Neuromuscular properties and fatigue in older men following acute creatine supplementation

Abstract The purpose of this study was to investigate the effects of creatine (Cr) supplementation in 12 older (65–82 years) men. The subjects were randomly assigned to a Cr or a placebo (P) group. Seven men were supplemented with 5 g of Cr and 5 g maltodextrin four times a day for 5 days (Cr), and 5 men consumed 5 g of maltodextrin four times a day for 5 days (P). Following this treatment body mass increased significantly in the Cr group (1 kg), but did not change in the P group, and measurements of arm anthropometry were not affected in either group. Prior to and following supplementation maximal isometric voluntary force (MVC), muscle activation, contractile properties and surface electromyography (EMG) were measured in the elbow flexor muscles at baseline, during a fatiguing task and over 10 min of recovery. The fatigue protocol involved both voluntary and contractile stimulated. Stimulated contractile properties, MVC, and muscle activation were not affected by Cr supplementation. Furthermore, there were no changes in time to fatigue, decline in MVC force, muscle activation, EMG or contractile properties during the fatigue protocol. The rates of recovery of voluntary force, and stimulated contractile force did not change following Cr supplementation. These results indicate that short-term Cr supplementation in older men does not influence isometric performance of the elbow flexor muscles.

Key words Strength · Aging · Electromyogram · Elbow flexor muscles

Introduction

Following short-term (≤5 days) creatine (Cr) supplementation in young men, several investigators have reported an elevation in Cr and phosphocreatine (PCr) content (Harris et al. 1992; Balsom et al. 1993), an increase in body mass (Balsom et al. 1993), strength (Earnest et al. 1995; Maganaris and Maughan 1998), and endurance (Balsom et al. 1993). There are a limited number of studies, and the results are equivocal, with respect to the effects of Cr supplementation in older adults. It seems Cr supplementation in older adults results in an increase in endurance (Rawson et al. 1999; Rawson and Clarkson 2000) independent of any alteration in maximal strength (Berman et al. 1998; Rawson et al. 1999; Rawson and Clarkson 2000) or body mass (Rawson et al. 1999; Rawson and Clarkson 2000). Further comparisons among the few studies (Smith et al. 1998; Rawson et al. 1999; Rawson and Clarkson 2000) of short-term Cr supplementation in older men are difficult because strength and endurance have not been measured in the same muscle groups and during similar tasks. The effect of acute Cr supplementation on endurance has been investigated during dynamic tasks in the lower limb (Rawson and Clarkson 2000), whereas strength has been investigated in isometric tasks in the upper limb (Rawson and Clarkson 2000). The effect of long-term (8 weeks) Cr supplementation on strength and fatigue has been reported in the same muscle groups and tasks (Berman et al. 1998).

It has been suggested that the performance benefit of Cr supplementation occurs through an elevation in Cr and
PCr content (Harris et al. 1992; Balsom et al. 1993) which enables greater PCr hydrolysis for adenosine triphosphate (ATP) resynthesis (Terjung et al. 2000). Since the PCr content in skeletal muscle of older men is lower (Moller et al. 1980) than in young men, Cr supplementation may augment Cr and PCr content and enhance performance during an endurance task. Furthermore, if adenosine diphosphate rephosphorylation is more rapid and the removal of high energy phosphates faster following Cr supplementation it is likely that recovery from exercise will be quicker. No study has assessed the immediate recovery from fatigue in older men following Cr supplementation.

Force and endurance time can be affected by muscle activation, and this has not been measured in previous Cr supplementation studies in older men. Muscle activation is determined by central nervous system factors related to practice, effort (Gandevia et al. 1995) and neural drive (Bigland-Ritchie et al. 1986), and can be assessed objectively by using the techniques of twitch interpolation and surface electromyography (EMG). The application of these techniques could help determine whether changes in voluntary strength following Cr supplementation are due to peripheral changes in contractile, or because of central neural factors affecting muscle activation.

It has also been suggested that an increase in PCr content would increase exercise performance by increasing the supply of ATP which would enhance Ca2+ kinetics at the level of the sarcoplasmic reticulum, thereby decreasing contractile speed (Van Leemputte et al. 1999). Furthermore, since muscle relaxation accounts for a significant proportion of the energy required for muscle activity (Bergstrom and Hultman 1988) endurance times could be lengthened by faster contractile properties. Van Leemputte et al. (1999) reported a decrease in relaxation time of a voluntary contraction in young men, and in one animal study electrically induced twitch relaxation times were decreased in adult rat soleus muscle after Cr supplementation (Wakatsuki et al. 1994). However, we did not find a change in electrically stimulated contractile properties in young men following Cr supplementation (Jakobi et al. 2000). Discrepancies may exist among these studies because of differences in measurement techniques, variations in fibre type among muscles and the role high energy phosphates play in human compared to animal muscle (Casey et al. 1996; Terjung et al. 2000). Since skeletal muscle of older men is slower (Porter et al. 1995) and has lower Cr and PCr stores (Moller et al. 1980) than muscle of young men it is possible that Cr supplementation may elicit greater changes in contraction time of old men compared to young men.

The purpose of this study was to combine neural and contractile measurements to investigate the effect of short-term Cr supplementation on muscle strength and fatigue in the elbow flexor muscles of older men.

**Methods**

The subjects were healthy, moderately active independent older men living in London, Ontario. The study was conducted according to the guidelines established by The University of Western Ontario Review Board for Research Involving Human Subjects and the Declaration of Helsinki. Informed written consent was obtained from the 12 older men (ages 65–82 years) prior to participation in the study. Daily physical activity (Robinson et al. 1999), diet, and caffeine consumption (Fryer and Neering 1989; Vandenberghe et al. 1996) were controlled by urging participants to maintain their standard daily activities and energy intake, to discontinue the powdered supplements in non-cafeinated beverages, and to abstain from consuming substantial amounts (e.g. more than one cup of coffee or equivalent) of caffeine for several hours prior to visiting the neuromuscular laboratory. Exclusion criteria included having received Cr supplementation within the previous 12 months, any myopathies or neuropathies, diabetes, alcoholism, or hypertension.

**Study protocol**

The subjects visited the neuromuscular laboratory on three separate occasions (habituation, pre- and post-test sessions) for this double-blind control study. A habituation session was conducted because prior reports in young adults (Magararis and Maughan 1998) indicate that differences in force may exist between the first and second test as a result of familiarization with the experimental situation as well as learning how to perform maximal voluntary contractions (MVC). Approximately one half of the older men in this study performed consistently better voluntary contractions on the second session (pre), compared to the first (habituation). The second session was conducted 3–7 days following the first session, and the third session (post) was conducted within 8–14 h following the last day of dietary supplementation. Habituation involved positioning the subject in the arm device to ensure comfort and familiarity with the tests. Thorough measurements of arm, shoulder, head and hip placement were taken to ensure identical subject positioning during all test sessions. On the days of the pre- and post-tests, body mass (kilograms), height (centimetres) and arm anthropometry (Rice et al. 1990) were determined before assessment of strength, and performance of the fatigue protocol and recovery. Measurements of total arm cross-sectional area (centimetres squared) (TAA), muscle plus bone cross-sectional area (centimetres squared) (MBA), and skin plus subcutaneous tissue cross-sectional area (centimetres squared) (SST) were estimated from skinfold and arm girth measurements (Rice et al. 1990).

The 12 participants were randomly assigned to the Cr supplementation group, while the remaining 5 subjects formed the placebo group (P). In addition to their normal diets the subjects took supplements four times a day for 5 days, the Cr group taking 5 g of powdered creatine monohydrate blended with 5 g of maltodextrin, while the P group received 5 g of maltodextrin. Volunteers were instructed to dissolve the pre-weighed substance in warm water or a non-citric-acid juice and to consume a carbohydrate with the supplement (Green et al. 1996). The Cr and P samples were weighed and separated into 20 individual vials by someone not directly involved with the tests. Vials were given to each subject separately and the subjects did not compare samples, and the experimenters did not see the vials given to each subject.

**Muscle strength**

Elbow flexor muscle measurements were conducted with the subjects in a supine position on a padded examination table, with their legs elevated for comfort and as a means of preventing extraneous movement in the lower body, which might have influenced upper body positioning or force generation. The left elbow was flexed to 90° and the shoulders were secured to prevent extraneous movements of the trunk. The wrist was secured to a plate which was attached to a strain gauge (SST-700–100A, AS Technology) and the elbow was positioned and secured perpendicular to the wrist. The strain gauge was calibrated with known weights to confirm its linearity and to convert force values to newtons. The output from the strain gauge was sampled at 500 Hz, amplified and filtered.