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Effect of creatine supplementation and drop-set resistance training in untrained aging adults

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ABSTRACT

Objective: To investigate the effects of creatine supplementation and drop-set resistance training in untrained aging adults. Participants were randomized to one of two groups: Creatine (CR: $n = 14$, 7 females, 7 males; 58.0 ± 3.0 yrs, 0.1 g/kg/day of creatine + 0.1 g/kg/day of maltodextrin) or Placebo (PLA: $n = 17$, 7 females, 10 males; age: 57.6 ± 5.0 yrs, 0.2 g/kg/day of maltodextrin) during 12 weeks of drop-set resistance training (3 days/week; 2 sets of leg press, chest press, hack squat and lat pull-down exercises performed to muscle fatigue at 80% baseline 1-repetition maximum [1-RM] immediately followed by repetitions to muscle fatigue at 30% baseline 1-RM).
Methods: Prior to and following training and supplementation, assessments were made for body composition, muscle strength, muscle endurance, tasks of functionality, muscle protein catabolism and diet.
Results: Drop-set resistance training improved muscle mass, muscle strength, muscle endurance and tasks of functionality ($p < 0.05$). The addition of creatine to drop-set resistance training significantly increased body mass ($p = 0.002$) and muscle mass ($p = 0.007$) compared to placebo. Males on creatine increased muscle strength (lat pull-down only) to a greater extent than females on creatine ($p = 0.005$). Creatine enabled males to resistance train at a greater capacity over time compared to males on placebo ($p = 0.049$) and females on creatine ($p = 0.012$). Males on creatine ($p = 0.019$) and females on placebo ($p = 0.014$) decreased 3-MH compared to females on creatine.
Conclusions: The addition of creatine to drop-set resistance training augments the gains in muscle mass from resistance training alone. Creatine is more effective in untrained aging males compared to untrained aging females.

1. Introduction

The age-related loss of muscle mass and muscle performance has a negative effect on physical function (Balagopal et al., 1997), which subsequently decreases the ability to perform activities of daily living (Manini and Clark, 2013). Two interventions which may benefit aging individuals are creatine supplementation and resistance training (for reviews see Candow et al., 2014; Devries and Phillips, 2014; Gualano et al., 2016). Creatine has been shown to increase intramuscular total creatine (i.e. free creatine and PCr) in aging adults (Brose et al., 2003). The increase in high energy phosphates could allow one to train with a greater volume of resistance training leading to an increase in muscle mass (Chrusch et al., 2001). Furthermore, creatine may have a direct effect on muscle biology by influencing cellular hydration status (Balsom et al., 1995), satellite cell activity (Olsen et al., 2006), anabolic hormone production (i.e. IGF-1) (Burke et al., 2008; Deldicque et al., 2005), myogenic regulatory transcription factors (Hespel et al., 2001; Willoughby and Rosene, 2003) and muscle protein kinetics (Candow et al., 2008; Parise et al., 2001; Safdar et al., 2008).

Speculation exists that the age-related loss of muscle mass is partially caused by an attenuated response to resistance training (Breen and Phillips, 2011). Therefore, a greater volume of resistance training may be needed to produce significant muscle accretion and strength gains in aging individuals. One potential strategy which may help increase the volume of resistance training performed and subsequently benefit aging muscle is combining heavy loads with light loads in each working set. Young adults who performed 3 sets of light load resistance training (30% 1-RM to muscle fatigue) experienced similar gains in muscle mass compared to 3 sets of heavy load resistance training (80% 1-RM to muscle fatigue) after 10 weeks (Mitchell et al., 2012). However, the 80% 1-RM group had superior muscle strength compared to the 30% 1-RM group. In postmenopausal women, 3 sets of light load training (30% 1-RM to muscle fatigue) for 10 weeks produced significant gains in muscle mass and strength (Weisgarber et al., 2015). Results across studies indicate that heavy load (80% baseline 1-RM) and light load (30% baseline 1-RM) resistance training increases muscle size and strength. Since aging is characterized by a loss of muscle mass and muscle performance, it is plausible that a resistance training program which combines heavy

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and light loads (80% baseline 1-RM + 30% baseline 1-RM) in the same training set (i.e. drop-set) may benefit aging adults.

Based on the potential of creatine for increasing aging muscle mass, strength (for reviews see Candow et al., 2014; Gualano et al., 2016; Devries and Phillips, 2014) and muscle performance (i.e. number of repetitions at a specific percentage of maximal strength) (Rawson and Volek, 2003), the purpose of this study was to compare the effects of creatine supplementation and drop-set resistance training to placebo and drop-set resistance training in untrained healthy aging adults. It was hypothesized that creatine supplementation during drop-set resistance training would increase muscle mass, upper and lower body muscle strength and endurance, functionality and decrease muscle protein catabolism compared to placebo during drop-set resistance training.

2. Methods

2.1. Experimental design and participants

The study was a double-blind, repeated measures design. In order to minimize differences between groups at baseline, participants were matched according to gender, age, weight, height and baseline physical activity status. After exclusion criteria were applied, participants were randomized using a computer generated schedule on a 1:1 basis to supplement with creatine monohydrate (CR) or placebo (PLA) during 12 weeks of drop-set resistance training. A research assistant, who was not involved in any other aspect of the study, was responsible for randomization. The primary dependent variables assessed at baseline and after the intervention included: (1) body composition (muscle mass, fat mass), (2) muscle strength (1-RM for the leg press, chest press, hack squat, and lat pull-down exercise), (3) muscle endurance (leg press and chest press exercises; maximal number of repetitions performed at 80% and 70% baseline 1-RM respectively), (4) tasks of functionality (walking speed, balance, hand grip strength) and (5) urinary excretion of 3-methylhistidine (indicator of muscle protein catabolism). In addition, participants filled out a 3-day food diary during the first and final week of training to determine whether total energy (kcal) and macronutrient intake changed over time.

Forty participants (21 males, 19 females) volunteered to participate in the study. Both males and females were included to increase the impact of the study findings to the general population. Females were postmenopausal for at least 1 year (defined as having their last menstrual cycle ≥ 1 year prior to the start of the study). Participants were required to fill out a leisure time exercise questionnaire at the start of the study, which indicated the average number of times they performed strenuous (i.e. heart beats rapidly), moderate (i.e. not exhausting) and mild exercise (i.e. minimal effort) per week (Godin and Shephard, 1985). Participants also filled out a Physical Activity Readiness Questionnaire (PAR-Q+), which assessed their ability to participate in the resistance training program. If a participant indicated a contraindication to exercise, they were required to get medical clearance before starting the study.

Participants were excluded if they had taken medications that affect muscle biology (i.e. corticosteroids) or creatine monohydrate ≤ 12 weeks prior to the start of the study; if they had a history of fragility fractures; diseases that affect muscle biology (i.e. Crohn's Disease), if they suffered from severe osteoarthritis; if they had participated in moderate-vigorous resistance training (≥3 times per week) for 6 weeks prior to the start of the study; if they were vegetarian; if they were planning to travel during the study period for >2 weeks at a time or if they had pre-existing kidney or liver abnormalities.

Participants were instructed not to change their dietary habits, engage in any additional physical activity that was not part of their normal daily routine or consume non-steroidal anti-inflammatory drugs during the study as these interventions can affect muscle protein synthesis (Trappe et al., 2002). The Research Ethics Board at the University of Regina approved the study and participants were informed of the risks and purposes of the study before their written consent was obtained.

2.2. Creatine supplementation and blinding procedures

Creatine (Creapure® AlzChem Trostberg GmbH, Germany) and placebo (Globe Plus 10 DE Maltodextrin, Univar Canada) were administered in powder form. The creatine supplementation dosage was 0.1 g/kg/day which has previously been shown to be effective for increasing muscle mass in aging adults without resulting in adverse events (Candow et al., 2015, 2008). Creatine was mixed with equal parts maltodextrin (0.1 g/kg/day creatine + 0.1 g/kg/day maltodextrin) and the placebo group received 0.2 g/kg/day maltodextrin so the powders were identical in taste, texture, color and appearance. Contents of the creatine monohydrate powder were verified by testing in an independent laboratory (The Cary Company, Addison IL, USA; creatine purity > 99.9%). On training days, participants consumed half their supplement immediately before and half immediately after each exercise session. Creatine supplementation immediately before and immediately after resistance training sessions has a positive effect on muscle mass (Candow et al., 2014), strength (Candow et al., 2015) and muscle protein catabolism in aging adults (Candow et al., 2014). On non-training days, participants were instructed to ingest one third of their daily supplement with each meal (i.e. breakfast, lunch, dinner) as creatine retention has been shown to be higher if co-ingested with insulin-simulating nutrients (i.e., glucose or protein) (Jäger et al., 2011). An individual not involved in any other aspect of the study was responsible for mixing and packaging up the supplements in plastic bags and preparing individual study kits. Each study kit contained the participants' supplement for the duration of the study, detailed supplementation instructions, and measuring spoons. Participants were instructed to mix their supplement in water but not caffeinated beverages as this has been shown to decrease the ergogenic effects of creatine (Vandenberghe et al., 1996). A retrospective treatment identification questionnaire was administered to all participants upon completion of the study in order to assess whether participants thought they were administered creatine, placebo, or unsure about what supplement they consumed.

2.3. Drop-set resistance training program

Prior to the start of supplementation, participants became familiar with the resistance training equipment. The resistance training equipment consisted of four machine-based exercises, which included two upper body exercises (chest press, lat pull-down) and two lower body exercises (hack squat, leg press) using Atlantis® (Precision Series) and Equalizer machines in the Fitness and Lifestyle Centre at the University of Regina.

Familiarization 1-RM strength testing was performed for each exercise. Following a 5-minute warm-up on a stationary cycle ergometer at a self-selected intensity, participants performed two warm-up sets of each exercise to be tested in the following order: 1 set of 10 repetitions using a load, which was determined by each participant to be comfortable and 1 set of 5 repetitions using a heavier weight. Two-minutes after the warm-up sets, the load was progressively increased for each subsequent 1-RM attempt. Participants rested (passively) at least 2 min between 1-RM attempts. All participants reached their 1-RM in 6 sets or less. 5 min of passive rest separated each 1-RM assessment between different muscle groups.

The first training session of the familiarization phase (5 sessions) was directly supervised by a researcher, blinded to group allocation. Subsequent familiarization and study training sessions were indirected supervised by staff in the Fitness and Lifestyle Centre, University of Regina. During the familiarization phase, participants were properly shown how to use the equipment and perform repetitions to muscle fatigue using 80% and 30% of their familiarization 1-RM. During the first two familiarization sessions, participants performed 1 set of drop-set