JEPonline
Journal of Exercise Physiology**online**

Official Journal of The American Society of Exercise Physiologists (ASEP)

ISSN 1097-9751

An International Electronic Journal
Volume 6 Number 4 November 2003

Sports Nutrition

THE EFFECTS OF CREATINE SUPPLEMENTATION ON CRAMPING AND INJURY OCCURRENCE DURING COLLEGE BASEBALL TRAINING AND COMPETITION

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ABSTRACT

THE EFFECTS OF CREATINE SUPPLEMENTATION ON CRAMPING AND INJURY OCCURRENCE DURING COLLEGE BASEBALL TRAINING AND COMPETITION. **Michael Greenwood, Richard B. Kreider, Lori Greenwood, Darryn Willoughby, Allyn Byars**. **JEP**online. 2003;6(4):16-23. Anecdotal reports suggest that creatine supplementation during intense training and competition may increase the incidence of muscle cramping and injury. This study examined the effects of creatine supplementation on cramping and injury during collegiate baseball training and competition. Thirty-nine Division I baseball players participated in this study. Twenty-one (54.0%) of the thirty-nine athletes ingested 15 to 25g/d of creatine for 5 days followed by 5 g/day of creatine that was mixed with sports drinks or water. Athletes who were non-creatine users had access to a carbohydrate drink that contained no creatine (placebo) during the training/competition period. Injuries treated by the athletic training staff were recorded and categorized as cramping, heat/dehydration, muscle tightness, muscle strains, non-contact injuries joint injuries, contact injuries, and illness. The number of practices missed due to injury and illness were also recorded. While no heat/dehydration events were reported by either group, results revealed that creatine-users had significantly fewer total injuries, $?^2$ (1)=4.69, p=0.03 than non-creatine users ($p<0.05$). However, there were no significant differences between groups regarding cramping, $?^2$ (1)=2.94, p=0.08, muscle tightness, $?^2$ (1)=3.01, p=0.08, muscle strains, $?^2$ (1)=2.92, p=0.08, non-contact joint injuries, $?^2$ (1)=1.04, p=0.31, contact injuries, $?^2$ (1)=0.009, p=.92, illness, $?^2$ (1)=0.02, p=0.95, missed practices due to injury, $?^2$ (1)=.103, p=0.74, and players lost for the season, $?^2$ (1)=2.45, p=0.11. Based on the findings in this investigation, creatine supplementation during collegiate baseball training and competition does not appear to increase the incidence of injury or cramping. Additional research is warranted to evaluate the effect of creatine supplementation on athletes training in hot/humid climates.

Key Words: Exercise, Nutrition, Ergogenic Aids, Safety, Sport Injuries.

INTRODUCTION

Creatine supplementation has been reported to increase strength, enhance work performed during repetitive sets of muscle contractions, improve repetitive sprint performance, and increase body mass/fat free mass (1-3). Consequently, creatine has become a very popular nutritional supplement among athletes. The only documented side effect of creatine supplementation reported in the scientific/medical literature has been weight gain (2-4). However, concerns have been raised over the medical safety of creatine supplementation among athletes even though extensive research has yielded no negative effects in the areas of endogenous creatine synthesis (5-7), renal function (8-15), muscle and liver enzyme efflux (10,13,16-18), blood volume and electrolyte status (19-23), blood pressure (24-25), or general markers of medical safety (13,14,18,25-36). Additionally, there have been only anecdotal reports that creatine supplementation during intense training in hot and or humid environments may predispose athletes to increased incidence of muscle cramping, dehydration, and/or musculoskeletal injuries such as muscle strains (37-39). Therefore, the purpose of this investigation was to examine the effects of creatine supplementation on the incidence of dehydration/cramping and various musculoskeletal injuries observed in NCAA Division I college baseball players during training and competition. It should be mentioned that the present study was only conducted through the course of one season due to the August 2000 NCAA restrictions regarding the provision of various nutritional supplements (i.e., creatine) to athletes.

METHODS

Subjects

Injury rates of 39 Division I National Collegiate Athletic Association (NCAA) college baseball players participating in the 2000 baseball season at a mid-southern state university were monitored during this study. Subjects who volunteered to participate in this present study chose whether they wanted to take creatine or non-creatine containing supplements (placebo) during training and competition. No subject reported taking additional ergogenic supplements other than protein-carbohydrate shakes and or bars. All subjects underwent pre-season medical examinations and were cleared to participate in baseball according to NCAA criteria. In addition, all athletes were provided medical supervision by the team athletic training staff and physicians throughout the course of this observation period. Subjects were informed as to the experimental procedures, which were established in accordance with the guidelines developed by the American College of Sports Medicine. Informed consent statements were also signed in adherence with the guidelines of the Internal Review Board for use of Human Subjects. Subjects were 20.3±1.0 yrs (range 19–25 yrs), 180.0±7.0 cm (range 163–190 cm) and 91.0±13.0 kg (range 75–103 kg) upon reporting to spring baseball practice prior to the 2000 competitive season.

Procedures

Injuries treated by the athletic training staff during the 2000 college baseball season were monitored during this study. This was accomplished by having research personal attend training sessions, practice sessions and games and by recording all injuries treated by the athletic training staff. The primary investigator confirmed the type, category and degree of injury to the athlete with the certified athletic trainer when the injury occurred to ensure that the injury was accurately recorded. Additionally, a tabulation of missed practices was recorded to monitor the length of time an athlete was unable to participate due to their specific injury and not illness. The athletes were asked daily if they perceived any side effects associated with the creatine supplementation and this information was than recorded by the certified athletic trainer assigned to baseball. Injuries were categorized as cramping, heat disorders (e.g., dehydration, heat syncope), muscle tightness, muscle strains, non-contact joint injuries (e.g., sprained ankles), contact injuries (e.g., injuries resulting from collisions), illness, and the number of missed practices due to injury. These injuries were considered significant injuries because they required medical attention and they involved some limitation from participation in training sessions, practices and or games. Minor injuries that did not limit the athletes' ability to participate in practices and/or games (e.g., bruises, general soreness) and or require significant medical treatment were not recorded.

Supplementation Protocols

Subjects who volunteered for the study chose whether they wanted to take creatine while remaining subjects had access to a non-creatine containing commercial sport drink which was designated the placebo. Creatine was added to sports drinks or water that the players ingested following training sessions, practices, and competition during the five-month period. Subjects turned in weekly logs to verify the subject's compliance to the prescribed creatine dosage protocol. The 21 subjects who chose to take creatine ingested, in an open label manner, 15.75 g/d of powdered creatine monohydrate for 5 days and an average of 5 g/day thereafter in 5 g doses based on a formula known to increase creatine concentrations in relation to the athletes body weight (1). Further, these specific creatine dosage protocols were selected based on previous research recommendations (1). If for some reason a subject fell behind in taking creatine, subjects (n=2 subjects on one occasion) ingested up to 10 g/day in order to adhere to the average dose of 5 g/day.

Training

Training consisted of resistance training and conditioning drills (1-2 h/day, 3 days/wk), preseason scrimmages (3-6 h/day, 2-3 days/wk), and practicing and competition during baseball season (2-5 h/day, 6 days/wk). Athletic coaches, certified athletic trainers, and research assistants supervised all training sessions. Training/game averaged 211±67 min per session with an average intensity of 3.0±1 on a 1 – 5 scale where 1 was equivalent to a stretching/warm-up and throwing/batting practice the day prior to competition and 5 was equivalent to game competition. Environmental conditions during training and competition ranged from 27 to 35 °C (mean 30.4±0.6 °C) and 59 to 91% relative humidity (77.1±2.53%).

Data Analysis

The incidence of reported first time injuries observed in creatine users and non-creatine users for each category were monitored and recorded during the study (Table 1). Injuries treated by the athletic training staff were documented and categorized as cramping, heat illness/dehydration, muscle tightness, muscle strains, non-contact joint injuries, contact injuries, and illness. The number of missed practices due to injury/illness was also recorded as well as total injuries. Data were analyzed using a 2 x 2 Chi-square statistic to examine the incidence of reported first time cramping and injury occurrences for creatine users and non-users ($p<0.05$).

Table 1. First Time Injuries of NCAA Division I Baseball Players During Training and Competition (Creatine Users & Non Creatine Users)

Treated Injury	*Creatine Users (n=21)*		*Non-Creatine Users (n=18)*	
	*Injuries	No Injuries	*Injuries	No Injuries
Cramping	4	17	8	10
Heat/dehydration	0	21	0	18
Muscle tightness	7	14	11	7
Muscle strains	6	15	10	8
Non-contact injuries	5	16	7	11
Contact injuries	9	12	8	10
Illness	8	13	7	11
Missed practices	6	15	6	12
Players lost season	0	21	2	16
Total injuries	45	123	59	96

*Number of first time injuries for creatine and non-creatine users.

RESULTS

Only first time injuries were included in the Chi-square procedure in order to adhere to the nonparametric statistical assumption of mutual exclusiveness even though select athletes were treated for different/multiple/reoccurring injuries throughout the course of the study. If an athlete aggravated a previous injury (i.e., sprained ankle) that occurred before the season it was not recorded for the purposes of this study and there were no multi-sport athletes in the study. Results of this study revealed that creatine-users had significantly fewer total injuries, $?^2$ (1)=4.69, p=0.03 than non-creatine users. However, there were no significant differences between groups regarding cramping, $?^2$ (1)=2.94, p=0.08, muscle tightness, $?^2$ (1)=3.01, p=0.08, muscle strains, $?^2$ (1)=2.92, p=0.08, non-contact joint injuries, $?^2$ (1)=1.04, p=0.31, contact injuries, $?^2$ (1)=0.009, p=0.92, illness, $?^2$ (1)=002, p=0.95, missed practices due to injury, $?^2$ (1)=0.103, p=0.74, and players lost for the season, $?^2$ (1)=2.45, p=0.11. Furthermore, no detrimental events caused by heat stress or dehydration were reported by either group.

DISCUSSION

Anecdotal reports have suggested that creatine supplementation may promote dehydration, cramping, and musculoskeletal injury (2,4,38,40). Since many of these reports have emanated from certified athletic trainers and coaches, they are commonly reported as side effects from creatine supplementation (2,4,40). As a result, some certified athletic trainers and coaches have restricted availability of creatine to their athletes (particularly during intense training periods performed in the heat) and some have warned against the use of creatine until more long-term data demonstrates its safety. In addition, some athletic organizations (e.g., NCAA) have banned teams from "providing" creatine to their athletes citing safety and fairness issues, although athletes are still allowed to take creatine. Results of the present study indicated that creatine use among Division I baseball players training and competing in very hot and humid environments does not appear to increase the incidence of dehydration, cramping, and/or muscle injury in comparison to athletes who do not take creatine. Moreover, that the athletes' did not report a consistent pattern of perceived negative side effects as a result of the creatine supplementation protocol. Within the scope of this study, these findings add to the growing body of evidence indicating that creatine supplementation apparently does not increase the incidence of anecdotally reported detrimental side effects and/or cause unknown health problems (10,13,14,18,33-35).

One of the most commonly reported anecdotal side effects associated with creatine supplementation has been that creatine may increase the incidence of dehydration, muscle cramping, and/or decrease heat tolerance. In this regard, some have suggested that since creatine supplementation may increase work capacity, athletes who take creatine during training in hot and humid environments may experience a greater rate of dehydration, muscle cramping, and/or heat illness (40). Another theory suggests that since creatine has been suggested to promote fluid retention, it may alter electrolyte status and thereby promote muscle cramping by interfering with the muscle's contraction/relaxation mechanisms (2,4,40). Over the last few years, a number of studies have examined the effects of creatine supplementation on hydration status, electrolyte levels, and dehydration during exercise performed in the heat (20-23,41-43). Results of these studies have indicated that creatine does not promote dehydration, alter electrolyte levels, or increase thermal stress. In addition, there has been no evidence that creatine supplementation promotes muscle cramping among athletes (21,23,37,44-50). In fact, recent studies have indicated that creatine supplementation may actually promote hydration (21,23,41), reduce thermal stress during exercise in the heat (23,42), and/or possible reduce the incidence of injury based on occurrence rates (11,17,31,33,37,44-47,49-52). The results of our study suggest that the incidence of cramping and dehydration observed among creatine users was lower or proportional to non-users.

Anecdotal reports have also suggested that creatine may promote a higher incidence of muscle injuries such as muscle strains and pulls (2,4,40). Proponents of this theory have postulated that since creatine supplementation may promote rapid increases in strength and body mass, the athlete may be more predisposed to additional stress placed on muscles, bones, joints, ligaments, and connective tissues. Results of our investigation indicate that the incidence of muscle tightness, muscle strains, non-contact injuries, and contact injuries among creatine users were similar or lower than the non-users. There was also no evidence of a greater proportion of individual injuries (e.g., hamstring pulls, groin strains, etc). Moreover, the incidence of missed practices, players lost with a season ending injury, and total injuries observed were similar or lower than non-users. If creatine supplementation increased the incidence of these problems, the incidence of injury in creatine users should have been markedly higher than the nonusers. Yet, the incidence of injury among athletes who took creatine during training was similar or lower than the athletes not taking creatine. It could be speculated that creatine supplementation may have allowed the athletes to tolerate training to a greater degree and thereby lessened the incidence of injury, or simply that creatine has no causal effect on the injuries documented in the present study. These findings are similar to recent reports that creatine supplementation during training may lessen injury rates among athletes (11,17,31,33,37,44-47,49-52) and/or hasten recovery following immobilization injury (32).

In summary, the results of this study indicate that college baseball players ingesting creatine during training and competition had fewer incidences of dehydration, cramping, and or injury than college baseball players not taking creatine. Although athletes who take creatine during intense training may experience some of these problems, it appears that the incidence of these problems is lower than athletes not taking creatine. Therefore, these findings may help to dispel anecdotal myths suggesting that creatine supplementation may increase the prevalence of dehydration, cramping and/or injury among athletes. Further, it is hoped that these findings may help professionals involved in the training and/or medical supervision of athletes (i.e., athletic coaches, certified athletic trainers, researchers, certified strength & conditioning coaches, nutritional consultants, administrators, athletic governing bodies) to better examine the methods employed to train and/or manage athletes (i.e., over-training in extreme climates, exhaustive conditioning drills, hydration practices, etc). In this regard, it appears that the type and conditions that athletes are asked to train and/or compete in may place them at a greater risk of dehydration, cramping and/or injury than anecdotally associating these problems with creatine supplementation.

ACKNOWLEDGMENTS

We would like to thank the athletes who participated in this study and the coaches who allowed us to conduct this investigation. A special thanks goes to the athletic training staff for their participation in this study. The investigators independently collected, analyzed and interpreted data from this study and have no commercial, proprietary, or financial interest in the outcome of results reported. Presentation of the results in this study does not constitute endorsement by authors or their institutions of the supplement investigated.

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REFERENCES

1. Williams MH, Kreider R, Branch JD. *Creatine: The Power Supplement*. Champaign, IL: Human Kinetics Publishers, 1999.
2. Kreider R. Creatine supplementation: analysis of ergogenic value, medical safety, and concerns. ***J Exerc Physiol Online*** 1998;1:7-18. Available at http://www.css.edu/users/tboone2/asep/jan3.htm. Accessed November 27, 2001.
3. Kraemer WJ, Volek JS. Creatine supplementation: its role in human performance. ***Clin Sports Med*** 1999;18:651-666, ix.
4. Terjung RL, Clarkson P, Eichner ER, Greenhaff PL, Hespel PJ, Israel RG, et al. American College of Sports Medicine roundtable. The physiological and health effects of oral creatine supplementation. ***Med Sci Sports Exerc*** 2000;32:706-717.
5. Vandenberghe K, Goris M, Van Hecke P, Van Leemputte M, Vangerven L, Hespel P. Long-term creatine intake is beneficial to muscle performance during resistance training. ***J Appl Physiol*** 1997;83:2055-2063.
6. Guerrero-Ontiveros ML, Wallimann T. Creatine supplementation in health and disease. Effects of chronic creatine ingestion in vivo: down-regulation of the expression of creatine transporter isoforms in skeletal muscle. ***Mol Cell Biochem*** 1998;84:427-437.
7. Tarnopolsky MA, Parise G, Fu MH, Brose A, Mahoney D, Wallimann T. Creatine monohydrate supplementation at the recommended dosage does not affect creatine transporter content during resistance exercise training in either the young or the elderly. Presented at the 6th Internationl Conference on Guanidino Compounds in Biology and Medicine; September 3, 2001; Cincinatti, OH.
8. Kuehl K, Soehler S, Kulacki K, Goldberg L, Elliot D, Bennett W, et al. Effects of oral creatine monohydrate supplementation on renal function in adults. ***Med Sci Sports Exerc*** 2000;32:S168.
9. Kreider R, Ransom J, Rasmussen C, Hunt J, Melton C, Stroud T, et al. Creatine supplementation during pre-season football training does not affect markers of renal function. ***FASEB J*** 1999;13:A543.
10. Kreider R, Melton C, Rasmussen C, Greenwood M, Lancaster S, Cantler E, et al. Effects of long-term creatine supplementation on renal function and muscle & liver enzyme efflux. ***Med Sci Sports Exerc*** 2001;33:S207.
11. Rasmussen C, Kreider R, Melton C, Ransom J, Stroud T, Cantler E, et al. Long-term creatine supplementation during football training does not affect markers of renal stress. ***J Strength Cond Res*** 1999;13:431.
12. Almada AL, Kreider R, Melton C, Rasmussen C, Lundberg J, Ransom J, et al. Long-term creatine supplementation does not affect markers of renal stress in athletes. ***J Strength Cond Res*** 2000;14:359.
13. Robinson TM, Sewell DA, Casey A, Steenge G, Greenhaff PL. Dietary creatine supplementation does not affect some haematological indices, or indices of muscle damage and hepatic and renal function. ***Br J Sports Med*** 2000;34:284-288.
14. Poortmans JR, Francaux M. Long-term oral creatine supplementation does not impair renal function in healthy athletes. ***Med Sci Sports Exerc*** 1999;31:1108-1110.
15. Poortmans JR, Auquier H, Renaut V, Durussel A, Saugy M, Brisson GR. Effect of short-term creatine supplementation on renal responses in men. ***Eur J Appl Physiol Occup Physiol*** 1997;76:566-567.
16. Ransom J, Kreider R, Hunt J, Melton C, Rasmussen C, Stroud T, et al. Effects of creatine supplementation during training on markers of catabolism and muscle & liver enzymes. ***Med Sci Sports Exerc*** 1999;31:S265.
17. Ransom J, Kreider R, Rasmussen C, Melton C, Stroud T, Cantler E, et al. Effects of long-term creatine supplementation during training on markers of catabolism and enzyme efflux. ***J Str Cond Res*** 1999;13:431.
18. Schilling BK, Stone MH, Utter A, Kearney JT, Johnson M, Coglianese R, et al. Creatine supplementation and health variables: a retrospective study. ***Med Sci Sports Exerc*** 2001;33:183-188.
19. Kreider RB, Ferreira M, Wilson M, Grindstaff P, Plisk S, Reinardy J, et al. Effects of creatine supplementation on body composition, strength, and sprint performance. ***Med Sci Sports Exerc*** 1998;30:73-82.

20. Rasmussen C, Kreider R, Ransom J, Hunt J, Melton C, Stroud T, et al. Creatine supplementation during pre-season football training does not affect fluid or electrolyte status. ***Med Sci Sports Exerc*** 1999;31:S299.
21. Hulver MW, Campbell A, Haff G, Schroeder C, Comeau M, Potteiger JA. The effects of creatine supplementation on total body fluids, performance, and muscle cramping during exercise. ***Med Sci Sports Exerc*** 2000;32:S133.
22. Oopik V, Paasuke M, Timpmann S, Medijainen L, Ereline J, Smirnova T. Effect of creatine supplementation during rapid body mass reduction on metabolism and isokinetic muscle performance capacity. ***Eur J Appl Physiol Occup Physiol*** 1998;78:83-92.
23. Volek JS, Mazzetti SA, Farquhar WB, Barnes BR, Gomez, Al, Kraemer WJ. Physiological responses to short-term exercise in the heat after creatine loading. ***Med Sci Sports Exerc*** 2001;33:1101-1108.
24. Mihic S, MacDonald JR, McKenzie S, Tarnopolsky MA. Acute creatine loading increases fat-free mass, but does not affect blood pressure, plasma creatinine, or CK activity in men and women. ***Med Sci Sports Exerc*** 2000;32:291-296.
25. Peeters BM, Lantz CD, Mayhew JL: Effect of oral creatine monohydrate and creatine phosphate supplementation on maximal strength indices, body composition, and blood pressure. ***J Strength Cond Res*** 1999;13:3-9.
26. Earnest CP, Snell P, Rodriguez R, Almada A, Mitchell TL. The effect of creatine monohyerate ingestion on anaerobic power indices, muscular strength and body composition. ***Acta Physiol Scand*** 1995;153:207-209.
27. Earnest CP, Almada A, Mitchell TL. High-performance capillary electrophoresis-pure creatine monohydrate reduced blood lipids in men and women. ***Clinical Science*** 1996;91:113-118.
28. Bemben MG, Bemben DA, Loftiss DD, Knehans AW. Creatine supplementation during resistance training in college football athletes. ***Med Sci Sports Exerc*** 2001;33:1667-1673.
29. Bermon S, Venembre P, Sachet C, Valour S, Dolisi C. Effects of creatine monohydrate ingestion in sedentary and weight- trained older adults. ***Acta Physiol Scand*** 1998;164:147-155.
30. Eijnde BO, Hespel P. Short-term creatine supplementation does not alter the hormonal response to resistance training. ***Med Sci Sports Exerc*** 2001;33:449-453.
31. Greenwood M, Kreider R, Melton C, Rasmussen C, Lundberg J, Stroud T, et al. Short- and long-term creatine supplementation does not affect hematological markers of health. ***J Strength Cond Res*** 2000;14:362-363.
32. Hespel P, Eijnde BO, Van Leemputte M, Urso B, Greenhaff PL, Labarque V, et al. Oral creatine supplementation facilitates the rehabilitation of disuse atrophy and alters the expression of muscle myogenic factors in humans. ***J Physiol*** 2001;536:625-633.
33. Kreider R, Rasmussen C, Melton C, Greenwood M, Stroud T, Ransom J, et al. Long-term creatine supplementation does not adversely affect clinical markers of health. ***Med Sci Sports Exerc*** 2000;32:S134.
34. Stone MH, Schilling BK, Fry AC, Johnson M, Keith RE, Kearney JT, et al. A retrospective study of long-term creatine supplementation on blood markers of health. ***J Strength Cond Res*** 1999;3:433
35. Sipila I, Rapola J, Simell O, Vannas A. Supplementary creatine as a treatment fo gyrate atrophy of the choroid and retina. ***New Engl J Med*** 1981;304:867-870.
36. Vannas-Sulonen K, Sipila I, Vannas A, Simell O, Rapola J. Gyrate atrophy of the choroid and retina. A five-year follow-up of creatine supplementation. ***Ophthalmology*** 1985;92:1719-1727.
37. Greenwood M, Farris J, Kreider R, Greenwood L, Byars A. Creatine supplementation patterns and perceived effects in select division I collegiate athletes. ***Clin J Sport Med*** 2000;10:191-194.
38. Juhn MS, O'Kane JW, Vinci DM. Oral creatine supplementation in male collegiate athletes: a survey of dosing habits and side effects. ***J Am Diet Assoc*** 1999;99:593-595.
39. LaBotz M, Smith BW. Creatine supplement use in an NCAA Division I athletic program. ***Clin J Sport Med*** 1999;9:167-169.

40. Juhn MS, Tarnopolsky M. Potential side effects of oral creatine supplementation: a critical review. ***Clin J Sport Med*** 1998;8:298-304.
41. Ziegenfuss TN, Lowery, LM, and Lemon, PWR. Acute fluid volume changes in men during three days of creatine supplementation. ***Journal of Exercise Physiology Online*** 1998;1:1-9. Available at http://www.css.edu/users/tboone2/asep/jan3.htm. Accessed November 27, 2001.
42. Kern M, Podewils LJ, Vukovich M, Buono MJ. Physiological response to exercise in the heat following creatine supplementation. ***Journal of Exercise Physiology Online*** 2001;4:18-27, 2001. Available at http://www.css.edu/users/tboone2/asep/Kern.pdf. Accessed November 27, 2001.
43. Papadopoulos C, Imamura R, Bandon LJ. The effect of creatine supplementation on repeated bouts of high-intensity exercise in the heat. ***Med Sci Sports Exerc*** 2001;33:S203.
44. Greenwood M, Kreider R, Rasmussen C, Ransom J, Melton C, Stroud T, et al. Creatine supplementation does not increase incidence of cramping or injury during college football training II. ***J Strength Cond Res*** 1999;13:425-426.
45. Greenwood M, Greenwood LD, Kreider R, Byars A. Effects of creatine supplementation on the incidence of cramping/injury during college football three a day training. ***Med Sci Sports Exerc*** 2000;32:S136.
46. Greenwood LD, Greenwood M, Kreider R, Byars A. Effects of creatine supplementation on the incidence of cramping/injury during collegiate fall baseball. ***Med Sci Sports Exerc*** 2000;32:S136.
47. Hunt J, Kreider R, Melton C, Ransom J, Rasmussen C, Stroud T, et al. Creatine does not increase incidence of cramping or injury during pre-season college football training II. ***Med Sci Sports Exerc*** 1999;31:S355.
48. Kreider R, Rasmussen C, Ransom J, Almada AL. Effects of creatine supplementation during training on the incidence of muscle cramping, injuries and GI distress. ***J Strength Cond Res*** 1998;12:275.
49. Kreider R, Melton C, Ransom J, Rasmussen C, Stroud T, Cantler E, et al. Creatine supplementation does not increase incidence of cramping or injury during college football training I. ***J Strength Cond Res*** 1999;13:428.
50. Kreider R, Melton C, Hunt J, Rasmussen C, Ransom J, Stroud T, et al. Creatine does not increase incidence of cramping or injury during pre-season college football training I. ***Med Sci Sports Exerc*** 1999;31:S355.
51. Ortega Gallo PA, Dimeo F, Batista J, Bazan F, Betchakian L, Garcia Cambon C, et al. Creatine supplementation in soccer players, effects in body composition and incidence of sport-related injuries. ***Med Sci Sports Exerc*** 2000;32:S134.
52. Greenwood M, Kreider R, Greenwood LD, Comeau M, Brown LE, Stahura K, et al. Perceived health status and side-effects associated with creatine supplementation during the collegiate baseball season. ***Med Sci Sports & Exerc*** 2001;33:S205.