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Creatine Use Among Young Athletes

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ABSTRACT. *Objective.* Creatine is a nutritional supplement that is purported to be a safe ergogenic aid in adults. Although as many as 28% of collegiate athletes admit taking creatine, there is little information about creatine use or potential health risk in children and adolescents. Although the use of creatine is not recommended in people less than 18 years of age, numerous anecdotal reports indicate widespread use in young athletes. The purpose of this study was to determine the frequency, risk factors, and demographics of creatine use among middle and high school student athletes.

Methods. Before their annual sports preparticipation physical examinations, middle and high school athletes aged 10 to 18 in Westchester County, a suburb north of New York City, were surveyed in a confidential manner. Information was collected regarding school grade, gender, specific sport participation, and creatine use.

Results. Overall, 62 of 1103 participants (5.6%) admitted taking creatine. Creatine use was reported in every grade, from 6 to 12. Forty-four percent of grade 12 athletes surveyed reported using creatine. Creatine use was significantly more common ($P < .001$) among boys (53/604, 8.8%) than girls (9/492, 1.8%). Although creatine was taken by participants in every sport, use was significantly more common among football players, wrestlers, hockey players, gymnasts, and lacrosse players ($P < .001$ for all). The most common reasons cited for taking creatine were enhanced performance (74.2% of users) and improved appearance (61.3%), and the most common reason cited for not taking creatine was safety (45.7% of nonusers).

Conclusions. Despite current recommendations against use in adolescents less than 18 years old, creatine is being used by middle and high school athletes at all grade levels. The prevalence in grades 11 and 12 approaches levels reported among collegiate athletes. Until the safety of creatine can be established in adolescents, the use of this product should be discouraged. *Pediatrics* 2001;108:421–425; *creatine, nutritional supplements, ergogenic aids, adolescent sports medicine, preparticipation examination.*

ABBREVIATIONS. FDA, US Food and Drug Administration; ATP, adenosine triphosphate; ADP, adenosine diphosphate.

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Creatine is a nutritional supplement that falls under the broad category of products known as ergogenic aids, substances designed to chemically improve athletic performance. Certain ergogenic aids, such as anabolic steroids, growth hormone, and erythropoietin, are banned by major sports organizations including the International Olympic Committee, the National Athletic Association, and the United States Olympic Committee.¹ These prohibited substances have been shown to offer an unfair advantage to competitors and to predispose athletes to life-threatening health risks such as increased cancer risk and stroke.^{2–4}

Nutritional supplements, largely made up of naturally occurring compounds, are marketed as safe and legal performance-enhancing alternatives to banned agents. The Proxmire Amendment of 1993 limited the jurisdiction of the Federal Food and Drug Administration (FDA) over nutritional supplements, greatly reducing federal control over the content or use of these products.⁵ Because nutritional supplements are not subject to FDA testing, the safety profiles of these products often are unknown. Recently, ephedryl alkaloid (Ma Juang), a popular nutritional supplement, was implicated as the cause of death or permanent disability in 23 previously healthy athletes over a 2-year period.⁶

Creatine is the most popular nutritional supplement, with yearly sales over \$400 million.⁷ 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.⁸ Creatine is readily available for purchase, both in health food stores and over the Internet.

Creatine is formed by combining the amino acids glycine, arginine, and methionine and is produced in physiologic amounts by the liver, kidneys, and pancreas.⁹ In addition to natural synthesis, creatine is also found in protein-rich sources such as meat and fish. The total daily requirement of creatine is 2 g/d, approximately half of which comes from in vivo production and the other half from dietary sources.¹⁰

The role of creatine during exercise lies in the following reaction:



Acting as a substrate for hydrogen ions, creatine facilitates the production of adenosine triphosphate (ATP) from adenosine diphosphate (ADP), thus increasing the amount of free energy available for muscle contraction.¹¹ Several studies have documented

that creatine supplementation improves baseline strength in adults.^{11,12} No studies have shown the effectiveness of creatine supplementation in people less than 18 years old.

There are no data documenting the safety of creatine in children or adolescents.¹³ Because creatine has not been studied thoroughly, both the short-term and long-term effects of routine use, especially in adolescents, are of great concern. There are currently 2 documented cases of adult-onset renal failure with creatine use reported in the medical literature.^{14,15}

METHODS

Sports preparticipation physical examinations were performed at 5 schools in the spring of 1999. These schools represented a sample of middle school and high school students in Westchester County, a suburb of New York City. Study participants included all 6th- to 12th-grade students who were considering participation in any school-sponsored sport during the coming academic year (1999–2000). These sports included football, lacrosse, hockey, wrestling, hockey, gymnastics, swimming, cheerleading, skiing, tennis, baseball, soccer, field hockey, and track teams and athletes involved in weight training.

Personnel who were not involved directly in the sports evaluations administered a confidential questionnaire (“Appendix”) to all students before their preparticipation examination. Information was collected on school grade, sex, and sports in which the student planned to compete. Athletes were asked whether they had thought about using creatine, knew someone using it, or had tried creatine themselves. They were also asked about factors influencing their decisions whether to use creatine.

χ^2 analysis, with Yates correction when indicated, was used to compare creatine users and nonusers. This information was cross-referenced with variables including sport, age, sex, knowledge about creatine, and reasons why each student chose to use or not use creatine. In addition, each school was separately analyzed to detect individual rates of creatine use, both overall and by sex and grade, and then compared with the other schools in the study. The questionnaire form is listed in appendix 1.

RESULTS

Sixty-two of 1103 participants (5.6%) admitted taking creatine. The prevalence of creatine use varied greatly among the schools, from 1.9% in school A to 9.3% in school C. Of the 5 schools sampled, creatine use was most prevalent in the private high school (Table 1). Boys were significantly ($P < .001$) more likely to take creatine (53/604, 8.8%) than girls (9/492, 1.8%). As shown in Table 2, the prevalence of creatine use was similar in 6th through 10th grades but increased significantly in 11th and 12th grades ($P < .001$). The creatine use rate in the 12th grade student athlete population was 44%.

Participants in every sport tried creatine. As summarized in Table 3, use was significantly more common among strength-dependent athletes such as

TABLE 2. Creatine Use by Grade

Grade	Number of Participants	Users	% Use
6	69	2	2.9
7	240	5	2.1
8	195	9	4.6
9	233	7	3.0
10	173	8	4.6
11	158	19	12.0
12	27	12	44.4
11 and 12	185	31	16.8

TABLE 3. Creatine Use by Sport of Participation

Sport	Number of Users/Total Number of Participants (%)
Gymnastics	4/11 (36.4)
Hockey	8/40 (20.0)
Wrestling	8/56 (14.3)
Football	24/179 (13.4)
Lacrosse	18/143 (12.6)
Cheerleading	3/40 (7.5)
Swimming	4/61 (6.6)
Skiing	3/52 (5.8)
Tennis	4/91 (4.4)
Baseball	7/162 (4.3)
Soccer	10/256 (3.9)
Field hockey	2/117 (1.7)
Track	4/280 (1.4)
Weight training	51/527 (9.7)

football players, wrestlers, hockey players, and lacrosse players ($P < .001$ for all). However, creatine use was reported among athletes involved in every sport. Young athletes involved in weight training were statistically more likely to take creatine than those who did not lift weights ($P < .001$).

The most frequently reported expectations of creatine use were enhanced performance (74.2% of users), improved appearance (61.3%), improved endurance (45.2%), and improved speed (40.3%). The most common reasons cited for not taking creatine were safety concerns (45.7% of nonusers), ignorance about creatine (39.5%), lack of perceived benefit (19.7%), and expense (13.0%). In addition, 32.9% of the participants knew someone taking creatine, and 13.6% had thought about trying it.

DISCUSSION

This study confirms the disturbing trend of ergogenic aid use among middle school and high school student-athletes.¹⁶ Popular belief has been that athletes participating in sports emphasizing strength,

TABLE 1. Creatine Use by School and Sex

School	Type	Grade Level	Socioeconomic Status	Number of Creatine Users/Number of Subjects (%)	Number of Female Users/Number of Females (%)	Number of Male Users/Number of Males (%)
A	Public	Middle	M/U	5/260 (1.9)	2/101 (2.0)	3/159 (1.9)
B	Public	High	M/U	25/325 (7.7)	2/146 (1.4)	23/175 (13.1)
C	Private	High	M	10/108 (9.3)	2/56 (3.6)	8/52 (15.4)
D	Public	High	M	11/162 (6.8)	0/74 (0)	11/88 (12.5)
E	Public	Middle	M	11/248 (4.4)	3/115 (2.6)	8/130 (6.2)
Total				62/1103 (5.6)	9/492 (1.8)	53/604 (8.8)

M/U indicates middle and upper class; M, middle class.

such as football, wrestling, and weightlifting, predominantly used ergogenic aids. These results demonstrate that creatine is being taken not only by young athletes involved in strength sports but also by those in activities such as tennis, cheerleading, and field hockey. Young athletes participating in every sport studied reported taking creatine. Although girls were significantly less likely to use creatine than boys, there was a 1.8% prevalence among girls, including 5 middle school students.

The overall prevalence of athletes taking creatine was 5.6% (62/1103). User rates were similar in the 6th through 10th grades (ranging from 2.9% to 4.6%). In the 11th and 12th grades the user rate increased significantly, approaching reported levels among collegiate athletes.¹⁷ Because the physical examination sessions were intended for students planning to participate in sports during the following school year, fewer 12th graders were studied compared with other grades. However, the rate of creatine use among them was exceptionally high (12 of 27, 44.4%).

There were no statistically significant differences in creatine use among the 3 different high school socioeconomic populations (public middle class, public middle and upper class, private). Comparing all 5 schools, however, the user rate was the highest in the private high school, 9.3% of all student athletes. The issue of correlation between socioeconomic class and creatine use deserves additional study among a wider cross-section of students to assess whether use is related to family income. In addition, it is possible that in other regions of the country, young athletes are taking creatine at rates that are different from those found in suburban New York. This issue also warrants additional investigation.

There are a number of possible explanations for creatine use in young athletes. First, creatine and other nutritional supplements are touted as safe and natural methods of improving sports performance. They are widely marketed through television, radio, and print media and are readily available for purchase over the Internet. Young athletes may be especially vulnerable to these aggressive marketing initiatives. Second, the trickle-down phenomenon is important to consider. Initially, high-level Olympic and professional athletes began using ergogenic aids, followed by collegiate athletes. More recently, ergogenic aid use has been reported among high school and middle school athletes.¹⁸ Teenage users may be taking ergogenic aids to imitate famous athletes. Finally, young athletes are under increased pressure from parents, coaches, and peers to succeed in athletics, and the win-at-all-costs mentality has emerged in youth sports. In our study, most athletes reported taking creatine to improve sports performance. Based on the growing numbers of young athletes participating in organized sports,¹⁹ the use of this product probably will increase in the future.

The widespread use of creatine in young athletes is troubling for 2 main reasons. First, the safety of creatine in people less than 18 years old is not known, and use is not advised in this age group. The short-term and particularly the long-term health risks in adolescents and preadolescents are un-

known. Second, we believe that young athletes taking performance-enhancing nutritional supplements and young athletes taking banned substances such as anabolic steroids represent 2 points on a continuum. Adopting a permissive attitude toward nutritional supplement use in young athletes might encourage a more lenient attitude toward the use of more dangerous performance-enhancing products. This point is especially important in light of the recent Sydney Olympics, where performance-enhancing drug use was highlighted in the international media. A consistent message of disapproval toward all performance-enhancing substances should come from the medical community to help the athletic community deal with the issue of performance-enhancing drug use.

However, young athletes and their parents often are receptive to information about optimum nutrition and training. Educational opportunities include annual physical examinations, sports preparticipation examinations, and other episodic visits to health care providers. Because the preparticipation examination is the most frequent interaction between medical system and the otherwise healthy adolescent,²⁰ it is an especially important time to address the issue of ergogenic aid use. Health professionals must take advantage of these opportunities to discuss the importance of healthy behaviors with their patients, including the potential hazards of ergogenic aids such as creatine. The 13.6% of nonusers who reported considering creatine use may be a specific subgroup that would benefit from an educational program on the potential side effects of ergogenic aids.

Open communication is needed among a team of physicians, nurses, coaches, and athletic trainers, all of whom are responsible for the health and safety of young athletes. Until more information is available about safety in children and adolescents, health care providers should actively discourage use of creatine in their young patients.

REFERENCES

1. Stricker PR. Other anabolic agents. *Clin Sports Med.* 1998;17:283-297
2. Ekblom B. Blood doping and erythropoietin. *Am J Sports Med.* 1996;24:S40-S42
3. Elashoff JD, Jacknow AD, Shain SG, et al. Effects of anabolic steroids on muscular strength. *Ann Intern Med.* 1991;115:387-393
4. Deyssig R, Frisch H, Blum WF, et al. Effect of growth hormone treatment on hormonal parameters, body composition, and strength in athletes. *Acta Endocrinol.* 1993;128:313-318
5. Short SH, Marquart LF. Sports nutrition and fraud. *N Y State J Med.* 1993;93:112-116
6. Haller, CA, Benowitz NL. Adverse cardiovascular and central nervous system events associated with dietary supplements containing ephedra alkaloids. *N Engl J Med.* 2000;343:1886-1887
7. Kramer W. Proceedings of the American College of Sports Medicine Advanced Team Physician Course. Orlando, FL: American College of Sports Medicine; 1999
8. Tjerung RL, Clarkson P, Eichner ER, et al. The physiological and health effects of oral creatine supplementation. *Med Sci Sports Exerc.* 2000;32:706-717
9. Balsom PD, Soderlund K, Ekblom B. Creatine in humans with special reference to creatine supplementation. *Sports Med.* 1994;18:268-280
10. Kambler M, Koster M, Kreis R, et al. Creatine supplementation—Part I: performance, clinical chemistry, and muscle volume. *Med Sci Sports Exerc.* 1999;31:1763-1769

11. Kreider RB, Ferreira M, Wilson M, et al. Effects of creatine supplementation on body composition, strength, and sprint performance. *Med Sci Sport Exerc.* 1998;30:73–82
12. Birch R, Noble D, Greenhaff PL. The influence of dietary creatine supplementation on performance during repeated bouts of submaximal exercise. *Eur J Appl Physiol.* 1996;69:268–270
13. Metz J. Strength training and nutritional supplement use in adolescents. *Curr Opin Pediatr.* 1999;11:292–296
14. Prichard NR, Kalra PA. Renal dysfunction accompanying oral creatine supplements. *Lancet.* 1998;351:1252–1253
15. Koshy KM, Griswold E, Scheenberger EE. Interstitial nephritis in a patient taking creatine [letter]. *N Engl J Med.* 1999;340:814–815
16. Buckley W, Yesalis C, Freidl K, et al. Estimated prevalence of anabolic steroid use among high school seniors. *JAMA.* 1988;260:3441–3445
17. LaBotz M, Smith BW. Creatine supplement use in an NCAA Division I athletic program. *Clin J Sports Med.* 1999;9:167–169
18. Faigenbaum AD, Zaichowsky D, Gardner DE, Micheli LJ. Anabolic steroid use by male and female middle school students. *Pediatrics.* 1998;101(5). URL: <http://www.pediatrics.org/cgi/content/full/101/5/e6>
19. National Federation of Youth Sports. *Participation Survey: 1998–1999.* Kansas City, MO: National Federation of State High Schools; 1999
20. Hergenroder AC. The preparticipation sports examination. *Pediatr Clin North Am.* 1997;44:1525–1541

BOO YOURSELF OFF THE STAGE

Charles Lamb attended the opening of one of his plays and, having seen that the thing was very bad, stood up and started to boo—beating the rest of the audience by seconds. Unlikely as it sounds, there may be one or two occasions in your life when you do something not up to your usual high standard. When that occurs, lead the booing yourself. It is good for one’s health, and it will deprive others of the satisfaction of your embarrassment.

Rosenblatt R. *Rules for Aging: Resist Normal Impulses, Live Longer, Attain Perfection.* New York, NY: Harcourt, Inc; 2000

Noted by JFL, MD

Appendix

QUESTIONNAIRE: CREATINE USE IN ATHLETES

PLEASE CHECK THE BEST ANSWER FOR EACH QUESTION

1) Current Grade: 6th 7th 8th 9th 10th 11th 12th

2) Sex: Female Male

3) Which sports do you play for the school (you can choose more than one)?

Baseball Basketball Cheerleading
 Field Hockey Football Gymnastics Hockey
 Lacrosse Skiing Soccer
 Swimming Tennis
 Track/Field Wrestling

4) Do you know anyone who has taken creatine? Yes No

5) Have you thought about taking creatine? Yes No

6) Have you taken creatine? Yes (*go to question 7*) No (*go to question 8*)

7) If you *have taken* creatine, check the reason(s) why:

improve sports performance
 increase speed
 improve endurance
 improve physical appearance
 other (specify): _____

8) If you *have not* taken creatine, check the reason(s) why:

unsafe
 using creatine is "unfair"
 no real benefit
 too expensive
 do not know what creatine is
 other (specify): _____

9) Do you lift weights? Yes No

10) If you could take a substance that would make you a better athlete, but might be dangerous, would you take it? Yes No

11) Would you be interested in an educational program to learn more about creatine? Yes No

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