CREATINE AND OTHER NUTRITIONAL SUPPLEMENTS:

ISSUES FOR YOUNG ATHLETES

By

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Abstract of Thesis

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Health, Human Performance and Recreation

Creatine and Other Nutritional Supplements: Issues for Young Athletes

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Creatine and Other Nutritional Supplements: Issues for Young Athletes

Never before in the history of American sport has there been such a demand to win and such an expectation to excel. This demand has led many young athletes to experiment with creatine and other nutritional supplements. This study aimed at determining the efficacy and safety of several nutritional supplements, primarily creatine, used by young athletes.

A total of 51 studies of creatine were included in the meta-analysis of existing research. The search for literature was conducted by searching the electronic databases MEDLINE and SPORTDiscus using the terms “creatine supplementation” or “nutritional supplements”. Only data from the years 2000-2011 was selected for inclusion in the meta-analysis.

The results of the meta-analysis revealed a slight increase in isotonic force, isokinetic force, jumping and sprinting, lean mass gain and strength gain. There was no noticeable change in hydration status or thermoregulatory capabilities. There was essentially no ergogenic gain in isometric force, power cycling as well as intermittent cycling and running endurance.

This study concluded that creatine and other nutritional supplements do provide generally positive results for young athletes. However, there is not enough scientific evidence supporting the safety of performance-enhancing nutritional supplements to support their use by athletes.

CHAPTER I

INTRODUCTION

In the past twenty years, America has become a sports-crazed society! Much emphasis has been placed on the development of the human body as well as the development of the skills of athletes to be able to compete and win against their opponents. There has also been a dramatic increase in the level of competitive play among athletes in the past twenty years. There are several factors contributing to this trend. One factor has been the impact of Title IX legislation, which has drastically changed the number of females participating in competitive sport. Figures published by the National Federation of High Schools indicate more than a 1000 % increase in female participation at the high school level since the inception of Title IX. The NFHS reports that in 1971-1972 there were 294,015 female participants in high school sports nationwide. By 2009-2010, this number had grown to 3,172,637 (NFHS participation survey, 2011).

The NCAA experienced a roughly 600% increase in female participation from 1972-2011: roughly 30,000 female participants in 1972 and 191,000 female participants in 2011 (http://www.ncaa.com/news/ncaa/article/2011-11-02/ncaa-participation-rates-going#anchorTop). This increase in female sport participation has led to a deterioration of the social stereotype which once implied that sport was only for males. A second factor has been the unprecedented emphasis placed upon winning. Never before in the history of American sport has there been such a demand to win and such an expectation

to excel. A third factor has been economic strain that has encouraged young people to look for an edge over their peers (rising costs of education, leading to the desire to secure an athletic scholarship, etc.). Parents may have often been to blame for this factor, believing that an athletic scholarship will relieve their economic pressure to provide college tuition for their child.

All of these expectations have driven young athletes to begin looking for a competitive edge over their opponents, and even, at times, over their teammates. All athletes seem to want to get ahead of their competition. To gain that competitive edge, a large percentage of competitive athletes have turned to products that will serve as ergogenic aids. Nutritional supplement use among athletes is partly due to the athletes' desire to succeed and improve performances in their chosen sports. However, another significant factor in their choice to use supplements is the message that is being sent by those whom they follow in professional sport. Many young athletes model themselves after their professional sports heroes. This becomes dangerous when those professional athletes send a message that fame and respect can be achieved through success on the athletic field or in the arena. Fame and respect are good things, but only when they are achieved through ethical and fair means.

Successful athletes are revered in our society, not to mention the incredible monetary compensation that is rendered for those who are sufficiently skilled and are fortunate enough to make sport their profession. Sport has become almighty in some circles, even to the point of tempting some athletes to risk dangerous supplement behavior to become elite in their chosen sport. Eichner (1997) stated,

> It is a sad commentary on human nature and society that so much effort is spent trying to detect and deter drug abuse among athletes. But a big-money, winning-is-everything mentality grips much of our social life. Since sport mirrors society, the field of competition is a stage where athletes enact social values. And if winning is everything, some athletes may try anything to win. (p. 74)

Today's media has done much to fuel this unrealistic expectation to "win at all costs." There is the looming danger that the message being sent to our youth is one that implies that supplements and ergogenic aids are acceptable in the sports world. Some even imply that it is necessary to be a "user" to remain competitive. All of these expectations have driven athletes to begin looking for that competitive edge over their opponents, and, at times, over their teammates. Many athletes risk the future of their health on the altar of the immediate.

The availability and use of supplements has risen drastically over the last ten years. Research by Calfee and Fadale (2006) found that investigators at one university discovered that 88% of athletes used nutritional supplements, and among a high school cohort of 270 athletes, 58% had used some form of supplementation. The familiarity of young athletes with nutritional supplements has become disturbing to those in the athletic arena. According to Calfee and Fadale (2006), "Most nutritional supplements can be purchased legally at any health store. Yearly sales in the United States approach $12 billion to $15 billion, with sport supplements being responsible for $800 million" (p. 583).

Every two or three years the newest and most fashionable "wonder supplement" creates anticipatory excitement that it will produce quick and gratifying results. However, science eventually shows that, like others before it, the supplement just does not live up to the claims and hype. Creatine fits that description.

In an effort to gain this competitive edge, many athletes also partake of a variety of anabolic-androgenic steroids. Some of these steroids are legal, yet many are banned by the governing agencies that the athlete finds himself competing in. For instance, the NCAA has a long list of banned substances that it tests for. A sampling of this list includes Boldenone, Testosterone, Dromostanolone, Dihydrotestosterone, Methenolone, Norethandrolone, Oxymetholone, Clostebol, DHEA, Mesterolone and Nandrolone, just to name a few. (National Collegiate Athletic Association, 2011). Each of these steroids has the promise of raising testosterone levels in athletes. The bottom line is still that increased testosterone by itself does not improve the performance of an athlete. The training that develops coordination and sport specific skill must occur in conjunction with strength, power and speed development. Simply increasing testosterone levels may produce hypertrophied muscles, but may have no effect on athletic performance. In addition to this fact came the legislation by the Drug Enforcement Agency in 2004 that made possession of anabolic steroids an illegal act on or after January 20, 2005. "As of January 20, 2005, manufacture, import, export, distribution, or sale of the listed steroids except by DEA registrants has been a violation of the CSA that may result in imprisonment and fines (21 U.S.C. 841, 960). Possession of the steroids unless legally

obtained is also subject to criminal penalties (21 U.S.C. 844)". (retrieved from http://www.deadiversion.usdoj.gov/fed_regs/rules/2005/fr1216.htm)

This legislation leaves fewer options for the athlete wishing to gain a competitive edge. One of those options is the nutritional supplement creatine. Creatine has enjoyed amazing popularity among young athletes over the past twenty years or so.

What is creatine?

Creatine is a naturally occurring substance in the human body. It is synthesized from the amino acids arginine, glycine, and methionine, and is naturally produced by the liver, kidneys, and pancreas. Creatine is also naturally present in the diet, found primarily in meat and fish. The daily requirement for creatine is 2 g. In most people, the body stores a sufficient amount of creatine and even disposes of some of its store.

Bemben and Lamont (2005) noted that:

> Almost all of the creatine in the human body is located in skeletal muscle, with approximately 40% of the creatine in the free form (Cr) and 60% in the phosphorylated form (PCr). In general, a 70kg person with a Cr pool of 120-140g would lose about 2 g/day as creatinine in the urine. (p.108)

Mechanisms of Action

Creatine is typically taken in two phases. First is the loading phase, which typically consists of 20g/d for 5 days, then the maintenance phase, typically consisting of 3-5 g/d thereafter. The process of hypertrophy takes place

in muscles typically in response to increased resistance. However, creatine supplementation can also cause muscles to increase in size. This process is caused by either the muscle retaining fluids (a process called muscle volumizing) or through the production of new muscle proteins (a process called protein synthesis). Creatine is synthesized by the body and plays an important role in the resynthesizing of ADP into ATP within the cell. Dempsey et al. (2002) stated that "Oral creatine monohydrate increases skeletal muscle creatine concentration by 16% to 50%" (p. 945).

Historical Perspective of Creatine

Creatine is not a new substance. Creatine was discovered in 1832 by a French scientist, Michel Eugene Chevreul, who extracted from meat a new organic constituent and named it creatine (Williams, Kreider and Branch, 1999). The discovery of creatine did not impact the athletic world until much later. Some have theorized that the Russians and Eastern block country athletes experimented with creatine as a supplement in the 1970's. Bemben and Lamont (2005) argue that "…the real push toward studying creatine supplementation did not occur until the early 1990's in the U.S. and Great Britain." (p. 108).

Who Needs Nutritional Supplements?

High performance athletes have a special need for protein and hormonal precursors. Nutritional supplements are often taken by athletes to offset these needs. The

McKinley Health Center at the University of Illinois at Urbana-Champaign (2007) claims:

> The availability and use of supplements as ergogenic aids have risen dramatically in the past decade. Some surveys have indicated that approximately 50% of the general population, 76% of college athletes, and 100% of bodybuilders take supplements. New products appear on the market every week. (Who Uses Them? section, para. 1)

Many of these supplements fall into the category of "dietary" supplements. Others would fall into the category of "nutritional" supplements. Zaggelidis, Kanioglou, Mavrovouniotis, and Galazoulas (2008) noted that "Supplements include non-pharmaceutical products such as herbal preparations, nutritional products and other supplements which may fall into either of the categories such as dietary supplements (also known as food supplement or nutritional supplement), and nutritional ergogenic aids" (p. 3). Dietary supplements are ingredients added to the diet, mainly vitamins, minerals, amino acids, herbs or botanicals, and metabolites/constituents/extracts, or a combination of any of them. Dietary supplements can also be extracts or concentrates, and may be found in many forms such as tablets, capsules, soft gels, gel caps, liquids, or powders. Nutritional supplements, on the other hand, are taken to meet the dietary needs of high performance athletes. Ergogenic aids are the products in this category used to enhance performance and to improve and enhance the training effect. Nutritional ergogenic aids refer to substances that enhance performance and are either nutrients, metabolic by-products of nutrients, food (plant) extracts, or substances commonly found

in foods (e.g., caffeine and creatine) that are provided in amounts more concentrated than typically found in the natural food supply.

Many people involve themselves in nutritional supplementation due to body image, thinking that they will be more attractive because of the supplement. Body image is often glamorized in "health or fitness" magazines. The Harvard Medical School conducts an ongoing study of children 9 to 14 years of age which was established in 1996 and named the Growing Up Today Study (GUTS). In the 2005 study, it was determined that

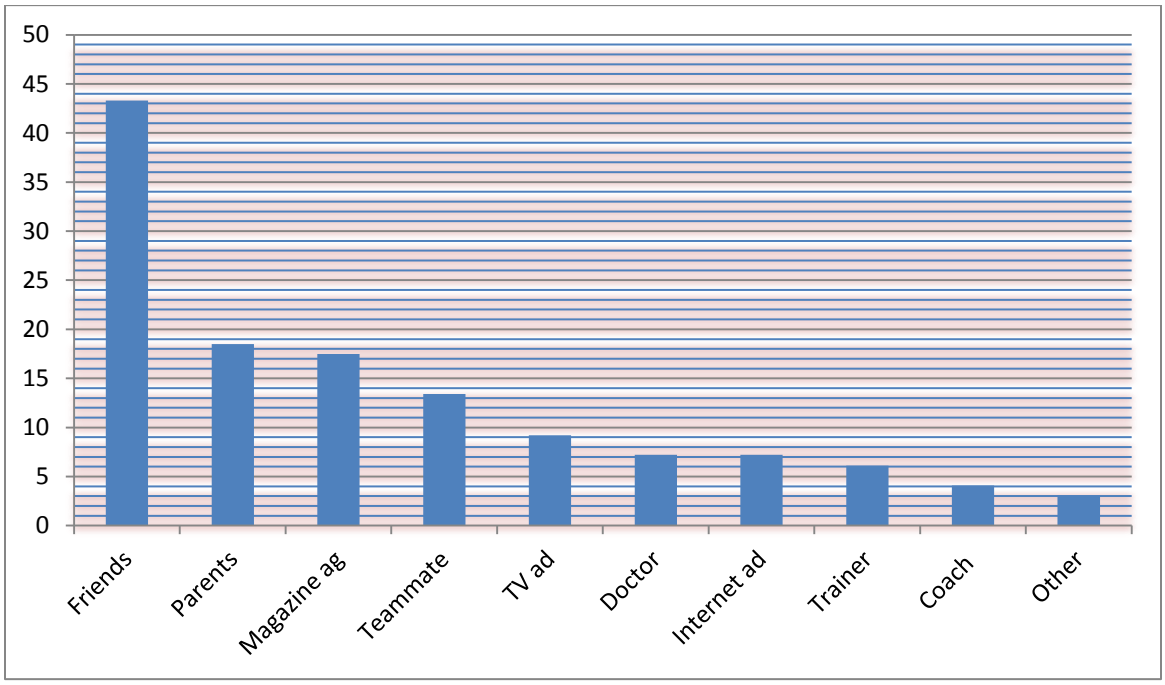
> "Protein powder or shakes" were the products used most often to improve appearance, muscle mass, or strength. Approximately 8% of girls and 10% of boys had used protein powder or shakes in 2004, but less than 4% of either gender had used the product frequently (Field et al., 2005, p. 217).

Many people also choose to participate in supplementation because of the need to enhance their health. However, most of the nutritional supplementation among young athletes is an attempt to create some form of ergogenic aid. Some athletes are trying to create aerobic benefits, some are more interested in anaerobic benefits, still others are seeking increased explosive power that would provide for them an advantage in more explosive sports or sport movements. Most are simply trying to improve athletic performance and/or enhance their overall training investment.

All of today's athletes are continually looking for a competitive advantage. Athletics today places great demands on athletes to be bigger, faster, and stronger than ever before. In a 2003 study, Reeder, Patel, Rai, Cucos and Smith (2003) reported that

"the most common reason for use of a supplement was to increase strength (51.5%, 50 out of 97 responses)" (p. 172). The perceived need to take a nutritional supplement may come from their own desire to improve athleticism (intrinsic motivation), or it may come from extrinsic pressure. This extrinsic pressure may come from, among others, parents, coaches, or teammates. Figure 1 illustrates that the leading source of encouragement to partake of nutritional supplements is friends (43.3%).

Figure 1: Sources of encouragement to partake of nutritional supplements.



Source: Reeder et al., (2003)

Competitive sports today have also become much more specialized than ever before. Athletes today are receiving pressure from different sources to choose "their sport", one in which they feel most skilled. This sport specificity has encouraged those athletes involved in power movements (such as football lineman, baseball pitchers and catchers, wrestlers, swimmers, etc.) to train in a specified way as well as to increase

overall strength and power. This sport specialization may lead to increased energy demands and injury.

The media has a huge impact upon the youth of today. Today's youth are surrounded by a variety of mass media forms. That media can be in the form of television, e-mail, the internet, radio, fitness and health publications, etc. In a recent study of exposure to media, participants were asked how many hours per week they watched television, how many sports events they had seen on television during the past month, and which specific sports they watched (i.e., gymnastics, football). Field et al. (2005) discovered that "Boys watched more hours per week of television (12.3 hours versus 9.5 hours) and watched more sporting events on television in the past month (5.5 hours versus 3.3 hours) than did girls" (p. 217).

Field et al. (2005) also discovered that "girls and boys who reported thinking frequently about wanting more defined muscles and those who were making a lot of effort to look like same-gender figures in the media were more than 3 times more likely than their peers to use products to build muscle or improve appearance" (p. 217). Field et al. (2005) also determined that:

> Type of magazine read was also associated with at least weekly use of products. Girls who read sports magazines and boys who read men's magazines were significantly more likely than their peers who did not read magazines to use products at least weekly. (p. 217)

Athletic leadership today needs to be alert to the influence of the mass media. A great percentage of today's athletes are obtaining their entire knowledge base from the

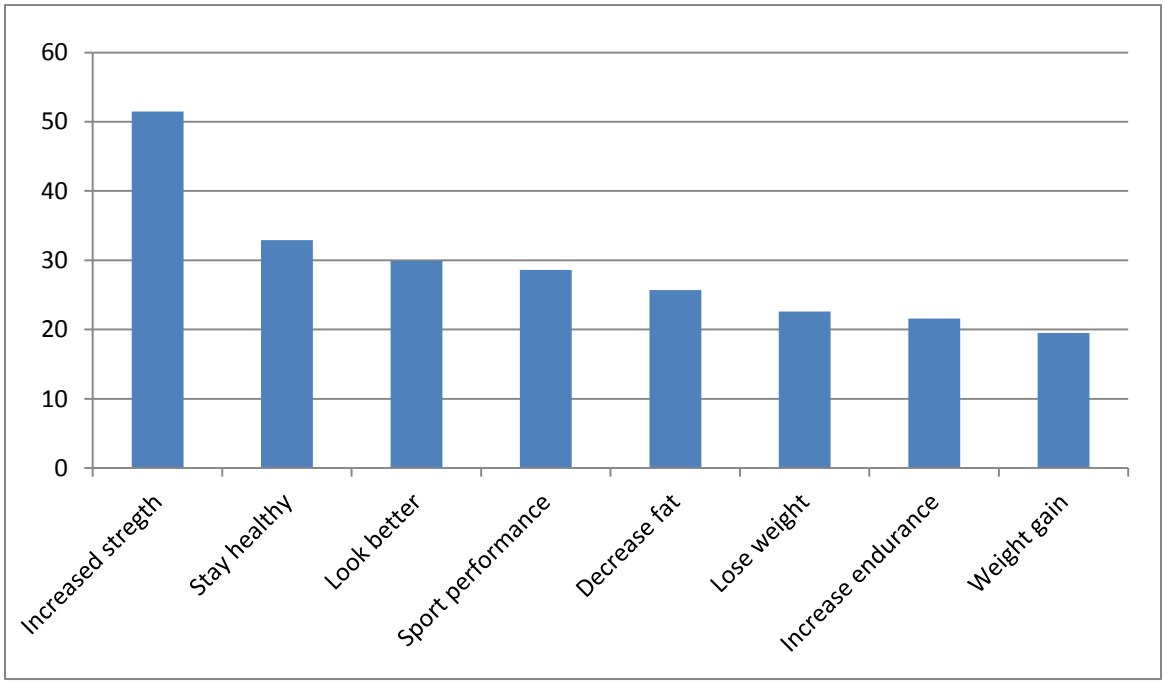
mass media. Many segments of the mass media do not have the health concerns of youth in mind. Field et al. (2005) revealed that:

> Reading magazines was more common among the girls (91%) than the boys (83%), and there was a large difference in types of magazines read. Among the girls, women's, teen, fashion, and health/fitness magazines were the most popular types of magazine read (77%), whereas among the boys, sports magazines (29%) were popular, but men's, teen, and health/fitness were read by only 3% of the sample. Nevertheless, 4% of the boys reported making a lot of effort to look like male individuals in movies, in magazines, or on television. Independent of whether a boy was making a lot of effort to look like male individuals in the media, boys who read men's, teen, fashion, or health and fitness magazines were two times more likely than their peers who did not read magazines to use products that were perceived to enhance appearance, muscle mass, or strength. (p. 217)

It is clear that the media is quite attuned to the market of children. The media is very aware of the strategy of reaching the pocketbooks of parents through the avenues of their children. Why not? It has worked for years! Is there any chance of this phenomenon changing? Not in the near future. Parents vote for what is popular with their pocketbooks. This voting can be very prevalent in the area of nutritional supplements. As was mentioned earlier, parents are often the initiating factor in a child experimenting with supplement usage.

Why do athletes feel the need to involve themselves with nutritional supplements? Figure 2 illustrates that the leading reason for such involvement is increased strength (51.5%).

Figure 2: Reasons to partake of nutritional supplements.



Source: Reeder et al., (2003)

Thus, the need for nutritional supplementation is often a perceived need. Athletes today do understand one aspect of supplement use: Nutritional supplements are much safer than other forms of ergogenic aids available to them, such as anabolic steroids.

Is Taking Nutritional Supplements Ethical?

Athletes today have been pressured to the point of being very vulnerable to the pressures to compete at a high level. Winning has become the pinnacle of many sports efforts. This drive to win has made many athletes blind to the consequences of nutritional supplementation. Many athletes have placed their own accomplishments above the accomplishments of their team. The recent admissions of androstenedione use by Mark McGuire and Barry Bonds have fuelled the performance-enhancing ethics debate in Major League Baseball. This debate has gone as far as to question the legitimacy of home run records broken by these two men. This practice has had a trickle-down effect in the lives of young athletes. Calfee and Fadale (2006) supported this notion when they stated:

> Ergogenic drugs are substances that are used to enhance athletic performance. These drugs include illicit substances as well as compounds that are marketed as nutritional supplements. Many such drugs have been used widely by professional and elite athletes for several decades. However, in recent years, research indicates that younger athletes are increasingly experimenting with these drugs to improve both appearance and athletic abilities. Ergogenic drugs that are commonly used by youths today include anabolic-androgenic steroids, steroid precursors (androstenedione and dehydroepiandrosterone), growth hormone, creatine, and ephedra alkaloids. Reviewing the literature to date, it is clear that children are exposed to these substances at younger ages than in years past, with use starting as early as middle school. (p. 577)

Determining whether nutritional supplement use is ethical or unethical is a difficult determination and can only be left to the discretion of those close to the situation (coaches, parents, administrators, etc.). Several states have issued position statements disallowing persons in positions of leadership (teachers, coaches, trainers, etc.) to dispense any such supplementation. A frequent question to be heard in the locker rooms of America is "Hey coach, does this stuff really work?" Young athletes have many curiosities.

Creatine is currently a legal substance. However, there is debate as to whether it should be allowed by governing sport bodies. Rawson and Clarkson (2000) stated, "It could be argued that consuming any substance in abnormal quantities with the intent of artificially enhancing performance is in violation of the International Olympic Committee's anti-doping legislation and should be considered doping" (p.8). So, after all, what is the big deal? All of the products are legal and can be purchased freely by persons of any age.

Do Nutritional Supplements Have Ergogenic Advantages?

The use of ergogenic aids by athletes has a very long history. Stories about athletes using performance-enhancing aids have become plentiful over the past twenty years. The question that must be asked is: Do all of these nutritional strategies really benefit the athlete to the point that it justifies the involved risk? Creatine seems to provide an ergogenic advantage in explosive, short-term, high energy activities. Rawson and Clarkson (2000) stated,

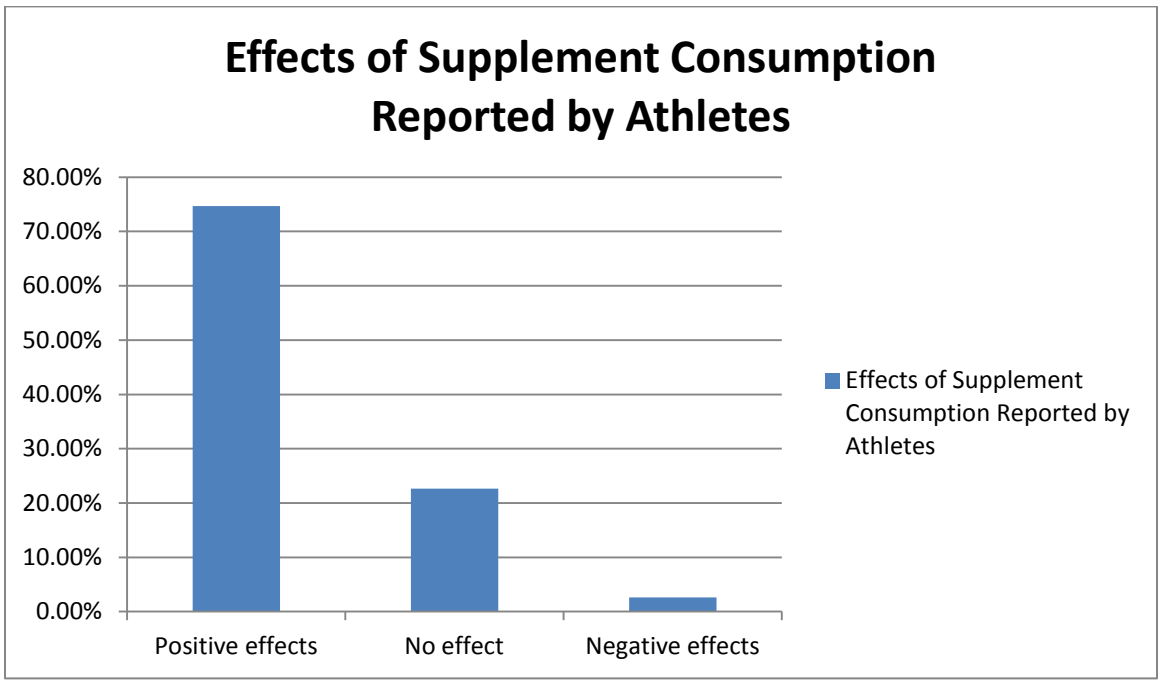
> Manufacturers of this supplement claim creatine is a safe and legal alternative to steroids that build muscle mass, reduce muscle fatigue, and improve exercise performance. Although many studies support an ergogenic effect of creatine in a laboratory setting, far fewer studies have used field tests that mimic sports performance. Thus, although creatine use is common among, and heavily marketed towards, athletes, the effect of this nutritional aid on sports performance is unclear. (p. 7)

Success in sport is not predicated solely upon the contribution that nutritional supplementation can provide. There is more to the success of an athlete than can be found in a bottle or powder mix. Rawson and Clarkson (2000) took the position that:

> Although creatine may increase muscle levels of phosphocreatine and laboratory studies show positive effects, success in sports is not exclusively determined by substrate availability or enhanced energy production. Numerous factors including skill, teamwork, coordination, and luck can make the difference between winning and losing. (p. 9)

The egrogenic advantage of nutritional supplements is very much open to debate. Many athletes taking nutritional supplements describe positive effects. A smaller number have experienced a neutral effect, whereas another group have described negative side effects. Figure 3 illustrates athletes' reported supplement consumption effects.

Figure 3: Effects of Supplement Consumption Reported by Athletes.



Source: adapted from Zaggelidis et al., (2008)

What Does Recent Research Report About Creatine?

Creatine has had a large impact on the nutritional supplement community. There are currently over 500 studies on creatine as an ergogenic aid. Creatine supplements are recommended to be taken first in a loading phase, with athletes consuming 5 g 4 times per day for the first 4 to 6 days. The standard dosing then is 2 g per day for the next 3 months. A month of abstinence is standard practice after each use cycle. Metzl et al. (2001) noted this caution of creatine:

> Creatine is the most popular nutritional supplement, with yearly sales over $400 million. In the most recent position statement on creatine use the American College of Sports Medicine discouraged creatine use in people less than 18 years

old because of unknown potential adverse health effects. Creatine is readily available for purchase, both in health food stores and over the internet. (p. 421)

What are the Side Effects of Nutritional Supplements?

Debate on the side effects induced by creatine supplementation is often based on emotional arguments rather than rationality. Several side effects have been identified anecdotally. These include the development of fat-free mass, muscle cramps, gastrointestinal distress, liver dysfunction, kidney impairment, impairment of exercise heat tolerance and hydration status. Laboratory studies are many and mixed regarding creatine and new studies appear fast. Very little data is available to indicate the consequences or safety of creatine use. Some supplements can have serious side effects even when taken alone. For example, supplements containing ephedra (also called ma huang) may cause irregular heartbeat, strokes and seizures. (Moss, 2003) Others may be relatively safe when taken alone, but when combined with other supplements or medications, can cause disastrous results.

In their ergogenic aids article, The McKinley Health Center (2007) stated:

"If an athlete decides to take a supplement, there are many ways to go about evaluating its safety and efficacy:

- Look for supplements with the U.S. Pharmacopoeia (USP) or National Formulary (NF) notation. These mean the manufacturer has undergone voluntary evaluation of product purity, strength, labeling and weight variation.
- Ask a health care professional who is knowledgeable about nutrition and supplements.

- Do a literature search, being wary of articles or publications funded by the manufacturer of the supplement.
- Determine the reputability of the manufacturer. Have they been in business for a long time? Do they have quality control standards? Do they publish their own research? Is their research cited in peer-reviewed journals?
- Note any side effects associated with the supplement.
- Is the proposed benefit worth the cost or risk?
- Are there any illegal or banned substances contained within the supplement?
- Will the supplement interfere with or otherwise affect any medications or other supplements you may be taking?" (What Can I Do? section, para. 1)

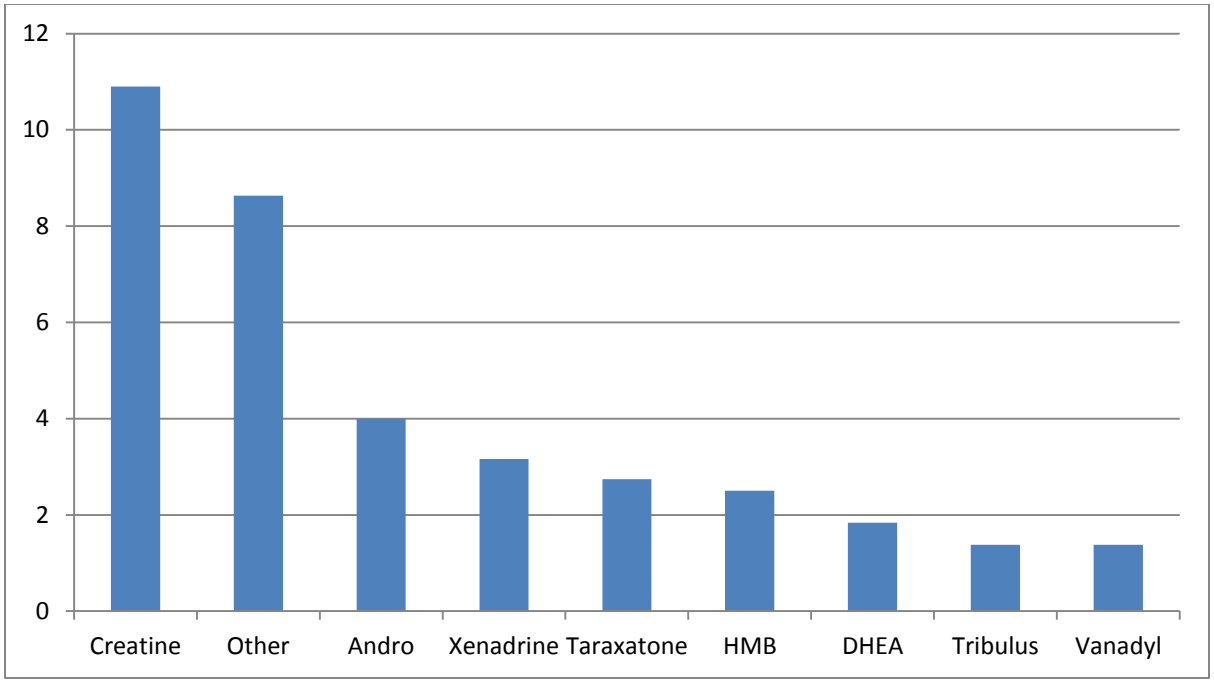
Prevalence of Use

Field et al. (2005) reported:

> Protein powder or shakes were the products used most often to improve appearance, muscle mass, or strength. Approximately 8% of girls and 10% of boys had used protein powder or shakes in the past year, but ‹4% in either gender had used the product frequently. Creatine was used by 4% of the boys during the past year, but it was used by only 0.4% of the girls. At least weekly use of any products to improve appearance or muscles was almost 3 times more common among boys (5%) than girls (2%). The gender difference was even larger when protein powder or shakes were not included as 1 of the products to improve appearance of muscles (2% of boys and 0.3% of girls). (p. 217)

The prevalence rates of different supplements for the last 12 months are depicted in Figure 4. The overall prevalence of having tried at least one supplement was 20.4% (97 out of 475). The most commonly used supplement was creatine (10.9%, 52 responses), followed by androstenedione (4%, 19 responses). (Reeder, 2003)

Figure 4: Prevalence Rates of Different Supplements.



Source: Reeder et al., (2003)

Research by Field et al., (2005) found that: approximately 4.7% of the boys and 1.6% of the girls used protein powder or shakes, creatine, amino acids/HMB, dehydroepiandrosterone, growth hormone, or anabolic/injectable steroids at least weekly to improve appearance or strength. The problem is not one that can easily be ignored. Field et al. (2005) also noted that:

> In a study of 16,119 Canadian students, 27% reported using "extra protein," which was nine times greater than the prevalence (2.8%) of using anabolic steroids. The

> prevalence of creatine use has been studied in several cross-sectional studies of athletes, but data are lacking on the prevalence and correlates of creatine use among a general sample of children and adolescents. (p. 215)

Are Nutritional Supplements Worth the Risks?

The debate over the safety of nutritional supplements is a very controversial one. Proponents of either position are very passionate. Consider the position of the American Academy of Pediatrics (Gomez, 2005) which makes the following recommendations to assist the pediatrician in dealing with users or potential users of performance-enhancing substances:

1. Use of performance-enhancing substances for athletic or other purposes should be strongly discouraged.
2. Parents should take a strong stand against the use of performance-enhancing substances and, whenever possible, demand that coaches be educated about the adverse health effects of performance-enhancing substances.
3. Schools and other sports organizations should be proactive in discouraging the use of performance-enhancing substances, incorporating this message into policy and educational materials for coaches, parents, and athletes.
4. Interventions for encouraging substance-free competition should be developed that are more positive than punitive, such as programs that teach sound nutrition and training practices along with skills to resist the social pressures to use performance-enhancing substances.

5. Colleges, schools, and sports clubs should make use of educational interventions that encourage open and frank discussion of issues related to the use of performance-enhancing substances, with the aim of promoting decisions about personal drug use based on principles of fair competition and character rather than on the fear of getting caught.
6. Coaches at all levels, including youth sports, should encourage wholesome and fair competition by emphasizing healthy nutrition and training practices, taking a strong stand against cheating, and avoiding the "win-at-all-costs" philosophy.
7. Inquiries about the use of performance-enhancing substances should be made in a manner similar to inquiries about use of tobacco, alcohol, or other substances of abuse. Guidelines for patient confidentiality should be followed and explained to the patient.
8. Athletes who admit using performance-enhancing substances should be provided unbiased medical information about benefits, known adverse effects, and other risks. When appropriate, additional testing may be necessary to investigate or rule out adverse medical effects.
9. The pediatric health care professional providing care for an athlete who admits to using a performance-enhancing substance should explore the athlete's motivations for using these substances, evaluate other associated high-risk behaviors, and provide counseling on safer, more appropriate alternatives for meeting fitness or sports-performance goals.

10. Nonusers of performance-enhancing substances should have their decisions reinforced while establishing an open channel of communication if questions about performance-enhancing substances arise in the future.
11. Pediatric health care professionals should promote safe physical activity and sports participation by providing or making available sound medical information on exercise physiology, conditioning, nutrition, weight management, and injury prevention and by helping to care for sports related medical conditions and injuries. (p. 1105-1106)

These cautions and warnings question the wisdom of engaging in nutritional supplement use. For athletes who eat optimal diets, there is no solid evidence that protein powders or amino acids build muscle mass. There appears to be no ergogenic benefit from HMB. The position of Eichner, King, Myhal, Prentice and Ziegenfuss (1999) was that,

> "Andro" products are prohormones and should not be classified as dietary supplements. The limited published research on DHEA and androstenedione, taken as a whole, suggests that, depending on dose, both compounds are likely androgenic and possibly anabolic, especially in women, but maybe also in men. Anecdotal evidence suggests the same for the other supplements. (p. 2)

Purpose of the Study

The purpose of this study was to evaluate the efficacy and safety of creatine, hydroxy methylbutyrate, proteins, and androstenedione as nutritional supplements by

young athletes by analyzing available literature in a meta-analysis format. I predicted that creatine and other nutritional supplements would produce a marginal ergogenic effect on young athletes but be considered risky behavior.

CHAPTER 2

METHODS

A total of 51 studies of creatine were included in the meta-analysis of existing research. The search for literature was conducted by searching the electronic databases MEDLINE and SPORTDiscus using the terms “creatine supplementation” or “nutritional supplements”. Only data from the years 2000-2011 was selected for inclusion in the meta-analysis. The studies were evaluated relative to gains in isokinetic force, isokinetic torque, isometric force, jumping and sprinting improvement, power cycling improvement, intermittent endurance cycling and running, lean mass gain and strength gain as a result of nutritional supplement use by subjects. The 51 studies of creatine accounted for approximately 750 participants.

The treatment participants measuring isotonic force consisted of 105 males, 30 females and 34 identified only as “both” by the researchers. The treatment participants measuring isokinetic force consisted of 72 males, no females and 31 identified only as “both” by the authors. The treatment participants measuring isometric force consisted of 61 males. The treatment participants measuring jumping and sprinting improvement consisted of 30 males, 12 females and 36 identified only as “both” by the researchers. The treatment participants measuring power cycling consisted of 99 males, no females and 94 identified only as “both” by the researchers. The treatment participants measuring intermittent endurance cycling/running consisted of 61 males, no females and 16 identified only as “both” by the researchers. The treatment participants investigating

hydration status and exercise heat tolerance consisted of 153 males, no females and 33 identified only as “both” by the researchers. The treatment participants measuring lean mass gain as well as strength gain totaled 30 male participants and 7 female participants.

CHAPTER 3

RESULTS

The results for the 51 studies of creatine are presented in Tables 1-8. Table 1 represents the first group of studies which pertain to isotonic force. Nine studies were included in this group. Isotonic force is important to all athletes, but especially to athletes whose task is to produce explosive movement (such as football linemen). Isotonic force would involve muscular contractions that produce movement and encounter no real change in resistance. These studies showed an increase in the 1RM of participants in six of the nine studies, with the remaining three showing no difference between groups. Table 2 represents the group of studies which pertain to isokinetic torque. There are five studies included in this group. Isokinetic force would be a measure of a turning force. This would be important to football linemen, baseball pitchers, etc. The results indicated a slight ergogenic benefit to the creatine group. Two of the studies indicated no difference between groups. The remaining three indicated an increase in torque. Table 3 represents the next group of studies which pertain to isometric force. There are three studies in this group. Isometric force would include muscular contraction against a stable object. Isometric force would be a factor in power lifting, etc. The results revealed no difference between groups in two of the three studies, with the other two indicating an increase in the creatine group. Table 4 represents the group of studies which pertain to jumping and sprinting. There are four studies in this group. Jumping and sprinting are important to basketball players as well as short distance track athletes. Jumping and

sprinting are explosive events, which would be benefitted by creatine supplementation. The studies revealed an ergogenic effect in this area, indicated by all four studies reporting an increase in jumping and sprinting performance. Table 5 represents the group of studies which pertain to power cycling. There are ten studies in this particular group. Power cycling expertice would be a beneficial to such athletes as cyclists as well as to defensive backs in football, actions that require a strong core and low center of gravity. There was an even division among these studies, with five studies indicating no difference between groups and the remaining five indicating an increase in performance. Table 6 represents the group of studies which pertain to intermittent endurance cycling and running. There are five studies included in this group. This type of activity would be beneficial to cyclists as well as sprinters. The majority of these studies (3 out of 5) indicated no difference between the two groups. The remaining two indicated an ergogenic gain. Table 7 represents the group of studies which investigates the influence of creatine on hydration status and exercise heat tolerance. There are eleven studies included in this group. Hydration status and exercise heat tolerance are two critical issues for all athletes. It is essential that the body be able to implement thermoregulation during and after exercise bouts. Perhaps the greatest concern with creatine supplementation is its potential impairment of exercise heat tolerance and hydration status. These eleven studies investigate the relationship between creatine supplementation and hydration as well as heat tolerance. The studies investigating hydration status reported the following: Four indicated no difference between groups, five reported an increase in hydration status, and one study indicated a decrease in hydration status. Regarding body temperature

difference, four studies reported no difference between groups and four reported a decrease in body temperature difference. Table 8 represents the group studying lean mass gain and strength gain. The creatine group reported a slight lean mass gain in all four studies. The strength gain group reported a slightly higher gain in all four studies.

Table 1: Studies Investigating the Effect of Creatine Supplementation on Isotonic Force

Study	Dosage	Subjects	Effect
Wilder, 2001	CR loading: Gr1: 3 g/d Gr2: 7 g/d for 7d Maint.: 5 g/d for 12 wk	College football players: Gr1=8; Gr2=8; Gr3=9 (PL)	↔ between groups
Bemben, 2001	CR loading: 20 g/d for 5d Maint.: 5 g/d for 8 wk	College football players: CR=9; PL=8	↑ 1RM
Chrusch, 2001	CR loading: 0.3 g/kg BW for 5d Maint.: 0.07 g/kg BW for 11 wk	30 older men: CR=16; PL=14 resistance training	↑ 1RM
Tarnopolsky, 2001	Gr1: 10g CR + 75 g CHO Gr2: 10g prot + 75g CHO for 8wk	Untrained males: Gr1=11; Gr2=8; resistance training	↔ between groups
Becque, 2000	CR loading: 5g, 4 x/d for 5d Maint.: 2 g/d for 5 wk	Weight-trained males: CR=10; PL=13	↑ 1RM and muscle hypertrophy
Brenner, 2000	CR loading: 20 g/d for 7d Maint.: 2 g/d for 5wk	Female college lacrosse players: CR=7; PL=9; resistance training	↑ 1RM
Larson-Meyer, 2000	CR loading: 7.5g 2 x/d for 5d Maint.: 5 g/d for 12wk	Female college soccer players: CR=7; PL=7; resistance training	↑ 1RM
Rossouw, 2000	CR loading: 9g 3 x/d for 5d	Trained power lifters: CR=8; PL=5	↑ 1RM

Study	Dosage	Subjects	Effect
Syrotuik, 2000	Gr1: 0.3 g/kg for 5d Maint.: PL 32d Gr2: 0.3 g/kg for 5d Maint.: 0.03 g/kg for 32d Gr3: PL for 32d	Recreationally active men and women Gr1=7; Gr2=7; Gr3=7 Resistance training	↔ between groups

Key: **1RM**=one-repetition maximum; ↑ indicates increase; ↔ indicates no difference; **CR=**creatine group; **PL=**placebo group.

Table 2: Studies Investigating the Effect of Creatine Supplementation on Isokinetic Torque

Study	Dosage	Subjects	Effect
Stevenson, 2001	CR loading: 20 g/d for 7d Maint.: 5 g/d for 8wk	Male and female college students: CR=12; PL=6; resistance training	↑ peak torque
Chrusch, 2001	CR loading: 0.3 g/kg BW/d for 5d	30 older men: CR=16; PL=14 resistance training	↑ power output
Tarnopolsky, 2001	Gr1: CR 10g = 75g CHO Gr2: prot 10g = 75g CHO for 8wk	Young untrained men: CR=11; prot=8; resistance training	↔ between groups
Gilliam, 2000	CR loading: 5g, 4 x/d for 5d	Active untrained men: CR=11; PL=12	↔ between groups
Rossouw, 2000	CR: 5g, 3 x/d for 5d	Trained power lifters: CR=8; PL=5	↑ peak torque

Key: ↑ indicates increase; ↔ indicates no difference; **CR=**creatine group; **PL=**placebo group.

Table 3: Studies Investigating the Effect of Creatine Supplementation on Isometric Force

Study	Dosage	Subjects	Effect
Kilduff, 2002	CR: 20 g/d for 5d	Resistance-trained men: CR=21; PL=11	↔ between groups
Jakobi, 2001	CR: 5g, 4 x/d for 5d	Older men: CR=5; PL=5	↔ between groups
Izquierdo, 2002	CR: 5g, 4 x/d for 5d	Male handball players: CR=9; PL=10	↑ sprint and Jump

Key: ↑ indicates increase; ↔ indicates no difference; **CR=**creatine group; **PL=**placebo group.

Table 4: Studies Investigating the Effect of Creatine Supplementation on Jumping/Sprinting

Study	Dosage	Subjects	Effect
Cox, 2002	CR: 5g, 4 x/d for 6d	Elite female soccer players: CR=6; PL=6	↑ sprint and jump
Skare, 2001	CR: 5g, 4 x/d for 1d	Male track sprinters: CR=9; PL=9	↑ sprint and jump
Romer, 2001	CR: 0.075 g/kg, 4 x/d for 5d	Male squash players	↑ sprint
Haff, 2000	CR: 0.3 g/kg BW for 6wk CR=15; PL=21	Male and female track-and-field athletes:	↑ vertical jump

Key: ↑ indicates increase; **CR=**creatine group; **PL=**placebo group.

Table 5: Studies Investigating the Effect of Creatine Supplementation on Power Cycling

Study	Dosage	Subjects	Effect
Ziegenfuss, 2002	CR: 0.35 g/kg FFM for 3d	Male and female college athletes: CR=10; PL=10	↑ total work and peak power
Green, 2001	CR: 5g, 4 x/d for 6d	Physically active men: CR=9; PL=10	↑ peak power and ↓ in % decline for endurance
Wiroth, 2001	CR: 5g, 3 x/d for 5d	Sedentary elderly men: CR=7; PL=7 Trained elderly cyclists: CR=7; PL=7 Young sedentary men: CR=7; PL=7	↑ maximal power for CR sedentary groups only
Rockwell, 2001	CR: 20 g/d for 4d during energy restriction	Active training young men: CR=8; PL=8	Nonsignificant ↑ for higher total sprint work
Volek, 2001	CR: 0.3 g/kg for 7d	Young men: CR=10; PL=10	Significantly better peak power and repeated sprint performances
Deutekom, 2000	CR: 5g, 4 x/d for 6d	Well trained rowers: CR=11; PL=12	↔ between groups, peak power, time to peak power and work

Key: ↓ indicates decrease; ↑ indicates increase; ↔ indicates no difference; **CR=**creatine group; **PL=**placebo group.

Study	Dosage	Subjects	Effect
Vogel, 2000	CR: 5g, 4 x/d for 5d	Active young men: CR=7; PL=9	↔ supramaximal cycle performance (hypohydration)
Jones, 2002	CR: 20 g/d for 5d	Young men and women	↔ between groups
Syrotuik, 2001	CR: 0.3 g/kg/kg/d for 5d Maint.: 0.03 g/kg/d for 5wk	Male and female rowers: CR=11; PL=12; resistance training	↔ repeated interval times
Rico-Sanz, 2000	CR: 20 g/d for 5d	Highly trained cyclists: CR=7; PL=7	Significant improvements for CR

Key: ↓ indicates decrease; ↑ indicates increase; ↔ indicates no difference; **CR=**creatine group; **PL=**placebo group.

Table 6: Studies Investigating the Effect of Creatine Supplementation on Intermittent Endurance Cycling/Running

Study	Dosage	Subjects	Effect
Yquel, 2002	CR: 20 g/d for 6d	Young men	Significant ↑ total power output
Cottrell, 2002	CR: 0.3 g/kg/d for 7d	Highly trained male cyclists: CR=15; PL=15	Significant ↑ for power outputs when rest intervals ≤ 3 min
Preen, 2002	CR: 2 x 15g, 1h apart	Eight active young men	↔ between groups for cycling
Finn, 2001	CR: 20 g/d for 20d	Active triathletes: CR=8; PL=8	↔ between groups for cycling
Edwards, 2000	CR: 20 g/d for 6d	Moderately active men: CR=11; PL=10	↔ treadmill running

Key: ↑ indicates increase; ↔ indicates no difference; **CR=**creatine group; **PL=**placebo group.

Table 7: Studies Investigating Influence of Creatine on Hydration Status and Exercise Heat Tolerance

Study	Dosage	Subjects	Body Temp. Difference	Difference in Hydration Variables
Wright, 2007	CR: 20 g/d for 6d; PL: 20 g/d maltodextrin	Physically active, heat-acclimatized men n=10	↔ in Tre	↑ BM w CR ↔ sweat loss
Easton, 2007	Two 7d, 2 x daily regimens: CR: 10 g; PL: 85 g glucose	Endurance-trained men CR=12; PL=12	↓ Tre Post exercise v. pre-exercise w/CR	CR: ↑ BM, TBW, ICW, ECW, ↔ in sweat rates
Branch, 2007	CR: 20 g/d for 5d; PL: 20 g/d dextrose	Competitive male cyclists and triathletes (n=7)	Tympanic temp not a valid measure for exercisers	↔ in pre-exercise BM or post-exercise % dehydration
Watson, 2006	CR: 21.6 g mono, 7d PL: 21.6 g, 7d	Non--heat-acclimated, active males (n=12)	↔ in Tre	CR: ↑ BM days 1-7 PL: ↑ plasma volume
Weiss, 2006	CR: 25 g/d for 5d PL: isocaloric capsules	Aerobically trained males CR=12; PL=12	↔ in TGI	CR: ↑ TBW, ICW, ECW; ↔ in sweat losses

Study	Dosage	Subjects	Body Temp. Difference	Difference in Hydration Variables
Kilduff, 2004	CR: 20 g/d for 7d; PL: 160 g/d glucose for 7d	Endurance-trained, non--heat-acclimated males CR=11; PL=10	Tre lower at 35 min, 40 min, and exhaustion post-supp v. pre-supp	CR: ↑ BM, TBW, ICW; ↓ sweat rate post-supp
Powers, 2003	CR: 25 g/d for 7d; then 5 g/d for 21d PL: sucrose	Resistance-trained males and females CR=16; PL=16	No thermoregulatory measures reported	CR: greater urinary CR; ↑ BM pre-supp to post-supp
Kern, 2001	CR: 21 g/d for 5d, then 10 g/d for 23d; PL: Phosphagen HP matrix minus creatine	Healthy, college-aged moderately to highly active males CR=10; PL=10	CR: Tre 0.37°C lower than pre-supp CR: Tre 0.20°C lower than PL	CR: ↑ BM, TBW
Volek, 2001	CR: 0.3 g/kg for 7d PL: powdered cellulose	Healthy men CR=10; PL=10	↔ in Tre (0.75 kg),	CR: ↑ BM TBW pre-supp to post-supp, serum creatine after 1 wk

Key: **BM**=body mass; **ECW**=extracellular water; **ICW**=intracellular water; **TBW**=total body water**; TGI**=gastrointestinal temperature; **Tre**=rectal temperature; ↓ indicates decrease; ↑ indicates increase; ↔ indicates no difference; **CR=**creatine group; **PL=**placebo group.

Table 8: Studies Investigating Influence of Creatine on Lean Mass Gain and Strength Gain

Study	Subjects	Lean Mass Gain	Strength Gain
Arciero, 2001	20 males: CR=10; PL=10	0.23%/wk	0.56%/wk
Bemben, 2001	17 males: CR=9; PL=8	0.50%/wk	0.27%/wk
Jowko, 2001	21 males: CR=11; PL=10	0.16%/wk	0.45%/wk
Brenner, 2000	16 females: CR=7; PL=9	0.11%/wk	0.25%/wk

Key: **CR=**creatine group; **PL=**placebo group.

Table 9: Treatment Subjects Demographics

Study	Males	Females	Both
Isotonic Force Study	105	30	34
Isokinetic Force Study	72	0	31
Isometric Force Study	61	0	0
Jumping and Sprinting Study	30	12	36
Power Cycling Study	99	0	94
Intermittent Endurance Cycling/Running Study	61	0	16
Hydration Status/Heat Tolerance Study	153	0	33

CHAPTER 4

DISCUSSION

These findings illustrate clearly the problems discussed in this document concerning ethical issues in the area of nutritional supplementation. Why take the risk when so little gain is promised? The research reviewed for this project reinforced the notion that most athletes today are looking for that competitive edge. Many have turned to creatine for that competitive edge. Rawson and Clarkson (2000) noted that m"…most studies that examined the effects of creatine supplementation on repeated bouts of intense exercise have shown an ergogenic effect, and only a few have not" (p.7). Creatine does seem to produce a noticeable increase in body mass. However, this is most likely a result of water retention. Although creatine produced the greatest ergogenic aid of the four nutritional supplements studied, it produced such a small benefit for the risk taken.

The wrong message is being sent to our young athletes, one implying that supplements are the foundation of enhanced athletic performance rather than proper diet, training, and good old fashioned practice in one's particular sport. Furthermore, just because a product claims to be "natural" does not necessarily mean that it is safe. Supplement manufacturers are often guilty of presenting misleading information to consumers of nutritional supplements, a practice known in the consumer health field as "quackery". Because of the fact that nutritional supplements are not regulated by the FDA, there is a very real scenario facing young athletes today, and that is "buyer beware". Simply stated, there is not enough scientific evidence supporting the safety of

performance-enhancing nutritional supplements to support their use by athletes. Francaux and Poortmans (2006) take this position:

> We advise that creatine supplementation not be used by athletes with preexisting renal disease or those with a potential risk for renal dysfunction. Medical advice should be sought if there are any doubts on the suitability of creatine supplementation for individual athletes. Great care should also be taken as far as the purity of commercially available exogenous creatine supplements is concerned (p. 320).

Because supplements are not strictly regulated by the Food and Drug Administration, there is an ongoing concern that consumers heed the admonition, "buyer beware". The major health risk is arguably associated with the purity of commercially available creatine.

There is an increasing number of high school and college athletes that are willing to jeopardize their future health, and or shorten their life, for the moment of glory that nutritional supplement involvement may provide. The reliance on nutritional supplements among young athletes is a clear indictment for increased involvement of teachers, coaches, administrators, and physicians. Our young people need educated, unbiased information concerning their future health and how that future health hinges on choices they make today. The need is greater today than ever before for qualified, informed, honest leaders in the lives of our youth to direct them in the way they should go. It is time someone gets brutally honest with our athletes rather than fill their minds with false information about supplement use to advance their own cause!

Because of the fact that we live in a big-money, winning-is-everything society, our young people are receiving a tremendously mixed message from their adult leaders (professional athletes, parents, coaches, friends) concerning the use of nutritional supplements. One side of the issue says that the field of competition is almighty, therefore justifying the means to accomplish the end. The other side of the issue tells them that their future health is paramount. This presents our young athletes with a very disheartening dilemma: When one athlete makes a decision to jeopardize his or her future health, are the others expected to follow suit and try to keep pace, jeopardizing their own futures, or are they to compete naturally, trusting that the best athlete will win? Sounds like a simple choice to those of us who have already passed that stage of life, but in the world of a young athlete, this is a very difficult decision to make!

When asked the question, "Do nutritional supplements enhance athletic performance?" in an American College of Sports Medicine publication, Smith (2003) answered,

> "There is no substitute for good nutrition. Nutritional supplements are a multi-billion dollar industry. Parents, coaches, and athletes need to understand that there is little to no scientific evidence to support most, if not all, of the performance enhancement claims made by supplements. If they have any positive performance benefit, the effect is likely to be minimal and highly variable. As seen with recent ephedrine tragedies, supplements may also cause harm. Hard work, athletic skill, good coaching, and proper nutrition are the keys to enhancing athletic performance. It doesn't come from a jar, can, or plastic container. (p. 2, 4)

The good news is that athletes seem to be getting the message that nutritional supplements are much safer than many other ergogenic aids available to athletes today. Regardless of who wins the game, or who wins the championship, children need to be encouraged to keep their future in mind. They also need to hear continually from leaders that "the ultimate best supplement" to enhance athletic performance is simply good food and hard, proper training!"

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