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Prevalence & Rationale of Creatine Use in DIII NCAA Athletes

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PREVALENCE & RATIONALE OF CREATINE USE IN DIII NCAA ATHLETES

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ABSTRACT

Athletes often seek out ergogenic aids to improve sport performance. Creatine is one of the most popular supplements consumed among young athletes. At the Division III level of collegiate sports, certain perceptions or influences have led to or have sustained creatine use in this athletic population and needs to be examined. The purpose of this study was to determine the prevalence of creatine supplementation among Division III collegiate athletes and to summarize educational resources, attitudes, and rationale for its use across gender and sport. In the Spring of 2007, 61 Division III varsity athletes football (39/61), basketball (10/61), baseball (4/61), soccer (3/61), swimming (2/61), track and field athletes (2/61), and wrestling (1/61) representing John Carroll University, Cleveland, OH completed an anonymous questionnaire regarding creatine supplementation. The subjects (female, n = 6; male, n = 55) ranged in age from 18 to 24 years (mean = 20.6 years). Athletes that admitted to current creatine use completed a Likert scaled assessment of attitude toward creatine use. Survey results revealed that 16.4% (10/61) of athletes were current users of creatine while 42.6% (26/61) athletes admitted to past creatine use. Males were more likely than females to be current users of creatine. Of the total athletes sampled (61), only 10 (16.4%) admitted to current use, and all 10 were football players. The earliest initiation of creatine supplementation was reported at 15 years. Trends in the data suggested that male athletes participating in contact-collision based sports are more likely than females to use creatine as an ergogenic

aid to enhance performance. Participants received the bulk of their creatine information from two reported sources: the internet and GNC stores, as opposed to athletic support staff (ie. physician, strength coach, dietitian, athletic trainer, etc.). Athletes need accurate information about ergogenic supplements and their associated risks including proper dosing and instruction.

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INTRODUCTION

Athletes often seek out ergogenic aids to improve sport performance. Creatine is one of the most popular performance enhancing supplements consumed among collegiate athletes.[4, 39] The popularity of creatine among athletes was illustrated by survey results published via the National Strength and Conditioning Association, in which coaches and trainers reported that 86% of their athletes were taking creatine.[42] Labotz and Smith reported creatine use at 28% within a NCAA, Division I collegiate athletic program.[27] Past creatine has been reported at 30% among male collegiate athletes.[27] Subsequently, Greenwood et al. reported creatine use at 41% among Division I collegiate athletes with variances observed for gender and sport.[17] Lower prevalence rates of creatine use have been shown for females versus male athletes across gender and sport.[17, 27, 31, 41] Despite the popularity of creatine supplementation, there is controversy pertaining to its safety and effectiveness. At the Division III level of collegiate sports, certain perceptions or influences have led to or have sustained creatine use in this athletic population and needs to be examined. Currently, studies which examine the rationale and prevalence of creatine use in athletes participating at the Division III collegiate level are lacking.

Purpose of Study

The purpose of this study was to determine the prevalence of creatine supplementation among Division III collegiate athletes and to summarize educational resources, attitudes, and rationale for its use across gender and sport.

Hypotheses

1. The prevalence of creatine use in Division III collegiate athletes will be higher than 30%.
2. Males will be more likely than females to use creatine for performance enhancement.
3. Contact/collision-based sports (ie. football, basketball) will have a higher prevalence of use as compared to other sports.

Significance of Study

There are numerous studies that support both the positive and null effects of creatine supplementation on sport performance and health. Athletes desiring to increase sports performance and their competitive edge via supplementation may receive inaccurate or misconstrued information about creatine.[23, 27, 52] It is important that athletes understand the potential health and safety concerns regarding creatine supplementation. This exploratory study will assess the use of creatine supplementation in Division III athletes at John Carroll University, Cleveland, OH and will enhance our understanding of current practices. This information can be used to design educational programs regarding creatine use targeting the populations who are most at risk.

CHAPTER II

REVIEW OF LITERATURE

This chapter focuses on dietary and endogenous creatine sources, exogenous creatine supplementation, creatine supplementation relative to exercise performance, and health and safety concerns. Specific sections will review various studies that focus upon creatine supplementation relative to absolute strength and power, sprint performance, intermittent exercise capacity at maximal efforts, and endurance performance.

Endogenous Creatine

Creatine is produced naturally within the body and is found in skeletal and heart muscle, the brain, testes, and other organs.[5, 14] The liver and pancreas are responsible for the majority of creatine produced endogenously in humans at approximately 1 g per day.[14] Creatine is consumed at nearly 1 to 2 g per day in diets that include meats and fish.[14] The largest sources of creatine are found in herring, salmon, tuna, pork, and beef.[6, 14]

Creatine is mainly stored as free creatine and phosphocreatine (PCr) in skeletal muscle.[5, 39] PCr is the body's immediate energy source during short duration, high intensity exercise (~10-15 seconds) and subsequent adenosine triphosphate (ATP) resynthesis.[5, 39, 41, 45] Significant energy is released once the PCr bonds are broken. Maximal anaerobic work is thought to be limited secondary to the swift reduction of PCr within the muscle.[5] A higher PCr concentration may increase its availability for ATP re-phosphorylation which may improve performance during repeated high intensity exercise tasks.[50] PCr is believed to act as a buffer to accumulated lactic acid or H^+ ions within the muscle, delaying muscular fatigue according to the following formula:

$PCr + ADP + H^+ \leftrightarrow Cr + ATP$.[5, 31]

Exogenous Creatine - Types of Creatine Supplements

There are three basic types of creatine supplements: creatine monohydrate, creatine phosphate and creatine citrate (price range is $10-80 per formula type and amount).[53, 54]

Creatine Monohydrate

Creatine monohydrate is the most popular type of creatine supplement and the majority of scientific studies have been conducted using creatine monohydrate. Creatine monohydrate is creatine bound with water. One molecule of creatine monohydrate is made up of 88% creatine and 12% water, or it can be approximated that 1 gram of creatine monohydrate has 880 milligrams of creatine. An intake of 5 grams of creatine monohydrate would hypothetically yield 4.40 grams (5 * .88) of available creatine to the body.[53]

Creatine Phosphate

Creatine phosphate has 62.3% creatine and 37.7% phosphate, with 1 gram producing 623 milligrams of creatine. Creatine has to bond with a phosphate group in order to become effective. Based on this rationale, it is often assumed that creatine phosphate is superior to creatine monohydrate. A creatine phosphate supplement, however, has never been shown in scientific research to be more effective than creatine monohydrate, and its cost is more expensive.[53]

Creatine Citrate

Creatine citrate is more water-soluble than other forms of creatine and yields 400 milligrams of creatine per gram. Creatine citrate is believed to deliver a higher percentage of creatine via faster absorption by the muscles allowing for less consumption of creatine per gram. However, like creatine phosphate, citrate is more expensive than creatine monohydrate.[53]

Other Creatine Supplements

Creatine malate is a combination of malic acid and creatine. Malic acid and citric acids are energy substrates important in the Krebs cycle for oxidative phosphorylation. Malate dissolves in water very quickly which allows it to elicit faster results than monohydrates.[54]

Creatine ester, technically known as creatine ethyl ester hydrochloride, has a very high permeability in the intestine. Five grams of creatine ester is sufficient to produce the energy of 20 grams of creatine monohydrate. Other creatine variants include magnesium creatine and effervescent creatine. Creatine magnesium has the magnesium molecule bound with creatine whereas effervescent creatine is a mix of citric acid and bicarbonates, which have very good solubility in water.[54]

Forms of Supplemental Creatine

Creatine is manufactured in powder, liquid, pill, gum or effervescent powder forms. The powders are less expensive and are the most popular form of creatine supplementation. They are typically mixed in a juice or sports drink. Most studies have been conducted using powdered creatine. Creatine powder, however, is not effectively absorbed as it is digested and processed by the body.[53] Studies have shown that as much as 40 to 50 percent of creatine powder is lost before it reaches the muscles.[53] Creatine pills work in the same way as the powder (with the exception of inflexible dosage variability) and are considered easier to administer (no mixing into a beverage).[53] Gums and effervescent powders have similar dosing limitations as creatine pills.[53] Absorption is assumed to be better in the latter creatine products, however.[53] This is especially true for pre-manufactured liquid creatine.[53]

Studies Supporting Ergogenic Benefit

Hundreds of studies have investigated the ergogenic value of creatine. The research has shown improvements in strength, power, speed, and reduced fatigue in various types of athletic performance. Not all studies, however, support ergogenic claims. Creatine supplementation, whether short or long-term, has been shown to have no effect on endurance performance.[50] The following sections will review studies that support and refute the ergogenic claims of creatine. It is important to note that several study protocols have paired creatine with other carbohydrate and glucose containing substances (ingestion of carbohydrates together with 20 g of creatine may increase total creatine concentration about 60%) in order to maximize study results, whereas conventional thinking has related mechanisms of insulin-promotion via muscle creatine transport and glycogen supercompensation in the exercise exhausted muscle.[6, 8, 39]

The following sections review the ergogenic claims of creatine supplementation with various types of exercise.

Absolute strength and power

Bemben et al.[5] reported that creatine supplementation at 20 g· day^{-1} for 5-days followed by 5 g· day^{-1} for 9 weeks improved strength in 25 red-shirt, collegiate football athletes performing one repetition maximum (1-RM) bench press, power clean, and squat protocols. Strength improved for the creatine group for all three lifts with increases of 5.2%, 3.8%, and 8.7%. Isokinetic testing of the same group of athletes revealed an increase in average peak torque at 300˚S^{-1} by 17.6%, whereas the placebo group decreased by an average of 5.5% and the control group exhibited no change.[5, 7] Anaerobic power and capacity determined by the Wingate bicycle ergometer test improved significantly for the creatine supplementation group (19.5% and 18.4% respectively), whereas little or no change was shown by the placebo or control groups. Total body weight was increased by an average of 5.3% for the creatine group and lean body mass increased by 3.8% in the creatine group. There were no significant changes in body weight for the placebo or control groups.

Vandenberghe et al.[49] reported enhanced strength gains during resistance training in sedentary females (n = 19) aged 19 to 22 years secondary to creatine supplementation at 20 g· day^{-1} for 4 days followed by 5 g· day^{-1} for 10 weeks. Strength gains were observed as 20-25% greater when compared with placebo 1-RM for leg press, leg extension, and squat. Arm-flexion torque was 25% higher at 10 weeks in the creatine-supplemented group. Strength gains were maintained following a 10-week detraining period and concomitant creatine ingestion at 5-g· day^{-1}.

Outcomes relative to pre-and post-supplementation change in maximal weight lifted, cycle ergometry sprint peak power, and isokinetic dynamometer peak torque were measured by Dempsey et al.[11] Creatine supplementation was found to increase maximal weight lifted in young men accustomed to weight training. The data revealed that maximal weight lifted was 6.85 kg greater for bench press and 9.75 kg greater for squats in the creatine vs. placebo group. However, there were no differences found in cycle ergometer or isokinetic dynamometer performance.

Tarnopolsky and MacLennan[47] found that short-term creatine supplementation increased indices of anaerobic strength and power for 24 physically active participants (n=12 males, n=12 females); mean age for males was 23.3 ± 1.8 and 21.9 ± 1.7 for females. Creatine monohydrate (5 g, 4x/day x 4-days) and placebo (glucose polymer x 4 days) dosages were provided using a randomized, double blind crossover design, followed by a seven week washout period. An anaerobic cycle test (2 x 30-s) with plasma lactate pre-and post-test, dorsiflexor maximal voluntary contraction (MVC), 2-minute fatigue test, isokinetic knee extension torque, and 1-minute handgrip strength outcomes were measured. Peak and relative peak anaerobic cycling power increased by 3.7%, dorsiflexion MVC torque increased by 6.6% with a subsequent 20% increase in plasma lactate levels in the creatine group.

In determining the effects of two and five days of creatine loading on anaerobic work capacity (AWC) using the critical power test in 19 physically active women aged 19-34 years, Eckerson et al.[12] reported that creatine loading for 5 days resulted in a 22.1% increase in AWC without an associated increase in body weight in women, whereas no significant difference was noted following 2 days of creatine. There was no significant interaction found between creatine intake and body weight. Similar increases in AWC have been reported for men, where increases in performance were likely due to an increase in total muscle creatine, suggesting that the value of creatine loading on anaerobic performance is beneficial to physically active women and men alike.[12]

Maximal intermittent exercise capacity and/or muscular effort

Creatine supplementation has been reported to increase the amount of work performed during a series of maximal effort muscle contractions.[7] Kreider et al.[26] observed significant gains in bench press and total lifting volume (sum of bench press, squat, and power clean) for maximum repetitions performed among 25 NCAA Division IA football players given creatine at 15.75 $g \cdot day^{-1}$ for 28-days. The placebo group received a higher glucose-phosphagen containing solution. Significant increases were observed in total body weight and bone-free/fat-free mass for the creatine group.

The effects of creatine in the high performance athlete could vary significantly relative to performance times and physical performance in maximal intensity efforts. Havenetidis and Bourdas[18] subsequently investigated creatine supplementation relative to its effects on urinary excretion and anaerobic performance in 21 sprint-trained males (age $= 29.4 \pm 37$). Increases in anaerobic performance were found in all acute creatine loading groups (10 g, 25 g, and 35 $g \cdot day^{-1}$ for 4 days). Urinary excretion values were increased in all creatine supplementation groups when compared with placebo.

Ayoama et al.[3] reported that creatine supplementation of 20 $g \cdot day^{-}$ for 7 days improved mean strength and endurance of repeated contractions performed by 26 collegiate female softball athletes. The subjects this double blind study were divided randomly into 4 groups which were Creatine (Cr) 1 (n = 7), Cr 2 (n = 6), Control 1 (n = 7), and Control 2 (n = 6). In this 4-week study, athletes performed maximal 2-isometric and 30-isokinetic knee extensions at angular velocities of 180° and 60°/s. Thereafter, Cr

2 and Control 2 groups performed 10-RM resistance exercises (leg curl and extension, back extension, bench press, bent over row, wrist curl, upright row, trunk curls, calf raise, half squat, triceps and 2-hand curl) or 30 maximal 10-s cycling with a brake force of 0.1 kg· kg^{-1} body weight alternately during the first week to decrease creatine and PCr content in the muscles. During the second week, creatine users (Cr 1 and 2) were given 5 g Cr dissolved in 300 ml sports drink 4 times-a-day. Thereafter, the Cr 2 group continued to supplement with creatine at 3 g per day while the Cr 1 group was given 3 g placebo. The subjects of control groups 1 and 2 ingested the same amount and taste of placebo throughout the study. The study found that creatine improved not the maximal static strength and dynamic peak torque, but the mean strength and endurance of repeated contractions. However, the effects of creatine were enhanced by anaerobic exercise performed prior to supplementation and were likely to disappear in a week if usage of creatine ceased.

Ööpik et al.[35] reported the effects of creatine supplementation with simultaneous carbohydrate ingestion on the restoration of body mass and muscle performance capacity in five well-trained wrestlers (mean age 20.6 ± 0.9). The subjects, who reduced their body mass by 4.5-5.3%, consumed glucose or glucose plus creatine during a 17 hour recovery period. The capacity of the subjects to perform submaximal and maximal intensity work of the knee extensor muscles was measured using a Cybex II device before and after body mass loss and recovery. Total work was 12.6% higher in the creatine plus glucose groups versus consumption of glucose alone. Creatine supplementation with glucose ingestion during 17 hours recovery from rapid body mass loss was not found to accelerate the restoration of body mass, but muscular working capacity was enhanced.

According to Yquel et al.[55], higher mean power output was generated in individuals having the highest PCr percentages during sustained bouts of maximal dynamic plantar flexion. Higher PCr concentrations were observed within a few seconds (16 or 32 s) of recovery after creatine ingestion. Nine physically active, male subjects (mean age 24.1 ± 3.5) consumed 20g of creatine monohydrate in a warm water solution per day for 6 consecutive days. The better maintenance of muscle power output after creatine ingestion was due to a higher rate of PCr re-synthesis, lower inorganic phosphate, and higher muscle pH.[53]

In 2000, Iñigo et al.[21] reported that acute creatine supplementation favorably affected repeated sprint performance and limited the decline in jumping ability in 17 highly trained male soccer players (mean age 20.3 ± 1.4). A counter-movement jump test (CMJT), a repeated sprint test consisting of six maximal 15-m runs with a 30-s recovery, an intermittent endurance test consisting of forty 15-s bouts of high intensity running interspersed by 10-s bouts of low intensity running, and a recovery CMJT consisting of three jumps was performed by participants on two occasions seven days apart. The subjects were randomly assigned to a creatine (5 g of creatine, 4x/ day for 6 days) or a placebo group. The creatine group's average 5-m and 15-m times during the repeated sprint tests were consistently faster after intervention. No significant changes were noted in the CMJT or the intermittent endurance tests. The creatine group's recovery CMJT performance remained unchanged.

Sprint/High Intensity Performance

Creatine supplementation has also been reported to improve single effort and/or repetitive sprint performance, particularly in sprints lasting 6 s to 30 s with a 30 s to 6-

minute rest recovery between sprints.[7] Kreider et al. reported significant improvement in 6-s sprint performance following 28 days of creatine supplementation among collegiate football athletes.[26]

Van Loon et al.[50] researched the effects of short and long-term creatine supplementation on substrate utilization, sprint, and endurance performance in 22 healthy, young male subjects (age = creatine 20.6 ± 0.3, control 21.3 ± 0.3) with no prior exercise training. The subjects were given 20 g of creatine monohydrate per day for a 5 day loading period, followed by 2 $g \cdot day^{-1}$ during a succeeding 37 day maintenance phase. Subjects performed a VO_2 max test, high intensity exercise (12-s sprints), and an endurance test (20-min exercise loading states) on a mechanically braked cycle ergometer. A substantial increase in repeated high-intensity exercise performance capacity was observed following five days of creatine loading. Creatine supplementation resulted in a significant increase in average peak power and total external work generated during sprint tests compared with placebo groups. High-intensity exercise performance remained enhanced following continued use of creatine, suggesting an increase in total body creatine.

Okundan and Gökbel[34] investigated the effects of creatine supplementation on performance during supramaximal exercise in 23 untrained young males (18-24 years). Total power output was obtained from five Wingate sprint tests measured before and after creatine supplementation. Total power output increased 7.6% from 366.3 ± 65 W to 394 ± 67 W in the subjects that received creatine at 20 $g \cdot day^{-1}$ for 6-days. There was no change reported in the placebo group. Body weight was unchanged in both the creatine and placebo groups during the supplementation period.

Ziegenfuss et al.[56] reported the effect of creatine loading on anaerobic performance and skeletal muscle volume in NCAA Division I athletes (n = 10 male, n = 10 female) representing multiple sports (i.e. wrestling, ice hockey, basketball, softball, field hockey). Study participants ingested a 3-day dose regimen of a 20 g creatine and carbohydrate solution. Anaerobic performance was measured by 10-s sprints of maximal effort on a friction-loaded cycle ergometer. Significant increases were noted for body mass and total work during the first sprint. Total work and peak power values were greater for males than female participants in the study.

Koçak and Karli[24] subsequently studied the effects of high dose creatine supplementation on anaerobic performance among 20 male international level, elite-capacity wrestlers aged between 22 to 27 years. The subjects underwent 30-s Wingate anaerobic sprint tests until exhaustion in pre- and post-testing procedures. Average and peak power scores of the creatine group were significantly higher than placebo when supplemented at 20 $g \cdot day^{-1}$ for 5-days.

The effect of a low-dose, short-duration regimen of creatine supplementation relative to anaerobic exercise performance was reported by Hoffman et al.[19] Forty physically active, college-aged males were supplemented with 3 g of a creatine and a glucose containing solution for a six day period. The subjects performed three 15-second Wingate anaerobic sprint tests pre and post-supplementation. There was no significant group or time differences observed in body mass, peak power, mean power, or total work. However, the change in the rate of fatigue to total work was significantly lower in the creatine group when compared with placebo.

Havenetidis and Bourdas[18] used various acute creatine loading (ACRL) regimens to determine which would elicit the greatest benefit on repetitive all-out cycle performance among 28 active males (mean age 29.4 ± 3.7 years). The anaerobic Wingate testing protocol was performed. Experimental and control groups were given dosages over a 4-day period of 10 g· day^{-1}, 25 g· day^{-1}, and 35 g· day^{-1} of placebo and pure creatine monohydrate for 12 weeks. Creatine supplementation produced an average improvement of 0.7%, 11.8%, and 11.1% for the 10 g, 25 g and 35 g ACLR respectively.[17] The study found that the use of 25 g compared to 10 g acute creatine loading produced a greater and constant potentiation of sprint cycle performance. There was no significant benefit found with the use of a greater creatine dosage (35 g).

Studies Challenging Ergogenic Benefit

Claims of ergogenic benefit from creatine supplementation are variable within and across studies. A number of studies have reported no significant ergogenic benefit from creatine supplementation when compared to control. The reasons for the lack of benefit observed in these studies is sometimes unclear.[7]

Inconsistent results have been reported in the literature relative to the support of the favorable effects of creatine on swim performance.[20] Selsby and Beckett[46] noted faster swim times during 50 and 100-yd freestyle sprints following creatine supplementation in 15 Division III college swimmers (n = 8 male, n = 7 female). Peyrebrune et al., however, identified small performance differences between creatine and control groups that could possibly be of some practical significance to the elite swim competitor.[36]

Theodorou et al.[48] studied the effects of carbohydrate consumption on acute dietary creatine loading and mean swimming velocity among high-performance swimmers (6 men and 4 women). The group mean age was 17.8 ± 1.8 years. Each swimmer ingested 25 g (5 x 5 g) of creatine for four days, with the creatine plus carbohydrate group also ingesting ~100 g of simple carbohydrate 30 minutes after each dose of creatine. Swim performance was measured on five separate occasions at 50 and 100-m intervals. No performance advantage was gained from the addition of carbohydrate to a creatine-loading regime in high-caliber swimmers; however, all subjects swam faster after either dietary loading regimen. There was no significant improvement in performance between groups.

Preen et al.[40] reported no ergogenic benefit from creatine consumed prior to intermittent sprint exercise lasting 80 minutes in duration in eight active males (age = 25.4 ± 4.8 years). The subjects consumed 15 g of either a creatine solution or placebo 120 minutes or 60 minutes prior to the start of a maximal sprint cycling protocol. No significant chances were reported in any cycling performance parameters following creatine ingestion. Blood lactate, however, was found to be significantly lower post-creatine ingestion, suggesting that creatine does elicit some effect on blood-borne metabolites.

McKenna et al.[30] reported that maximal intermittent sprint performance was unchanged by creatine supplementation in 14 recreationally active male and female subjects. Creatine did not affect peak power output, cumulative work production, or fatigue index during sprint testing in this study. Participants were randomly assigned to treatment and control groups (mean age 19 ± 3 creatine, 21 ± 3 placebo). The treatment group received 30 g of creatine and dextrose over five days. The subjects performed five 10-s maximal cycle ergometer sprints with variable rest intervals. An elevation of creatine, PCr, and total creatine was observed at 0 and 2 weeks post-creatine supplementation and declined to pre-supplementation levels at 4 weeks.

Wilder et al. compared the effects of low-dose creatine supplementation (3 $g \cdot day^{-1}$) to a loading protocol of 20 $g \cdot day^{-1}$ for 7 days and 5 $g \cdot day^{-1}$ thereafter for 10 weeks on 1-RM squat strength, creatine excretion, and percentage of body fat in highly trained collegiate football players.[51] They found that creatine supplementation had no significant group, time, or interaction effects on strength, urinary concentration, or percentage body fat and concluded that creatine did not have any beneficial ergogenic effect at any amount in highly trained collegiate football players.

Relative to selected factors of tennis specific training, creation supplementation was found to be ineffective in improving tennis performance by Pluim et al.[37] Serving velocity, forehand and backhand velocity, arm and leg strength, and intermittent running speed were measured in 36 competitive male tennis players. No significant effects were noted in six days or five weeks of creatine supplementation.

Astorino et al.[2] investigated the effects of a creatine serum dubbed Runner's Advantage (RA) on running performance in cross-country runners. Subjects were given 5 ml of creatine serum containing 2.5 g of creatine or placebo. The runners completed a baseline outdoor 5,000-m test run on a 400-m track followed by a treadmill VO_2 max test on the same day (within 15 min-1.5 hours) before and after supplementation. With RA, the 5,000-m time was unchanged and the data did not support the ergogenic claims of RA.

Cornish et al.[10] conducted a study to determine the effect of acute creatine monohydrate loading on sprint skating performance in male Junior B and collegiate ice-hockey players. Creatine supplementation was found to be ineffective for improving performance in this group of ice-hockey players. No significant differences between groups were found pre- and post-supplementation for isokinetic peak torque and average power during knee extension/flexion (3 sets of 10 reps; 60-s rest between sets). Further, there were no reported differences between groups over time for blood lactate changes during repeated treadmill sprints.

Multiple sprint running performance was not benefited by short-term creatine monohydrate supplementation as shown by Glasister et al.[15] Forty-two active men (mean age 20 ± 1.0 creatine, 20 ± 0.9 placebo) completed a series of 30-m sprint intervals after 20 g of creatine plus maltodextrin and 24 g of placebo (maltodextrin) supplementation. No significant differences were found in multiple sprint measures of fastest time, mean time, fatigue, or post-test blood lactate concentrations.

Aerobic Performance and Creatine

Previous research that has investigated the ergogenic potential of creatine supplementation in prolonged endurance performance has yielded non-significant results.[43] This is believed to be secondary to the relatively small contribution that the PCr system provides to overall energy during endurance exercise. However, the exact influence of creatine on aerobic capacity and endurance performance is unclear.

Van Loon et al.[50] found that prolonged creatine supplementation did not increase muscle or whole-body oxidative capacity, and subsequently did not influence substrate utilization or performance during endurance cycling exercise. Twenty male subjects (mean age 20.6 ± 0.3 creatine, 21.3 ± 0.3 placebo) were given creatine or a placebo during a 5-day loading period of 20-g$\cdot$ day^{-1} followed by 2-g$\cdot$ day^{-1} of continued supplementation for up to six weeks. Subjects were exercise tested prior to supplementation, after a loading phase (between days 6-10), and six weeks of supplementation. Although whole-body and muscle oxidative capacity, substrate utilization and time-trial performances were not affected, short and long-term creatine supplementation improved performance during repeated supramaximal sprints on a cycle ergometer. The study also found that prolonged creatine ingestion induced an increase in fat-free mass in subjects.

Murphy et al.[32] subsequently found that Cr ingestion improved submaximal cycling efficiency with no effect on cardiovascular structure and function in male athletes. In this study, $V0_2$ max was measured (pre-, mid-, and post-) at increased cycling increments to volitional exhaustion after creatine ingestion at 20 $g \cdot day^{-1}$ for seven days followed by a 10 $g \cdot day^{-1}$ maintenance dose for 21 days. $V0_2$ max values, however, were not significantly changed in Cr or control groups following supplementation, despite decreases noted in maximal heart rate and $V0_2$ max between workloads and testing group phases (pre-, mid-, and post-). In addition, exhaustion times during incremental cycle tests performed between Cr and placebo groups were relatively unchanged, suggesting no absolute ergogenic benefit from creatine.

Inosine monophosphate (IMP), a marker of impaired energy metabolism within the muscle, was reduced during intense aerobic exercise following creatine ingestion in elite cyclists according to McConell et al.[29] Seven endurance-trained, male cyclists (mean age 21 ± 1 year) completed two experimental trials involving approximately 1 hour of intense endurance exercise (cycling 45 min at 78 ± 1% $VO_{2\ peak}$ followed by completion of 251 ± 6 kJ as quickly as possible). The subjects ingested about 42-$g \cdot day^{-1}$ dextrose for five-days before the first experimental trial (control), then approximately 21 g Cr monohydrate plus approximately 21-g· day^{-1} dextrose 5 days before the second experimental trial. Performance ride completion time was similar between the two treatments; however, IMP at the end of the performance ride was significantly lower in the Cr versus control group, suggesting creatine supplementation may improve muscle energy balance without significant ergogenic benefit.

Chwalbiñska-Moneta[9] found that creatine supplementation improved endurance performance and anaerobic capacity in elite rowers as expressed by individual lactate threshold values. In this study, 16 elite male rowers between 20 to 31 years were exercise tested before and after seven days of endurance training via a rowing ergometer. The participants ingested 20 g of creatine monohydrate for six days. A significant increase in mean individual lactate threshold (314.3 ± 5.0 W to 335.6 ± 7.1, as compared with 305.0 ± 6.9 W and 308.9 ± 5.9 W) was noted following creatine treatment when compared with pre and post-test placebo results. Athletes supplemented with creatine were able to row at longer intervals during anaerobic tests.

Reardon et al.[43] investigated the effect of creatine supplementation on muscle glycogen content, submaximal exercise fuel utilization and endurance performance following four weeks of endurance training. Submaximal aerobic training adaptations resulting from creatine use was not apparent within this study. Thirteen healthy, male and female subjects between the ages of 18-27 years were supplemented with either creatine monohydrate or placebo-maltodextrin. Submaximal fuel utilization and endurance performance were assessed before and after a four-week endurance-training program. A significant training effect was noted on submaximal fuel utilization and improved endurance performance independent of creatine supplementation. There was a significant increase in lipid oxidation at submaximal intensities accompanied by a significant reduction in the respiratory exchange ratios following training respectively.

Studies have shown that creatine may improve the following: absolute strength and power, sprint and high-intensity performance, and/or maximal intermittent exercise capacity and/or muscular effort.[7] The improvement in exercise capacity has been attributed to increased total creatine and PCr in the muscle, resulting in enhanced ATP resynthesis, improved metabolic efficiency, and/or enhanced quality of training promoting greater training adaptations.[7] However, the exact mechanism is still unclear.

Creatine and Exercise Performance: Summary of Ergogenic Effects

It has been hypothesized that in sprint activities (ie. 100-m or 200-m run, 25-m or 50-m swim), strength activities (ie. discus, throwing, weight-lifting) and multiple aerobic sports characterized by short, high intensity periods interspersed with intervals of low intensity (e.g. soccer, basketball, tennis, hockey), where performance may be influenced by enhanced PCr availability, oral creatine administration is likely to be useful as an ergogenic aid.[6] However, in activities with continuous aerobic exercise of longer duration (ie. 10-K run, marathon run, 800-m swim), any beneficial effects seem unlikely.[6]

Reports of weight gain after creatine supplementation are more consistent than other measures of performance.[6, 22] Body mass increases with creatine loading range from 1.0 to 2.2 kg.[50] It is not clear as to whether the initial gain in body mass during creatine loading is maintained with prolonged supplementation or is the result of a gain in total fat-free mass over time.[50] The increase occurs as a result of enhanced cellular osmolarity from water retention within skeletal muscle.[50] On the other hand, creatine ingestion has been suspected to stimulate muscle fiber growth via myofibril protein synthesis and/or to inhibit protein catabolism within the muscle.[50]

Health and Safety Concerns

Many young athletes practice creatine supplementation based on the assumption that the ingestion of creatine in amounts larger than those consumed in a normal mixed diet will enhance the possibility of maintaining power output during brief periods of high-intensity and intermittent exercise.[5] Some of the most commonly cited reasons that athletes consume creatine are to improve body appearance, increase speed and endurance, build muscle mass, enhance workout recovery, increase strength, and/or prevent illness.[13, 16, 17, 26] Safety concerns, ignorance about creatine, lack of perceived benefit, and expense were among the rationale for non-creatine use.[12, 15]

Creatine supplementation has been reported as more prevalent in men than women .[8, 16, 26, 31] Female athletes are significantly more likely to take nutritional supplements because of an inadequate diet or for health, while males are more likely to take supplements such as creatine to improve speed, agility, strength, and power or for weight and muscle gain.[8, 31] Strength-dependent athletes are more likely to use creatine (ie. football players, wrestlers, hockey players, and lacrosse).[16, 31, 38]

Athletes that use creatine as a dietary supplement are likely exceeding recommended dosages.[17, 23, 27] Several descriptive studies have reported the prevalence of excessive dosing habits in young athletes.[17, 23, 27] A major concern is that this behavior may increase the risk for adverse side effects affecting athletic performance.

Greenwood et al. reported that out of 41% of Division I varsity athletes using creatine (67% as football athletes), 54% were below recommended loading dosages, while 88%

were above recommended maintenance dosages.[17] Juhn et al. surveyed 52 male collegiate football and baseball athletes on the dosing habits and side effects of creatine and found that most athletes had exceeded recommended maintenance dosages and in a few athletes, by greater than 25%.[23]

Studies have shown that oral creatine supplementation of 20-30 g per day (0.3 g/kg/d) for a loading phase of 3-5 days followed by daily intake of 2-3 g · d (0.03 g/kg/d) increases intramuscular levels of creatine to as much as 20% and phosphocreatine by 12%.[19, 23, 28, 42] Similar muscle creatine concentrations can be achieved without using a loading phase by ingesting 2-3 g · d for 30 days.[19, 26] Dosing quantity and duration are variable across studies and no single protocol has been proven to supersede another.[6, 12, 19, 25, 49, 51]

The absence of safety studies performed on creatine according to standard protocols, as occurs in phase I products for human use is surprising, considering the large market for creatine.[6] The assumption that creatine use represents a nutritional application rather than pharmacological administration is put forward as justification for the lack of safety research in spite of uncontrolled daily dosage and long-term administration.[6] Potential side effects from creatine use are described in studies aimed at proving the ergogenic value of creatine, its modification on physical performance, muscle biochemical changes, etc., in teams devoted to applied physiology rather than to clinical pharmacology or toxicology.[6]

In healthy subjects, the regimen of ingesting 20 g of creatine daily for 5 days has shown no obvious side effects.[8] When creatine is administered on a long-term basis (20 g to 30 g/day for 5 to 7 days followed by < 10 g/day [usually 2 g] maintenance dose), regular checkups are recommended to test liver, muscle or kidney function.[8, 17, 23, 38, 42, 45] Specifically, as an amino acid, creatine is a nitrogen-containing compound that is metabolized into creatinine.[31] Impaired kidney function could be further complicated with high blood concentrations of creatine or any other protein supplement.[8, 31]

Currently, the side effects which oral creatine supplementation may cause on gastrointestinal, cardiovascular, musculoskeletal, renal and liver function remain inconclusive and no conclusive evidence linking creatine supplementation to deterioration of these functions has been found.[6, 8, 21, 27] Relative to musculoskeletal concerns, Greenwood et al. examined the effects of creatine supplementation on the incidence of cramping and injury observed during one season of NCAA Division IA football and found that the incidence of cramping or injury was significantly lower or proportional for creatine users versus nonusers.[16] The only well-documented adverse effect associated with creatine loading is an increase in body weight, secondary to enhanced protein synthesis and/or muscular water retention.[6, 45]

The effects of long-term creatine supplementation remain unsubstantiated.[8, 17, 23, 38, 42, 45] Schröder et al. investigated the long-term effects of low-dose creatine monohydrate supplementation on 16 clinical parameters of health and found no clinical evidence related to hepatic and renal pathology or muscle injury.[45] Low-dose creatine supplementation has been regarded as a relatively safe practice in young healthy athletes.[8, 45]

Despite the inherent risks of creatine supplementation, athletes are likely to continue its use. Social-cognitive predictors of creatine use have been found. Williams et al. found that creatine users had stronger beliefs in their personal ability to enhance performance through creatine use and expected fewer negative outcomes.[52] Friends, family, magazine ads, strength and conditioning coaches, etc. have all have been reported as primary resources of creatine information in creatine users and these sources are assumed to significantly influence supplement use.[23, 27, 52] Information from these sources may become distorted or inflated leading athletes to make decisions about creatine use that are not fact-based.[52] According to Williams et al., exaggerated claims related to creatine effectiveness may indirectly affect creatine use by influencing self-efficacy and outcome expectancies. [52] Thus, familiarization with the current literature is necessary by both athletes and professionals in order to minimize embellishment relative to the safety and efficacy of creatine.

CHAPTER III

METHODS

Subjects

In the Spring of 2007, 61 Division III athletes (female, n = 6; male, n = 55) representing seven varsity sports at John Carroll University, Cleveland, OH completed an anonymous questionnaire regarding creatine supplementation. The subjects ranged in age from 18 to 24 years (mean = 20.6 years). Of the 61 athletes surveyed, 86.9% were Caucasian, 9.8% were African-American, 1.6% were Native American or "Other" race/ethnicty.

After receiving approval via the Cleveland State University Institutional Review Board, the survey was distributed by the primary investigator and members of the John Carroll University athletics staff to the athletes that agreed to participate. The questionnaires were distributed to athletes who entered the athletic training and weight room facilities at John Carroll University. Copies of the survey were also given to head coaches and/or assistants for distribution. The athletes (and coaches) were informed about the study and the anonymity of the survey instrument. The athletes were allowed to stop answering questions at anytime and were assured that there was no reward or consequence for participating in the study. To protect the anonymity of the subjects, questionnaires were separated from consent forms.

Questionnaire

A creatine supplementation questionnaire (Appendix B) was developed according to surveys utilized by Metzl et al. and Ray et al.[31, 40] The survey response rate was 41% (61/150). Survey content was examined by health professionals of various backgrounds and expertise (e.g. senior athletic trainer, exercise physiologists, physical therapist) to determine content and construct validity of the survey instrument.

In the questionaire, athletes provided demographic information regarding their age gender, and sport. Athletes were allowed to indicate their participation in more than one sport. The subjects indicated whether they knew anyone who had taken creatine, thought about using it, or were currently using the supplement and why. The participants were asked to indicate whether or not they consumed other ergogenic aids or supplements in addition to or independently of creatine. Athletes were also asked to indicate where they had received the bulk of their supplement information.

Athletes that admitted to current creatine use were asked additional questions regarding their use of the supplement. Creatine users were asked to provide information regarding the amount of creatine they were taking (loading and maintenance doses), the length of current use, and the type/form of creatine they were using. Athletes that admitted to using creatine completed a Likert scaled assessment of attitude toward creatine use. The athletes were asked to circle "0" if they strongly disagreed (SD), "1" disagreed (D), "2" had a neutral opinion (N), "3" agreed (A) or "4" strongly disagreed (SA) with a given statement. The Likert scale included questions such as: "If used properly, creatine can improve sport performance"; "I can improve my workout performance faster if using creatine"; "I can improve my workout performance without creatine"; "I believe creatine can cause muscle cramping", etc. *Snap 9 Professional,* software for survey design and data compilation, was used exclusively for the creation of the present survey.

Data Analysis

Descriptive statistics were obtained, including frequencies/percentages of responses to each survey item. SPSS (version 13.0) was used for all analyses.

CHAPTER IV

RESULTS

Section 1. Total Sample (n = 61)

The demographic makeup of the total sample consisted of a greater representation of male to female athletes (~10:1 ratio). Seven varsity sports were represented in the sample: football (39/61), basketball (10/61), baseball (4/61), soccer (3/61), swimming (2/61), track and field athletes (2/61), and wrestling (1/61) as shown in Figure 1. The age of the subjects ranged from 18-24 years.

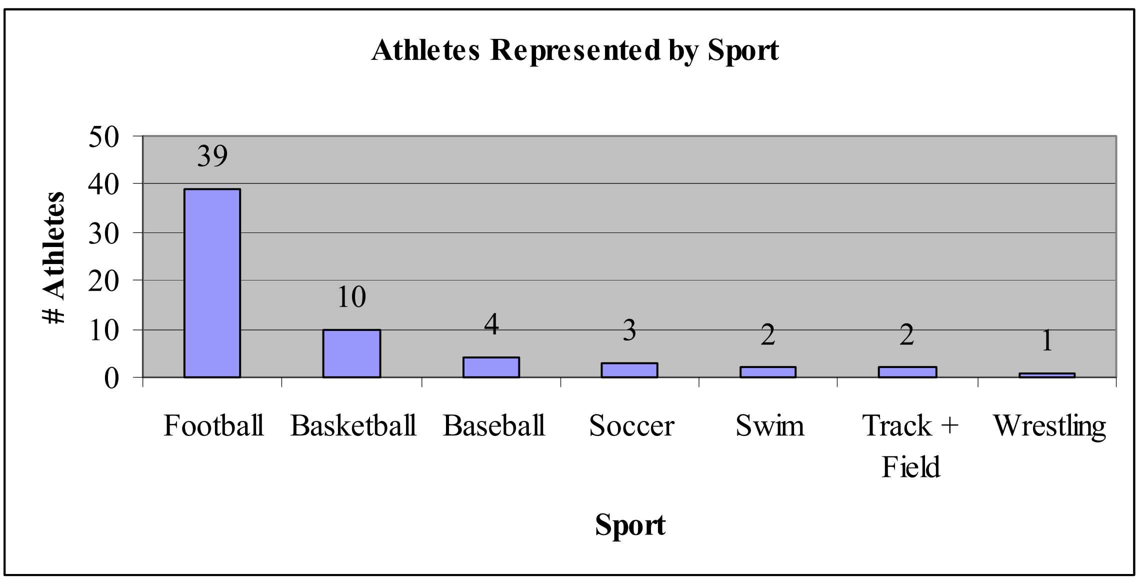

Figure 1. Athletes Represented by Sport (n = 61).

Over 85% (52/61) of study participants had heard of supplementing with creatine for ergogenic enhancement of performance and nearly 74% (45/61) of the sample considered the use of creatine during the course of their Division III athletic careers. Greater than 90% (57/61) of study participants admitted to at least knowing someone who had taken creatine. Past creatine use was reported by 42.6% (26/61) of athletes.

The most common reasons for not using creatine are depicted in Figure 2. Over 30% (19/61) of respondents expressed that creatine was not safe, 36% (22/61) felt that they did not need it, and 18% (11/61) indicated that they felt there was no real benefit from using creatine. Thirteen percent (8/61) felt that using creatine was too expensive (price per formula type ranges from $10-80). Eleven percent (7/61) responded that using creatine was unfair and 7% (4/61) felt that using creatine took too much discipline. Five respondents (female, n = 3; male n = 2) were concerned about weight gain. “Other” reasons given by athletes for not using creatine included statements like: “I don’t know what it is,” I don’t know enough about it,” or “kidney disorder.”

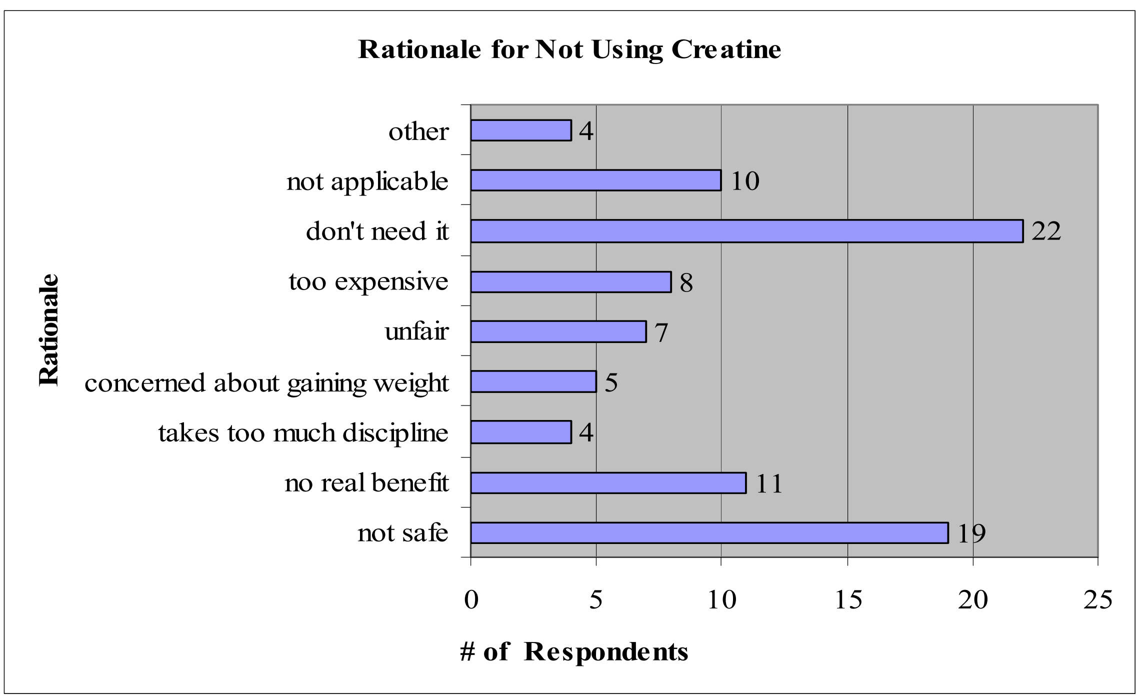

Figure 2. Reasons for Not Taking Creatine (n = 61).

As shown in Figure 3, 87% (53/61) of athletes admitted to consuming sports drinks and/or bars and 15% (6/61) acknowledged consuming caffeinated energy beverages such as Red Bull. Twenty-one percent (13/61) of athletes reported using mineral supplements such as calcium, zinc, or iron and 54% (33/61) admitted to taking vitamin supplements. Forty-nine percent (30/61) of subjects admitted to using protein supplements/weight gainers (e.g. whey protein, arginine, or Juven.) independently or in addition to creatine supplementation and 10% (6/61) admitted to supplementing with herbal alternatives such as Ma-Huang or Ginseng. Dietary products such as Boost or Slim Fast were used by 5% (3/61) of subjects.

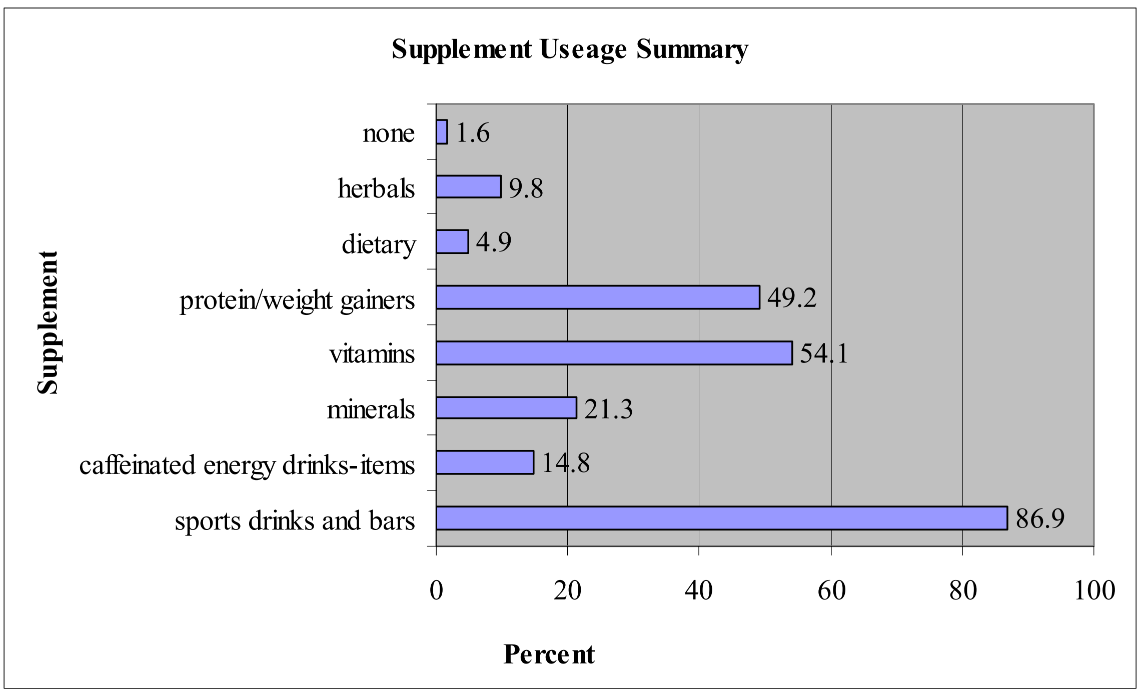

Figure 3. Supplement Usage Summary (n = 61).

The participants (n = 61) indicated that they received the bulk of their creatine information from two commonly reported sources: the internet and GNC stores, as opposed to athletic support staff (ie. physician, certified strength and conditioning specialist [CSCS], dietitian, athletic trainer, etc.). Figure 4 depicts the primary sources of creatine information by percentage.

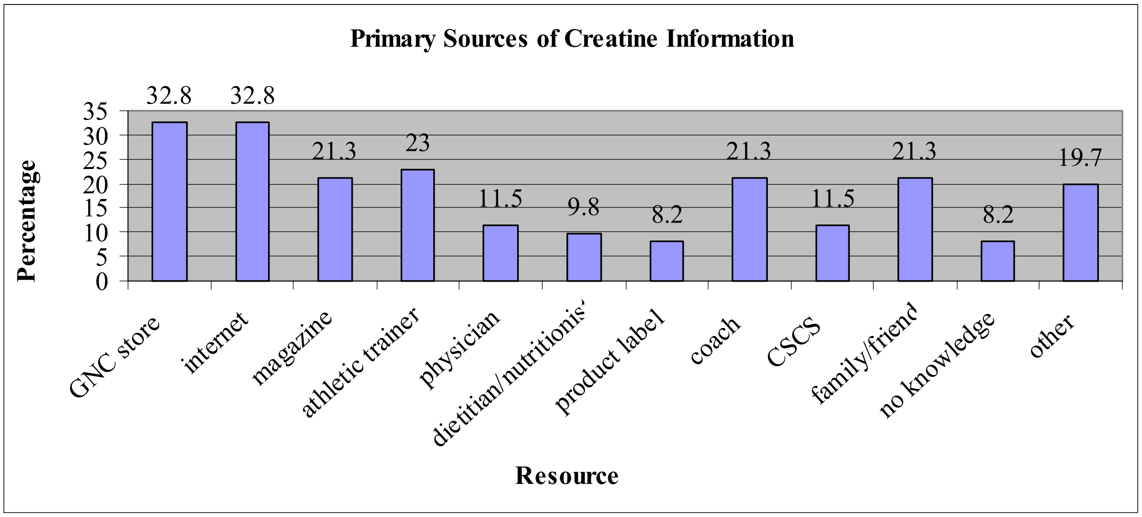

Figure 4. Primary Sources of Creatine Information (n = 61).

Section 2. Creatine Users (n = 10)

The study results revealed that of 61 athletes sampled, 16.4% (n = 10) were current creatine users, all of whom were football players. Of the current creatine users, 40% (4/10) had taken creatine for greater than six months. The earliest age of creatine supplementation was reported at 15 years.

Creatine users (n = 10) utilized the supplement in an effort to improve overall sport/ physical performance. Five athletes indicated that they felt creatine helped to improve appearance, endurance [capacity] and speed; 7 athletes felt it helped improve physical performance, 9 subjects used creatine for muscle/weight gain and to improve sport performance. Figure 5 shows the rationale for creatine use among the current users.

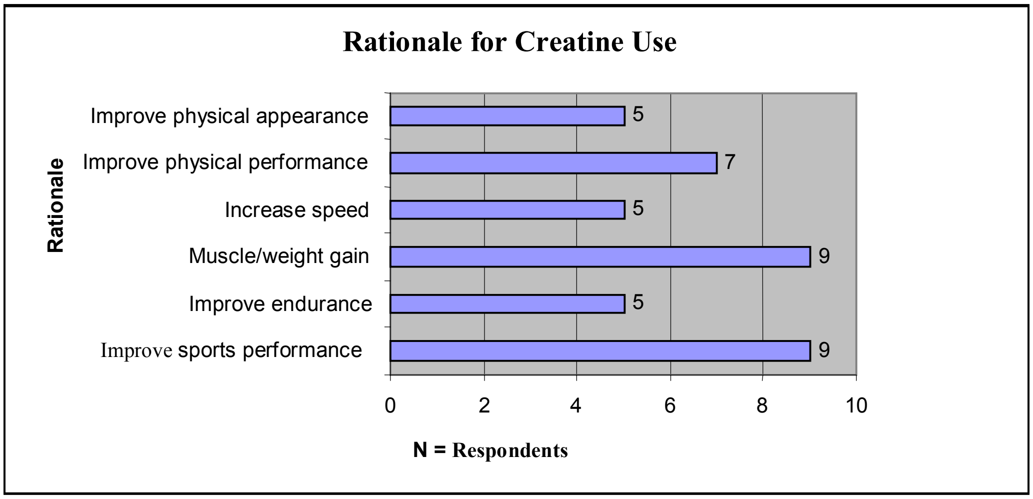

Figure 5. Rationale for Creatine Use (n = 10).

Creatine Administration and Dosage in Current Users (n = 10)

Creatine monohydrate was the most frequently used type of creatine reported by current users (n = 10). Eighty percent (8/10) of the subjects reported intake of creatine as a powder, while 20% (2/10) obtained creatine in pill form.

Sixty percent of athletes had not supported a loading regime as part of their creatine supplementation routine. Loading dosages were reported at 5-10 grams/day for three days by 20% (2/10) of subjects and maintenance doses of 2 to 5 grams/day were reported as customary in 80% (8/10) of users (the usual recommended regimen is a loading phase of 20 g/day for 5 days, followed by a maintenance dose of 2 to 5 g/day).[17, 23, 27] Twenty percent (2/10) of creatine users admitted to not knowing how much creatine they were using. All current users of creatine were informed of risks and benefits before use.

Attitudes about Creatine Use in Current Users (n = 10).

Mean scores for Likert scale questions and responses are listed in Table 7 (strongly disagree = 0, disagree = 1, neutral = 2, agree = 3, strongly agree = 4*)*. In general, attitudes towards creatine were favorable.

Table 1. Attitudes Towards Using Creatine (n = 10).

	Mean	**Std. Deviation**	**Range (0 - 4)**
Q1. If used properly, creatine can improve sport performance.	3.5	.7	2 – 4
Q2. There are no guidelines to proper creatine use.	.7	.8	0 – 2
Q3. I can improve my workout performance faster with creatine.	3.1	.7	2 – 4
Q4. I am confident that I can improve my workout performance without creatine.	2.6	1.1	0 – 4
Q5. Creatine can help decrease seasonal injuries.	1.7	1.3	0 – 4
Q6. I am likely to be a better athlete when taking creatine.	2.8	1.0	1 – 4
Q7. The benefits of using creatine are greater than its potential side effects.	3.0	.7	2 – 4
Q8. I risk being criticized by my peers if I use creatine.	.7	.8	0 – 2
Q9. I am easily upset when I don't perform my best.	3.2	1.0	1 – 4
Q10. I will likely use creatine to help prepare for a big game or tournament event.	2.0	1.2	0 – 4
Q11. I believe that creatine causes muscle cramping.	3.0	1.2	1 – 4
Q12. Creatine can contribute to heat related illnesses or dehydration in athletes.	2.8	1.4	1 – 4

CHAPTER V

DISCUSSION

Creatine use among Division III collegiate athletes during the post-season (spring 2007) was lower than hypothesized with only 16% of total respondents (10/61) admitting to current use of creatine. Although it was difficult to make general comparisons across gender and sport within the present study, trends in the current data (females, n = 6; males, n = 55) showed that men were more likely than women to use creatine as an ergogenic aid in sports. The prevalence rate of creatine use has been consistently documented as being higher in male versus female athletes.[17, 23, 27, 31, 41] Greenwood et al. reported creatine use at 41% in Division I collegiate athletes and found that creatine supplementation was more prevalent among men than women.[17] This study found that males were more aware of creatine and its use as an ergogenic aid than females. The early influences surrounding creatine use may have developed more so in male athletes at earlier periods secondary to weight room pressures from coaches and peers and/or the desire to perform well in sport.

As suggested within the literature, strength-dependent athletes in sports such as football, wrestling, hockey, and lacrosse are likely to use creatine.[16, 17, 31, 38] Since all 10 admitted creatine users were football athletes, it can be assumed that the present findings are consistent with general trends observed within the literature regarding contact-based sports and individual supplement use for performance enhancement.

Prevalence rates are likely blunted as training intensity and/or the drive for an ergogenic edge is apt to decrease during the post-season. Forty-three percent of the total sample admitted to past creatine use. Hence, it is very likely that the percentage of total creatine users during the course of the regular season for each sport was higher. Further, current creatine users were likely not new users, but intermittent users of creatine and were either restarting or continuing their creatine regimes in preparation for spring conditioning (since it is about a six month time lapse between fall and spring seasons). One participant reported using creatine according to three, 2-month interspersed cycles.

About 40% of current creatine users used creatine for greater than six months. Thirty percent of current creatine users (likely those using creatine greater than 6 months) started using creatine during their sophomore year of high school. According to the literature, creatine use is typically initiated when an athlete enters high school and more often than not, middle school.[31, 41] This was supported by the present study. It can be assumed that early use of creatine is influenced by various external factors, including but not limited to, needing to satisfy coaching demands, succumbing to peer influence or exaggerated outcome expectancies, and the compulsion to perform well during training and competition for athletic scholarships and rewards. Internal factors such as self-efficacy pertaining to sport and outcome expectancy are also likely to influence early creatine use.[44, 52] Williams et al. found that creatine users expected fewer negative outcomes from using creatine and considered those outcomes less important than non-creatine users.[52]

While a number of current creatine users in this study used creatine for extended time periods, there was no evidence that suggested that their dosing habits were excessive. In fact, most of the athletes that used creatine in this study were within or well below the recommended dosing parameters (the usual recommended regimen is a loading phase of 20 g/day for 5 days, followed by a maintenance dose of 2 to 5 g/day).[17, 23, 27]

Juhn et al. reported loading doses in male collegiate athletes at 20 to 30 g/day for 5 to 7 days and found that 75% of athletes surveyed exceeded the recommended maintenance dose of 2 to 5 g/day with the most common dosage being 6 to 8 g/day.[1, 23] Maintenance doses were reported as high as 17 to 20 g/day.[23] The majority of creatine users in the present study admitted to not using a loading regime prior to creatine dosing and 80% reported daily use of creatine at 2 to 5 grams/day with powdered creatine monohydrate as the supplement of choice (consistent with the low-dose protocol). Two study participants indicated the use of creatine ethyl ester.

Reasons for creatine use in this study were consistent with the literature.[17, 23, 27, 31, 41] The majority of athletes used creatine to enhance an aspect of physical and/or sport performance, as well as muscle mass. Athletes did not consider improvement of physical appearance as a primary reason for using creatine. It might be assumed that athletes tend to care more about performing well rather than aesthetic attributes.

Creatine users were likely to have favorable attitudes about creatine relative to their experiences using the supplement. Most creatine users agreed that creatine could improve sport performance if used properly. However, when surveyed as to whether or not creatine contributed to heat-related illness or dehydration in athletes, a high degree of variability was seen among participant responses (Table 7, question 12). Dehydration and muscle cramping were among the various side effects reported within the literature concerning creatine use.[17, 23, 27, 31, 41] Adverse effects claimed by athletes using creatine included increased thirst, dehydration, headache, nausea, dizziness, stomach and muscle cramping, etc.[23, 41]

Creatine users are likely to feel that the benefits of using creatine are greater than the potential side effects and are less likely to question common risks and benefits. This study found that most of the respondents were in agreement with the above statement. Athletes that used creatine felt that they could improve their workout performances faster and more confidently with creatine. Most athletes felt that they were overall better athletes when using creatine, however, this did not include the belief that creatine could help decrease seasonal injuries. The belief that creatine use could lead to the reduction of orthopedic injury and faster recovery from injury is likely not a premeditated factor to creatine use in young athletes. Greenwood et al,[16] however, reported significant reduction in muscle cramping, tightness, and/or muscle strains during one Division IA collegiate football season as a result of creatine supplementation.[16] Accordingly, this belief should not be ruled out, but adopted as one of the more unique reasons or motivators for creatine use in athletes.

Interestingly, many athletes were indifferent to the idea of using creatine to help prepare for major competitions. It appeared that the overall objective for athletes when using creatine was to improve athletic performance and was not related to specific games or tournament events. Peer pressure also did not appear to influence creatine use in this study.

Consistent with Williams et al.[52], current creatine users in this study appeared to have stronger beliefs in personal ability to enhance performance through creatine use. According to Williams et al., *self-efficacy,* as defined by Bandura in 1997, is the belief in one's ability to take certain actions (like using creatine) to produce desired attainments and is a strong predictor of creatine use even after outcome expectancies (expected behavioral effects) are controlled.[44, 52] Williams et al.[52] found that non-creatine users did not have higher self-efficacy without creatine versus creatine users. In addition, both groups were fairly confident that they could improve personal workout performance without creatine. In the present study, self-efficacy was not specifically measured. However, the current data does suggest that non-creatine users, similar to creatine users, are fairly confident in their abilities to enhance performance without creatine by modifying their diet and/or increasing their training regimes. On the other hand, it cannot be ruled out that these athletes are not using other supplements.

Athletes were asked to report nutritional supplement use in addition to creatine. The present study found that most athletes consumed energy drinks, bars, and powders (i.e. Gatorade or Power Bars). These products are marketed as energy and hydration sources that prevent fatigue and prolong performance in athletes and are most commonly utilized for these purposes. This study found that most athletes are also likely to supplement with over-the-counter vitamins (e.g. A, C, E, multi-vitamins) for nutritional supplementation. Minerals such as calcium, iron, or zinc were used by 21% of athletes. Forty-nine percent of athletes admitted to using weight gainers and/or protein supplements, and in several instances, while consuming creatine. Fifteen percent of athletes admitted to the use of energy drinks such as Red Bull or other supplements such as pyruvate. Ten percent of athletes experimented with natural supplements and herbs such as ginseng or Ma-Huang. Weight loss products such as Slim Fast or Boost were least likely to be consumed. No illegal supplement use was reported (e.g. DHEA, andrenosterone).

Even though most creatine users obtained information on the supplement before using it, some athletes were not informed of the risks and benefits surrounding creatine use. The majority of athletes in this study had heard of using creatine as an ergogenic aid, knew at least one person who had taken it, and at some point thought about taking creatine. Clearly, the influences surrounding creatine use are profound and the need for practical and relevant educational intervention is important. Ray et al. found that 43% of high school athletes learned of creatine monohydrate use via a friend.[41] Given that younger ages are likely when creatine supplementation begins, screening for supplement use should begin at early adolescence.

The internet and GNC stores were among the top resources utilized by athletes interested in creatine within this study. Athletic trainers were more likely than other health professionals to be a resource to athletes seeking creatine information. Athletes were least likely to refer to a dietitian/nutritionist or product labels for creatine information, which is assumed to be necessary in order to obtain specific product and dosing information. Twenty-one percent of respondents stated that they were likely to learn of creatine from magazines, friends/family, or from a coach. Interestingly, an athlete’s teammate was reported as a source for creatine information, which is likely considering that most athletes share similar goals and expectancies relative to sports performance enhancement.

The potential for misinformation about creatine is evident. While it is promising that most athletes in this study appeared to be informed consumers of creatine, the quality and content of the information received by these athletes cannot be taken for granted. Thirty-three percent of creatine users responded that they used the Internet to learn about creatine. While many Internet resources pertaining to creatine are accurate, others are biased, subjective, and unreliable.

Athletes need accurate information about ergogenic aids, proper dosing instructions, and associated risks from their team physicians and athletic trainers. According to O'Dea et al.,[33] health education theories such as Health Belief Models developed by Strecher and Rosentock in 1997 and the Theory of Reasoned Action by Fishbein and Ajzen in 1975 suggest that encouraging athletes to participate in an informed risk/benefit analysis may be beneficial in helping them make healthy decisions relative to supplements such as creatine. According to O'Dea and Williams et al.,[33] further addressing issues of self-efficacy, as proposed by Bandura in 1986, may help athletes choose more healthful behaviors and could be achieved by providing sports nutrition advice and skills development about hydration and balanced diets to improve sports performance via risk-free means.[52]

CHAPTER VI

SUMMARY AND CONCLUSION

Creatine use in Division III varsity, collegiate athletes in the present study was below 30%, which did not support the initial hypothesis. However, trends in the data supported the hypothesis that men were more likely than women to use creatine as an ergogenic aid to enhance sport performance in collision/strength-dependent sports (eg. football, lacrosse, hockey, wrestling, basketball). The popularity of creatine at the collegiate level remains unsubstantiated. Athletes need accurate information about all ergogenic supplements and their associated risks including proper dosing and instruction.

Limitations

Poor survey return and survey design issues were among limitations within this study. Several varsity coaches were given copies of the survey to distribute to their respective teams. The primary investigator received a 0% return rate among surveys distributed to coaches. Athletes were surveyed using convenience sampling methods, which further limited the generalizability of findings and representation across gender and sport. The times in which the questionnaire was distributed was likely a major factor in the survey return because a substantial number of the athletes were either home for the summer or were incoming freshman and were not yet part of an active team roster. If surveys were distributed at the beginning of the season (perhaps during pre-participation physicals) it is likely that prevalence rates would be higher and comparable to those reported in the literature.

The construct of several survey questions may have influenced or limited the athletes' response. For example, in retrospect, survey question #19 ("What type of creatine do you take currently?") should have been extended to allow participants to specify use of expanded or newer market creatine supplements (i.e. creatine malate, ethyl ester chloride). Further, based on the survey design, only current creatine users were required to answer attitude assessment questions (i.e. Likert scale) when filling out the survey. Thus, an attitudinal comparison among creatine users vs. non-creatine users could not be established by the present study. This information may have been important in determining self-efficacy, expectancies, and other social-cognitive factors leading to supplement use and should be considered for future investigations regarding creatine use.

Future Research

Researchers should continue to explore creatine use in Division III collegiate athletes. Future research should examine the relationship between intercollegiate division levels (ie. DI, II, III) regarding prevalence of creatine use. In this study, the relationship between creatine use and reduced muscle injury, as suggested by Greenwood et al., was not determined.[16] This should be examined further in addition to purported side effects associated with creatine use and other subjective or social-cognitive influences that may premeditate the use of supplements such as creatine across gender and sport.

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APPENDIX

A

Dear Student athlete:

We are asking you to complete a survey being administered to student athletes at John Carroll University. The purpose of this survey is to gain insight into creatine supplementation use in athletes at the Division III level. The survey will ask questions about the use of creatine and other supplements. It is our hope that information from this survey will supplement the health care professionals' understanding of creatine use in athletes and the role of education practices in the health care setting.

There are no apparent risks involved in participating in this survey. Your responses to the survey will be anonymous. Your name will not appear anywhere on the survey.

Participation is completely voluntary and you may withdraw at any time. There is no reward for participating or consequence for not participating. The survey will take approximately 10-15 minutes to complete.

For further information regarding this research please contact Raquisha Bailey, ATC/L at (216)798-9332, email: baileyr@ccf.org, or Dr. Kathleen Little at (216)687-4877, email: k.d.little@csuohio.edu. If you have any questions about your rights as a research participant you may contact the Cleveland State University Institutional Review Board at (216)687-3630.

A copy of this letter can be obtained upon request for your records. Otherwise, this form will be returned to the researchers. Thank you in advance for your cooperation and support.

APPENDIX

B

Division III Athlete Survey

PLEASE MARK THE BEST ANSWER FOR EACH QUESTION.

Q1 AGE

Q2 Gender
- *Male*
- *Female*

Q3 RACE/ETHNICITY
- *Caucasian*
- *African-American*
- *Other*
- *Native American*
- *Asian/Pacific Islander*
- *Hispanic*

Q4 What sports team are you currently on the roster for?
- *Football*
- *Baseball*
- *Swimming*
- *Basketball*
- *Softball*
- *Track/Field*
- *Soccer*
- *Wrestling*
- *Tennis*
- *Cross Country*
- *Golf*
- *Volleyball*

Q5 Did you ever hear of using oral creatine as a nutritional supplement to improve sports performance?
- *Yes*
- *No*

Q6 Do you know anyone who has taken creatine?
- *Yes*
- *No*

Q7 Have you thought about taking creatine?
- *Yes*
- *No*

Q8 Have you ever taken creatine?
- *Yes*
- *No*

Q9 If you currently DO NOT take creatine, check the reason(s) why:
- *Unsafe*
- *No real benefit*
- *Takes too much discipline*
- *Concerned about gaining weight*
- *Unfair*
- *Too expensive*
- *Don't need it*
- *Not applicable (I use creatine)*
- *Other:*

Please Specify Other

-Continue-

Q10 I am using the following energy/nutritional/dietary products:

- *Sports drinks and/or bars (e.g. Gatorade, Powerade, All Sport)* ☐
- *Caffeinated energy drinks/items (e.g. Redbull, 'V')* ☐
- *Minerals (e.g. calcium, iron, zinc, potassium)* ☐
- *Vitamins (e.g. A-E, folic acid, niacin, multi-vitamin)* ☐
- *Protein supplements/weight gainers (e.g. soy protein, whey protein, Juven, amino acids, glucose polymers)* ☐
- *Dietary (e.g. Boost, Simfast)* ☐
- *Herbals (e.g. Ginseng, Ginkgo Biloba, Ma-huang)* ☐
- *None* ☐
- *Other (e.g. steroids, DHEA)* ☐

Please Specify what you are using here ☐

Q11 Please indicate where you have received the bulk of your information about creatine:

- *GNC or store counselor* ☐
- *internet* ☐
- *magazine* ☐
- *athletic trainer* ☐
- *physician* ☐
- *dietitian/nutritionist* ☐
- *product label* ☐
- *strength and conditioning coach* ☐
- *certified strength and conditioning specialist* ☐
- *family/friend* ☐
- *I have no current knowledge of creatine* ☐
- *Other:* ☐

Please Specify Other ☐

Q12 Are you currently taking creatine? (If you are NOT currently or have never taken creatine, STOP here)

- *Yes* ☐
- *No* ☐

Q13 How long have you been taking creatine?

Less than six months .... ☐

Greater than six months .... ☐

Please Specify Length of Creatine Use ☐

Q14 At what age did you start taking creatine? ☐

Q15 If you currently take creatine, select or indicate the reason (s) why:

improve sports performance .... ☐

improve endurance .... ☐

muscle/weight gain .... ☐

increase speed .... ☐

improve physical performance .... ☐

improve physical appearance .... ☐

Other: .... ☐

Please specify Other ☐

Q16 How much creatine do you take when you load?

5-10 grams/day for 3 days .... ☐

15-20 grams/day for 3 days .... ☐

25-30 grams/day for 3 days .... ☐

5-10 grams/day for 5 days .... ☐

15-20 grams/day for 5 days .... ☐

I don't know .... ☐

I don't load .... ☐

Other: .... ☐

Please Specify Other ☐

Q17 Which of the following best represents the amount of creatine taken on a daily basis or as a maintenance dose?

less than 2 to 5 grams/day .... ☐

2 to 5 grams/day .... ☐

6 to 8 grams/day .... ☐

greater than 10 grams/day .... ☐

I don't know .... ☐

Other: .... ☐

Please Specify Other ☐

Q18 What form of creatine supplement do you currently take?

Powder .... ☐

Liquid (serum) .... ☐

Pill .... ☐

Gum .... ☐

Effervescent (fizz) .... ☐

powder .... ☐

Q19 What type of creatine do you take currently?

Creatine Monohydrate .... ☐

Creatine Phosphate .... ☐

Creatine Citrate .... ☐

I don't Know .... ☐

Q20 Did you educate yourself on the risks and benefits of creatine before using it.

Yes .... ☐

No. .... ☐

-Continue-

MARK THE ANSWER THAT BEST REPRESENTS YOUR ATTITUDE ABOUT CREATINE USE (0=STRONGLY DISAGREE, 1=DISAGREE, 2=NEUTRAL, 3=AGREE, 4=STRONGLY AGREE)

	SD (0)	*D (1)*	*N (2)*	*A (3)*	*SA (4)*
{Q21a} If used properly, creatine can improve sport performance.	☐	☐	☐	☐	☐
{Q21b} There are no guidelines pertaining to proper creatine use.	☐	☐	☐	☐	☐
{Q21c} I can improve my workout performance faster with creatine.	☐	☐	☐	☐	☐
{Q21d} I am confident that I can improve my workout performance without creatine.	☐	☐	☐	☐	☐
{Q21e} Creatine can help decrease seasonal injuries.	☐	☐	☐	☐	☐
{Q21f} It is important to know the basic risks and benefits of creatine before using creatine.	☐	☐	☐	☐	☐
{Q21g} I am likely to be a better athlete when taking creatine.	☐	☐	☐	☐	☐
{Q21h} The benefits of using creatine are greater than its potential side effects.	☐	☐	☐	☐	☐
{Q21i} I can rely on creatine for faster results.	☐	☐	☐	☐	☐
{Q21j} I risk being criticized by my peers if I use creatine.	☐	☐	☐	☐	☐
{Q21k} I am easily upset when I don't perform my best.	☐	☐	☐	☐	☐
{Q21l} I will likely use creatine to help prepare for a big game or tournament event.	☐	☐	☐	☐	☐
{Q21m} I believe that creatine can cause muscle cramping.	☐	☐	☐	☐	☐
{Q21n} Creatine can contribute to heat related illnesses or dehydration in athletes.	☐	☐	☐	☐	☐

-Thank You-

Your participation in this study is greatly appreciated!

We hope that the information from this survey will supplement the health care professionals' understanding of creatine use in athletes and the role of education practices in the health care setting.