when the subject hit 150 watts the weight would drop and the 30 second all-out effort would begin.
d. After the test was completed subjects cooled down at 50 watts for 2 minutes.

Wednesday- Bench Press

1. 1-Rep Max (Bench Press)

a. Participants partook in the testing of 1-Rep Max (1RM) in the Back Squat, Deadlift and Bench Press exercises.
b. Testing for these exercises followed the protocols set forth by the NSCA:

Participant warmed-up with a light resistance easily allowing 5-10 repetitions.

1-minute rest was provided. An estimated warm-up load was determined in order to allow the participant to complete 3-5 repetitions by adding: 10-20 pounds or 5-10% for upper body exercise or, 30-40 pounds or 10-20% for lower body exercise.

2-minute rest was provided. An estimated sub-maximal load was determined in order to allow the participant to complete 2-3 repetitions by adding: 10-20 pounds or 5-10% for upper body exercise or, 30-40 pounds or 10-20% for lower body exercise.

2- to 4-minutes of rest was provided. A load increase was made by adding: 10-20 pounds or 5-10% for upper body exercise or, 30-40 pounds or 10 20% for lower body exercise.

Participant was instructed to perform a 1RM. If successful, a 2- to 4-minute rest was provided and they repeated. If unsuccessful, a 2- to 4-minute rest was provided and the load was decreased by subtracting: 5-10 pounds or 2.5-5% for upper body exercise or, 15-20 pounds or 5-10% for lower body exercise.

Repeat Max attempt.

Participants continued increasing or decreasing the load until 3 testing attempts had been recorded for participant.

Thursday-Back Squat, Pro-Agility, T-Test

1. 1-Rep Max (Back Squat)

a. Participants partook in the testing of 1-Rep Max (1RM) in the Back Squat,

Deadlift and Bench Press exercises.

b. Testing for these exercises followed the protocols set forth by the NSCA:

Participant warmed-up with a light resistance easily allowing 5-10 repetitions. 1-minute rest was provided.

An estimated warm-up load was determined in order to allow the participant to complete 3-5 repetitions by adding: 10-20 pounds or 5-10% for upper body exercise or, 30-40 pounds or 10-20% for lower body exercise. 2-minute rest was provided. An estimated sub-maximal load was determined in order to allow the participant to complete 2-3 repetitions by adding:10-20 pounds or 5-10% for upper body exercise or, 30-40 pounds or 10-20% for lower body exercise. 2- to 4-minutes of rest was provided. A load increase was made by adding: 10-20 pounds or 5-10% for upper body exercise or, 30-40 pounds or 10-20% for lower body exercise.

Participant was instructed to perform a 1RM. If successful, a 2- to 4-minute rest was provided and they repeated attempt. If unsuccessful, a 2- to 4-minute rest was provided and the load was decreased by subtracting: 5-10 pounds or 2.5-5% for upper body exercise or, 15-20 pounds or 5-10% for lower body exercise.

Repeat step 1rm. Participants continued increasing or decreasing the load until 3 testing attempts had been recorded for participant.

2. Pro-Agility (5-10-5)

a. Participants started by straddling the middle cone using a three-point stance.
b. On the whistle/PI's command, participants sprinted to the cone on the left & touched the cone/line.
c. Participants immediately changed direction & sprinted to the far cone/line on the right.
d. Participants must touch the cone/line & change direction, sprinting through the middle cone/line.
e. A minimum of 1 minute rest was allotted.
f. Repeat for a total of 2 trials.
g. Designated cones/lines must be touched (foot or hand).
h. Best of two trials will be recorded (nearest 0.01 second).
i. Failure to comply with rule "g" will result in disqualification & restart.

3. T-Test

a. Participants started in a standing position at the first cone.
b. Participants then sprinted forward 10 yards to cone number 2 and touched it with their hand.
c. Participants then side shuffled 5 yards to the left and touched cone number 3 and touched with their outside hand.
d. After touching cone 3 participants then side shuffled 10 yards to the right and touched cone number 4.
e. After cone 4 participants side shuffled back to cone 2 initiating the final part of the test.
f. After reaching cone 2 back in the middle participants back pedaled to cone 1 in the starting position.
g. Participants were asked to perform this test twice and the faster of the 2 attempts was documented.

Friday-Deadlift, Vertical

1. 1-Rep Max (Deadlift)

a. Participants partook in the testing of 1-Rep Max (1RM) in the Back Squat, Deadlift and Bench Press exercises.

b. Testing for these exercises followed the protocols set forth by the NSCA: Participant warmed-up with a light resistance easily allowing 5-10 repetitions. 1-minute rest was provided. An estimated warm-up load was determined in order to allow the participant to complete 3-5 repetitions by adding: 10-20 pounds or 5-10% for upper body exercise or, 30-40 pounds or 10-20% for lower body exercise. 2-minute rest was provided. An estimated sub-maximal load was determined in order to allow the participant to complete 2-3 repetitions by adding: 10-20 pounds or 5-10% for upper body exercise or, 30-40 pounds or 10-20% for lower body exercise. 2- to 4-minutes of rest was provided. A load increase was made by adding: 10-20 pounds or 5-10% for upper body exercise or, 30-40 pounds or 10-20% for lower body exercise. Participant was instructed to perform a 1RM. If successful, a 2- to 4-minute rest was provided and they repeated max attempt. If unsuccessful, a 2- to 4-minute rest was provided and the load was decreased by subtracting:

5-10 pounds or 2.5-5% for upper body exercise or, 15-20 pounds or 5-10% for lower body exercise. Repeat 1rm. Participants continued increasing or decreasing the load until 3 testing attempts had been recorded .

2. Vertical Jump (Counter-movement)

a. Participants went through the warm-up protocol(s) designed for the off-season training program.

b. Participants stood on a *Just Jump System* (Probotics) mat in the WCU weight room and were asked to perform 2 jumps using a counter-movement (i.e., arm swing)

c. Participants were allowed 1 warm-up jump of each variation (counter-movement, static).

d. A minimum of 1 minute rest was allotted between each jump attempt.

e. A third jump was awarded if: Participant's previous readings were greater than 1 inch of difference or, Participant felt confident they could obtain a greater jump height. The average of the participants 2 jumps was recorded.

Statistical Analysis:

All data analyses were performed using SPSS Version 25 (IBM-SPSS Boston, MA). All basic subject characteristics were presented in terms of a mean ± SD. All the dependent variables (Vertical, pro-agility, t-test, bench press, back squat, and deadlift) were compared using paired-sample t-tests to determine statistical significance between treatment groups ($p<0.05$).

Results

A total of 17 subjects participated in this study. Eight were randomly placed in the pre-supplementation group and nine in the post-supplementation group. Over the course of nine weeks of training the

supplement was consumed during weeks 2-8 making a total of a possible 28 days of supplementation. During this time span eight subjects missed a dose due to absence. None of the subjects dropped out of the study due to supplementation related issues however, certain subjects were limited in training and testing due to lingering injury or injuries sustained outside of the training protocol. All subjects consumed the supplement within the strength and conditioning facility to monitor ingestion. No subjects complained of any side effects outside of some subjects mentioning feeling bloated. All 17 subjects that began the study with supplementation completed the study however. Table 2 illustrates overall testing numbers between groups for all testing parameters. (Bench press, Squat, Deadlift, Total, Pound for pound total, Pro-agility, T-test, Vertical and Wingate peak power.)

Table 2. Baseline and post-testing results for pre/post supplementation groups.

Variables	Pre-Supplementation n=8		Post-Supplementation n=9	
	Baseline	**POST**	**Baseline**	**POST**
Weight (kg)	63.8±12	64.5±11.7	59.1±5.4*	60.4±5.1*
Bench (lbs)	100.6±9.8*	111±11.4*	91.3±20.1*	98.1±21.4*
Back Squat (lbs)	174.3±17.9*	201±16.0*	174.4±41.2*	195.0±42.5*
Deadlift (lbs)	204.6±15.1*	224±14.2*	202.4±40.3*	221.3±34.2*
Total (lbs)	481.0±35.2*	540.7±33.8*	458.0±107.8*	503.6±103.6*
Total:Wt	1.1±0.2*	1.3±0.2*	1.2±0.2*	1.3±0.2*
Vertical (in)	17.9±2.4*	19.6±3.1*	19.1±2.0	20.3±1.7
T-Test (sec)	11.3±0.5*	12.4±0.4*	11.1±0.3*	12.5±0.5*
Pro-Agility (sec)	5.3±0.4	5.2±0.3	5.1±0.1	5.1±0.2
Wingate-PP (watts)	548.4±84*	621.7±98.8*	535.5±117.1*	587.6±117.9*

*indicates statistical significance ($p<0.05$)

Independent samples t-test were run to analyze any significant changes between testing variables. Changes in back squat max from baseline to post testing revealed a significant change ($t=0.39$, $p<0.05$). Changes in the bench press from baseline to post testing also showed a level of significance ($t=0.08$, $p<0.05$). Overall power drop levels during Wingate testing also showed significant changes from baseline to post ($t=0.033$, $p<0.05$). All other variables were shown to be insignificant ($p>0.05$).

Paired sample t-tests were run to break down individual changes between the pre-supplementation and post-supplementation group. Eight subjects were randomly placed into the pre-supplementation group. Paired t-tests showed no significant changes from baseline to post testing in body weight

(p>0.05). Significant improvements were found from baseline to post in all strength tests (Bench Press, Back Squat, Deadlift, Total, and Pound for Pound Total) p<0.05. There were also significant changes in performance measures (Vertical, T-Test, and Wingate Peak Power) p<0.05. There were no significant changes seen in the pro-agility, however.

Post-supplementation group consisted of nine subjects who experienced similar results to the pre-supplementation group. Unlike the pre-supplementation group, however, the post group did have a significant change in body weight from baseline to post testing (t=0.011, p<0.05). Consistent with the pre-group, all strength measurements were significantly different from pre to post for (Bench Press, Back Squat, Deadlift, Total, and Pound for Pound Total) p<0.05. There were also significant changes seen in Wingate peak power and the t-test (p<0.05), however, vertical and pro-agility were not significantly different (p>0.05). Mean averages (and individual responses) of the three most significant strength tests are presented in Figure 1.

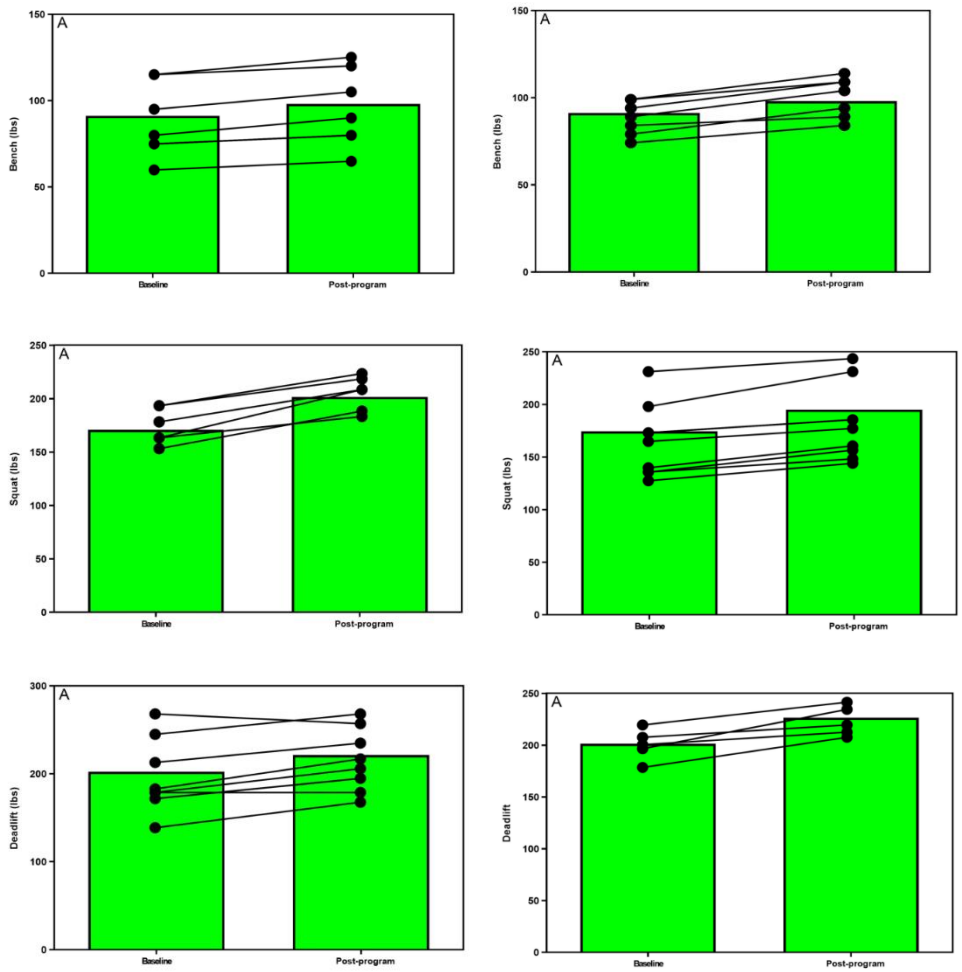

Figure 2. Mean averages and individual responses.

Discussion

Statistical analysis showed significant increases in the vast majority of subjects regardless of the timing of supplement ingestion. These findings help support the literature, showing that five grams of creatine monohydrate seems adequate to provide a beneficial response in athletic performance[13]. The suggestion in the literature that three grams of leucine is optimal for benefitting performance was also supported within this study[12]. The key differences in findings however came from the timing of ingestion. Much of the literature suggested that creatine and BCAAs be ingested post exercise to have the most optimal response[12]. However, this study concluded that subjects that consumed creatine and BCAAS prior to resistance training experienced the same level of benefit as those that took the supplement post-exercise.

In the study by Ramirez-Campillo et al. (2016) soccer players that supplemented with five grams of creatine for six weeks and resistance trained, experienced significant increases in both vertical jump and power performance. Our findings are consistent with the findings from this study as both the pre and post groups increased over the nine week program.

Aside from performance benefits, the dosages used seemed to back up previous literature very well[19]. Often with creatine use, there is a loading phase before training to ensure creatine stores are ready to be utilized by the time training begins. This study opted out of the loading phase and went with a five gram per day maintenance phase. It had been previously stated that slowly loading may elicit greater performance benefits and reduce side effects[6]. All subjects that completed the study saw performance benefits and did not report any serious side effects so it can be considered that a loading phase was not necessary for the duration of this study and that five grams/day over nine weeks was a sufficient dosage. Similarly, with leucine, the recommended dose would be a supplement with 30-35% of the BCAAs composed of leucine, and the dosage enough to supply 45mg/kg (Mero, 1999). ReCon met these requirements for the athletes used in the study and based on the results in strength improvements and increase in body weight it would seem that leucine was effective in promoting strength gains and promoting muscle anabolism.

There are instances in which the results of this study differed from the literature. A study by Syrotuik and Bell, (2004) found that around 20% of individuals who supplement with creatine are non-responders. However, based on the findings in this study, every subject proved to have a beneficial response from creatine supplementation. Another area that differed was that all our subjects improved even if they supplemented pre-workout. Previously, studies had hypothesized or stated that post-workout

creatine and leucine consumption was more beneficial[12]. Based on the fact that all the pre-supplementation athletes improved in every max test it can be argued that timing of supplementation is not important.

Biochemistry

The demands of soccer require several energy systems, with the phosphagen system and glycolytic system being the two primary systems utilized[10]. Soccer players often have many repeated sprints during the course of a game that drains ATP quickly. Creatine supplementation allows for greater regeneration of ATP[10]. Thus, providing more ATP to be utilized before the activation of glycolysis. The extra ATP may contribute to faster recovery and less fatigue which can be helpful in meeting the high demands of off-season training.

The amino acid leucine, plays an important role in the activation of the mTOR pathway[18]. By increasing signaling to both the mTOR pathway as well as the AMPK pathway, protein synthesis is elevated, allowing for greater recovery from muscle breakdown. This is due to an increased uptake of nutrients to the skeletal muscle. As previously stated, anything that allows for a quicker and more efficient recovery could prove to be an essential tool when paired with off-season strength and conditioning training.

Practical Application

The findings of this study have a benefit to all athletes; not just female soccer players. Creatine and leucine are nutrients that may be utilized by athletes year round. Maintaining elevated protein synthesis levels can keep athletes in an anabolic state for longer, allowing for some downtime between training sessions. This could prove to be helpful for in-season athletes that may only be training in the weight room a couple days a week rather than four, as seen in this study. Supplements such as ReCon also include small amounts of protein and carbohydrates that have been linked to enhanced protein synthesis and may help with insulin sensitivity[12]. At smaller NCAA schools there is often not a nutrition program for athletics, creatine and BCAAS are fairly inexpensive and could help combat poor nutrition and long training days.

Limitations

During the course of the study all training sessions and consumption of the supplement were monitored and controlled as delicately as possible however, there are still areas of the study that could not be totally accounted for. As the subjects were student-athletes, injuries associated with sport factored into the study. It is important to note however, that no one in the study dropped out due to any side effects associated with supplementation or the training protocol. Neuromuscular adaptation is not considered a limitation because these athletes had already been resistance training for a year or more prior to this off-season block. One limitation however, was that body composition was not accounted for. This was due to not

having a female assistant to take skin folds. This data could have provided more insight into whether weight gain was due to lean muscle mass or fat. With this being said, athletes pound for pound totals all increased over the course of the study. This hints that the athletes body weight stayed consistent or increased only slightly, while getting much stronger. This could potentially be associated with lean muscle mass increase. Future studies could benefit from monitoring body composition to ensure that changes in body composition are related to the training and supplementation consumption. Lastly, the study might have benefitted from a control group. However, the purpose of the study was to analyze supplement timing rather than supplement effectiveness. The benefits of creatine and BCAAS have been studied extensively and there are many accounts of positive increases in athletic performance. Less research exists on the timing of ingestion.

Conclusion

This study provided a closer look at nutrient timing in relation to off-season strength and conditioning training. It is important to acknowledge that timing was the focus rather than dosage. Based on the findings, there seems to be a significant benefit in athletic performance and power output when athletes supplement training with a creatine and BCAA supplement. The dosages of five grams of creatine monohydrate and three grams of leucine were selected based on previous literature and these dosages were sufficient inproviding increases in power output. Athletes utilizing this information should focus on dosage rather than timing if they wish to enhance their athletic performance. Further research monitoring changes in body composition would provide more insight into changes in lean muscle mass. Overall, the use of creatine and leucine as a combined ergogenic aid elicits significant increases in strength, power, and speed when paired with resistance training.

Address for Correspondence

Lance Dalleck, Ph.D., High Altitude Exercise Physiology Program, 600 N. Adams St., Western Colorado University, Gunnison, CO, United States, 81231. Phone: 970-943-3095;
Email: ldalleck@western.edu.

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