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Effects of Creatine and HMß Supplementation on Anaerobic Power and Body Composition in Basketball Players

by

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The main objective of this research was the evaluation of anaerobic power indices after long term (30days) supplementation with Cr, HMB and a combination of Cr and HMB in basketball players. Fifty two well trained basketball players took part in the experiment, with two resigning do to injury. The players were randomly assigned to four groups. The control group included 13 basketball players which were given a placebo consisting of 750ml of CHO per day. The second group of 12 athletes received creatine monohydrate with CHO over the 30 day period. The third group was supplemented with HMB, while the fourth group was given both supplements simultaneously. The supplements were ingested with a CHO solution to increase creatine uptakeAll of the basketball players performed a triple Wingate test before and immediately after the 30 day supplementation and training protocol. At rest and during the 4th minute of recovery, blood samples were drawn from the fingertip, for the evaluation of lactate concentration and acid-base equilibrium. Additional blood samples were taken from the antecubital vein, at rest and 60 minutes after the cessation of exercise in order to evaluate CK and LDH activity. Long term supplementation with creatine monohydrate seems to have a buffering effect, since greater values of Pmax and Wt are not accompanied by significantly higher post exercise LA concentration or lower pH values. This suggests a decreased rate of glycolysis do to an increase in ATP resynthesis from PCr.

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Introduction

Creatine was discovered in 1832 by a French scientist, Michel Chevreul, who extracted it from meat. Because extraction of creatine from fresh meat was an expensive process, early research was limited, but even in the early 1900s, creatine supplementation was shown to increase muscle creatine content in animals. Phosphocreatine (PCr), the phosphorylated form of creatine, was discovered in 1927, while creatine kinase, the enzyme that catalyzes PCr, was discovered in 1934. A breakthrough in effects of creatine supplementation on exercise metabolism occurred in 1968 when the when the needle biopsy technique was discovered.

Creatine is a naturally occurring amino acid found in the body primarily in muscle tissue. The daily requirements of creatine are about 2 to 3g/day depending on body size and daily turnover rate. The normal creatine content in muscle is about 120-125 mmol/kg dm although dietary availability of creatine may result in lower or higher creatine stores. Creatine supplementation has been reported to increase creatine stores to as much as 160 mmol/kg dm. Most of the creatine in muscle is stored in the form of PCr. Metabolically; PCr serves as an important contributor to energy metabolism during high intensity exercise. Increasing the availability of PCr would theoretically enhance the ability to maintain power output during intense exercise as well as promote recovery between bouts of intense exercise. However, creatine also serves as a buffer of acidity, plays an important role in many creatine kinase reactions, is intimately involved in the creatine phosphate shuttle, and may help regulate oxidative metabolism (Williams *et al.* 1999). Finally creatine has been reported to stimulate protein synthesis. Therefore, increasing the availability of creatine and PCr may affect body mass and lean body mass what may be beneficial to many strength-speed sport disciplines (Kreider 2002).

ß-Hydroxy ß-methylbutyrate (HMB), a metabolite of the essential amino acid leucine is one of the most often used dietary supplements to promote muscle strength and lean body mass associated with resistance training (Slater and Jenkins 2000). Unlike anabolic hormones that induce muscle hypertrophy by increasing muscle protein synthesis, HMB is claimed to influence strength and lean body mass by acting as ananticatabolic agent minimizing protein breakdown and damage to cells that may occur with exercise. Research on HMB has recently tested this hypothesis, under the assumption that it may be the active compound associated with the anticatabolic effects of leucine and its metabolites. A mechanism by which this may occur is unknown, but research undertaken to date suggests there may be a reduction skeletal damage, although this has not been assessed directly. HMB supplementation protocols have also been used in studies evaluating fat metabolism. Several studies reported greater fat mass loss with HMB supplementation and significant changes in lean body mass (Cheng *et al.* 1997).

Creatine and HMB are among the most often used dietary supplements in competitive sports. Most studies with these supplements have been conducted on representatives of body building, power lifting and Olympic weightlifting. Research conducted on team sports is limited to American football and baseball, with few observations among soccer, handball and basketball players. This seems unjustified since basketball is a sport discipline in which a high level of anaerobic power is crucial for success.

Material and methods

The main objective of this research was the evaluation of anaerobic power indices after long term (30days) supplementation with Cr, HMB and a combination of Cr and HMB in basketball players. Fifty two well trained basketball players took part in the experiment, with two resigning do to injury. Their average age, body mass and body height equaled respectively: 25.6±5.64 years, 193.2±7.18 cm, and 92.7±8.69 kg. The players were randomly assigned to four groups. The control group included 13 basketball players which were given a placebo consisting of 750ml of CHO per day. The second group of 12 athletes received creatine monohydrate with CHO over the 30 day period. The third group was supplemented with HMB, while the fourth group was given both supplements simultaneously. The supplements were ingested with a CHO solution to increase creatine uptake. Group three consisted of 12 players with 13 subjects assigned to group four.

All of the basketball players performed a triple Wingate test before and immediately after the 30 day supplementation and training protocol. From the many variables registered during the Wingate tests, the following were used for further analysis: rPmax – relative maximal power, rWt – relative total external work. At rest and during the 4^{th} minute of recovery, blood samples were drawn from the fingertip, for the evaluation of lactate concentration and acid-base equilibrium. Additional blood samples were taken from the antecubital vein, at rest and 60 minutes after the cessation of exercise in order to evaluate CK and LDH activity. To determine the changes in body mass and body composition the electrical impedance method was used. The following variables were recorded: BM-body mass, FFM- fat free mass, FM-fat mass, TBW-total body water, BMI-body mass index, BMR-basic metabolic rate. The data was analyzed with basic descriptive statistical methods. To determine the differences in chosen variables between groups, the analysis of variance (ANOVA) with repeated measures was used. For follow up purposes the Spjotvoll – Stolinea tests were applied.

Considering the fact that strength training increases the ergogenic effects of Cr and HMB supplementation, a specific program of strength exercises was prepared and followed by all athletes taking part in the experiment. The program included complex exercises, performed with free weights (bench press, squat, clean and jerk) three times per week.

Results

Long term (30days) supplementation with creatine, as well as combined ingestion of Cr and HMB along with an intensive strength training program allow for significant increases in relative indices of anaerobic power and anaerobic endurance. The combined supplementation with Cr and HMB allows for greater increases of the above mentioned indices, yet these differences are statistically insignificant. The ingestion of HMB alone causes minor changes in anaerobic power and endurance, significantly smaller than those obtained after Cr or Cr and HMB supplementation (Fig. 1 and 2).

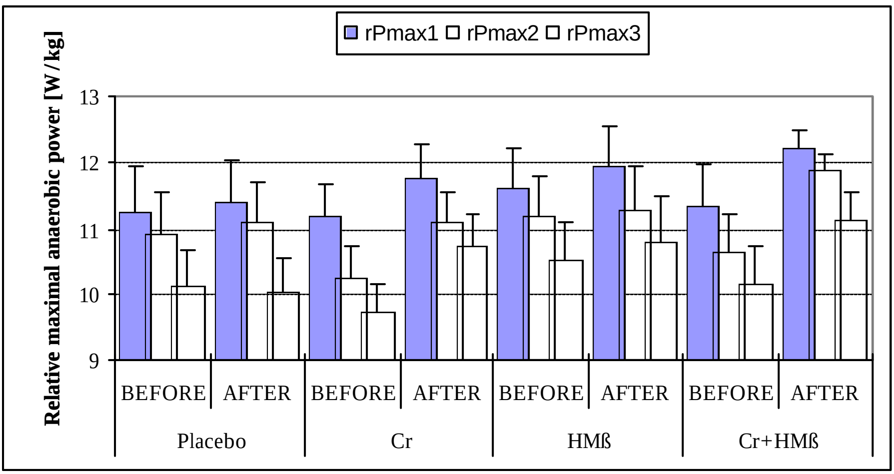


Fig. 1

Mean values of relative maximal anaerobic power of experimental and control groups

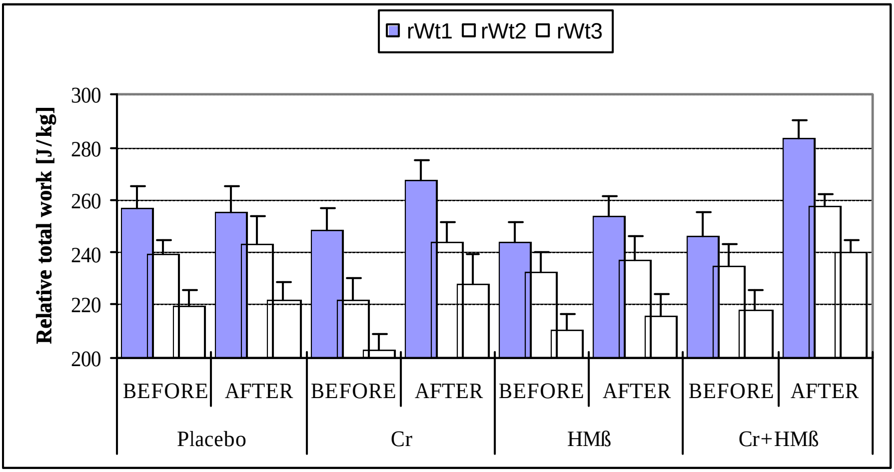


Fig. 2

Mean values of relative total work of experimental and control groups

Long term supplementation with creatine monohydrate seems to have a buffering effect, since greater values of Pmax and Wt are not accompanied by significantly lower pH values (Fig 3 and 4).

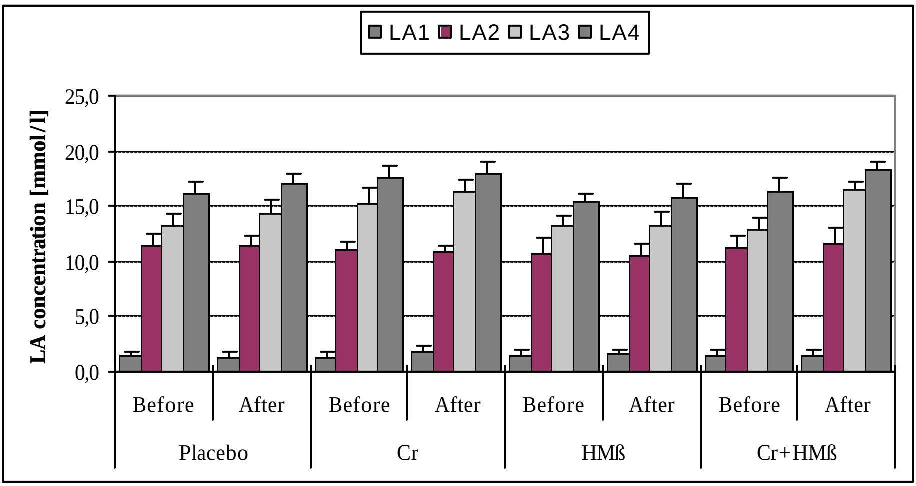


Fig. 3

Changes in LA concentration following 3 consecutive Wingate tests before and after supplementation

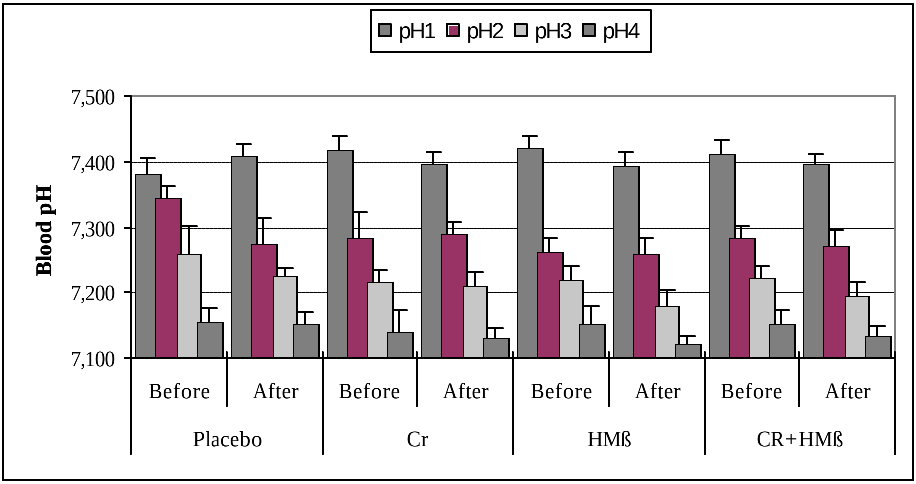
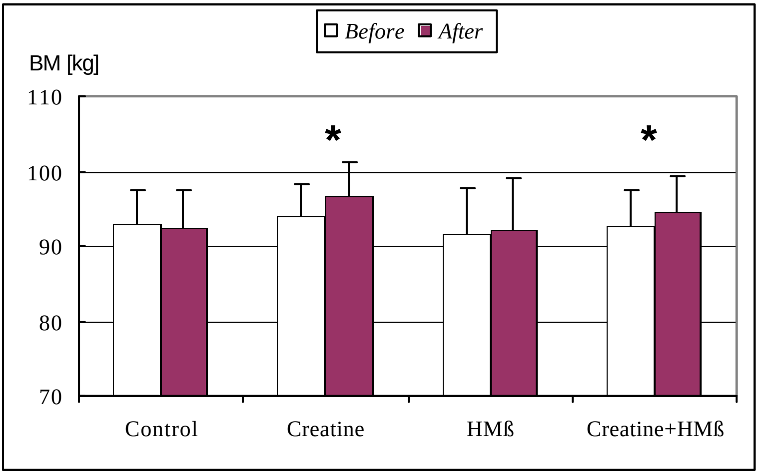


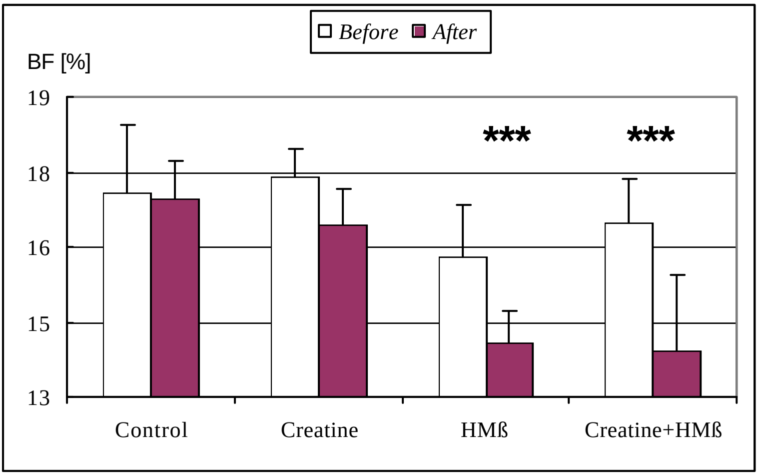
Fig. 4

Changes blood pH following 3 consecutive Wingate tests before and after supplementation

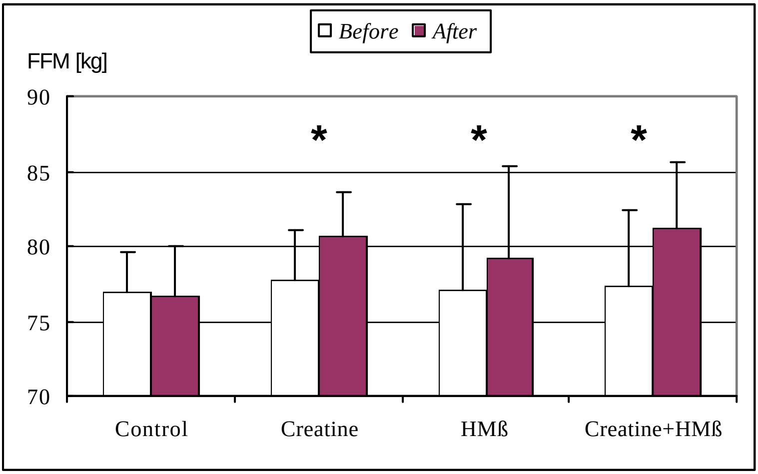
Long term supplementation with Cr and Cr with HMB, combined with a strength training program allows well trained basketball players for a significant increase in body mass and fat free mass. The ingestion of HMB causes a minor increase in body mass, y*et* allows for significant changes in body composition. HMB supplementation decreases body fat content and also allows for a significant increase in fat free mass. The combined supplementation of Cr and HMB has the greatest influence on changes in body mass and body composition (Fig. 5a-c).


Before
After
BM [kg]
110
100
90
80
70
*
*
Control
Creatine
HMß
Creatine+HMß

a)


Before
After
BF [%]
19
18
16
15
13
***
***
Control
Creatine
HMß
Creatine+HMß

b)

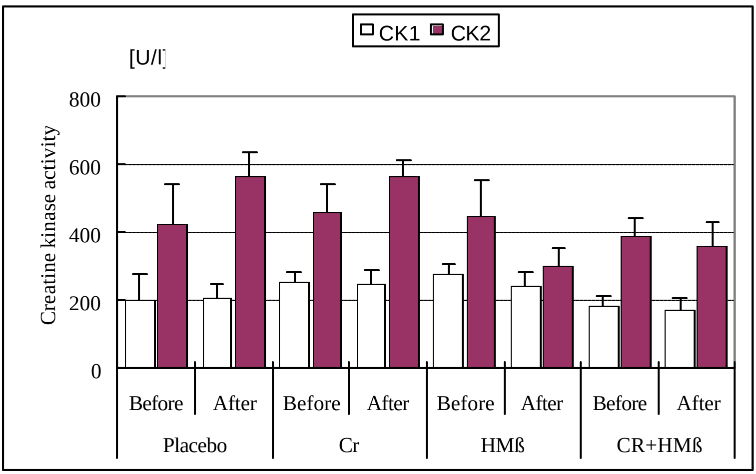


c)

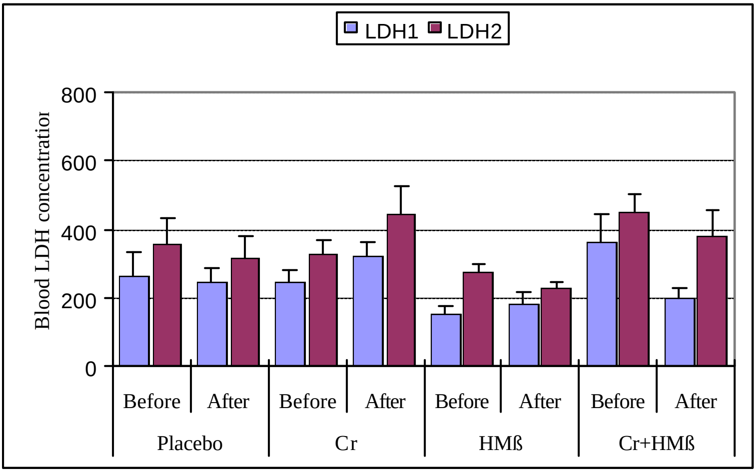
Fig. 5a-c

Changes in body mass, fat content and fat free mass after 30 days of strength training and supplementation with Cr, HMB and Cr-HMB combined (- p=0.05, ***- p=0.001)*

Long term ingestion of HMB decreases significantly post exercise CK and LDH activity. This ergogenic effect is limited when Cr is added to HMB Fig 6a-b).



a)



b)

Fig. 6a-b

Resting and post exercise plasma changes in CK and LDH activity related to the 30 day supplementation and exercise protocol.

Disscusion

Theoretically the phosphagen or ATP-PCr energy system is capable of providing ATP for only a few muscle contractions before being depleted. Since PCr is the substrate for this system, it is logical to hypothesize that creatine supplementation is a possible ergogenic strategy to rapidly replenish PCr and enhance performance in exercise tasks less than or equal to 30s in duration (Williams *et al*. 1999). Numerous studies have addressed the effects of creatine supplementation on performance of activities that rely primarily in the ATP-PCr energy system. Most of them reveal positive effects. Performance modes that appear to be more favorably affected include repetitive cycle ergometry, isokinetic torque production and isotonic force production (Kurosawa *et al*. 1997; Crowder *et al*. 1998; Kelly and Jenkins 1998; Kreider *et al*. 1998; Noonan *et al*. 1998; Stone *et al*. 1999; Volek 1996; Stout *et al*. 1999; Jones *et al*. 1998; Kirksey *et al*. 1997; Greenhaff *et al*. 1994). A much smaller number of beneficial effects of creatine supplementation are registered in field studies in which running or jumping tasks are used (Bosco *et al*. 1997; Stone *et al*. 1999; Lefavi *et al*. 1998). Many field studies with Cr supplementation revealed no improvements in repeated sprint performance in athletes representing basketball, baseball, soccer and football (Lefavi *et al.* 1998; Stout *et al.* 1998; Thorensen *et al.* 1998). This study confirms positive effects of long term creatine and combination of creatine and HMB on maximal anaerobic power, evaluated under laboratory conditions in repeated ergocycle tests in basketball players.

In contrast to findings for short duration (<30s) very high intensity activity, creatine supplementation is somewhat les likely to enhance performance of high intensity, more prolonged (30-150s) tasks in either laboratory or field settings. Ergogenic effects have been documented for laboratory-based cycle ergometry and both laboratory and field running tests, but not for swimming performance (Prevost *et al.* 1997; Smith *et al.* 1998; Nelson *et al.* 1998; Larson *et al.* 1998; Bosco *et al.* 1997; Burke *et al.* 1996; Peyrebrune *et al.* 1998). The lesser incidence of an ergogenic effect is probably explained by energy system specificity. The potential of creatine supplementation appears to be limited in tasks that rely primarily on anaerobic glycolysis for ATP synthesis.

Investigations on the effects of long term (2-12 weeks) creatine supplementation on body mass and composition have been conducted primarily with physically active individuals or athletes who are usually involved in some form of resistance training. Close to 80% of the available data indicates significant gains in either body mass or various measures of FFM after creatine supplementation. Even in those studies showing no effects, creatine intake induced gains in body mass or FFM, but the gains were not statistically significant (Becque *et al.* 1997; Francaux and Poortmans 1999; Kirksey *et al.* 1997; Knehans *et al.* 1998; Kreider *et al.* 1996, 1998; Stone 1998).

If creatine enables individuals to train more intensively, then part of the increase in FFM could be muscle tissue. Some investigators hypothesize that an increased cellular hydration induced by creatine supplementation may increase protein synthesis and decrease protein degradation (Volek *et al.* 1997; Ziegenfuss *et al.* 1998; Kreider 2000, 2002).

If HMB reduces muscle protein catabolism associated with exercise, resistance trained athletes may not respond to HMB supplementation in the same manner as untrained individuals, due to training induced suppression of protein breakdown. The repeated stimulus of resistance training appears to reduce muscle protein turnover after exercise, possibly due to effect training in decreasing contraction induced muscle damage. In support of this, skeletal muscle enzyme CK, LDH) efflux following resistance exercise is significantly attenuated by training (Clarkson *et al.* 1992; Faulkner *et al.* 1993). Existing data indicates that HMB supplementation may enhance gains in strength and lean body mass associated with resistance training, at least in untrained or moderately trained individuals mechanism by which this may occur is unknown, but preliminary results indicate that there may be a reduction skeletal muscle damage, although this has not been assessed directly. In well trained athletes, significant gains in body mass, fat free mass and anaerobic power indices may occur when HMB is combined with creatine in long term supplementation (Nissen *et al.* 1997; Gallagher *et al.* 1999; Powers and Arnold 1999; Almada *et al.* 2001; Kreider *et al.* 1999, 2002; Slater and Jenkins 2000).

Refferences

Almada A, Greenwod M, Kreider R, Rasmussen C, Earnest C (2001). Analysis of various nutritional formulation strategies on whole body creatine retention. *Medicine and Science in Sport and Exercise.* 33(5): 204.

Becque M, Lochmann J, Melrose D (2000). Effects of oral creatine supplementation on muscular strength and body composition. *Medicine and Science in Sports and Exercise.* 32(3): 654 – 658.

Bosco C, Tihanyi J, Pucspk J, Kovacs I, Gabossy A, Colli R, Puivirenti G, Tranquilli C, Foti C, Viru M, Viru A (1997). Effect of oral creatine supplementation on jumping and running performance. *International Journal of Sports Medicine,* 18: 369-372.

Burke LM, Pyne DB, Telford RD (1996). Effect of oral creatine supplementation on single -effort sprint performance in elite swimmers. *International Journal of Sport Nutrition* 6: 222-233.

Cheng W, Phillips B, Abumrad N (1997). Beta-hyrdoxy-beta -methylbutyrate increases fatty acid oxidation by muscle cells. *Federation of the American Society for Experimental Biology Journal* 11: 381.

Cheng W, Phillips B, Abumrad N (1998). Effect of HMB on fuel utilization, membrane stability, and creatine kinase content of cultured muscle cells. *Federation of the American Society for Experimental Biology Journal* 12: 950.

Clarkson PM (1996). Nutrition for improved sports performance: Current issues on ergogenic aids. *Sports Medicine* 21: 293-401.

Clarkson PM, Byrnes WC, McCormick KM (1986). Muscle soreness and serum creatine kinase activity following isometric, eccentric and concentric exercise. *International Journal of Sports Medicine* 2: 111-122.

Clrakson PM, Nosaka K, Braun B (1992). Muscle function after exercise induced muscle damage and rapid adaptation. *Medicine and Science in Sports and Exercise,* 24: 512-520.

Crowder T, Jensen N, Richmond S, Voigts J, Sweeney B, Mclntyre G, Thompson B (1998). Influence of creatine type and diet on strength and body composition of collegiate lightweight football players. *Medicine and Science in Sports and Exercise* 30: 264.

Faulkner JA, Brooks SV, Opiteck JA (1993). Injury to skeletal muscle fibers during contractions: conditions of occurrence and prevention. *Physical Therapy*. 73: 911-21.

Francaux M, Poortmans JR (1999). Effects of training and creatine supplementation on muscle strength and body mass. *European Journal of Applied Physiology,* 80: 165-168.

Gallagher PM, Carrithers JA, Godark MP (1999). ß-hydroxy-ß-methylbutyrate supplementation during resistance training. *Medicine and Science in Sports and Exercise* 31: 402.

Greenhaff PL (1995). Creatine and its application as an ergogenic aid. *International Journal of Sport Nutrition*, 5: 100-110.

Greenhaff PL, Bodin K, Söderlund K, Hultman E (1994). Effect of oral creatine supplementation on skeletal muscle phosphocreatine resynthesis. *American Journal of Physiology* 266: 725-730.

Jones AM, Atter T, George KP (1998). Oral creatine supplementation improves multiple sprint pertormance in elite ice-hockey players. *Medicine and Science in Sports and Exercise* 30: 140.

Kelly VG, Jenkins DG (1998). Effect of oral creatine supplementation on near-maximal strength and repeated sets of high-intensity bench press exercise. *Journal of Strength and Conditioning Research* 12: 109-115.

Kirksey KB, Warren BJ, Stone MH, Stone MR, Johnson RL (1997). The effects of six weeks of creatine monohydrate supplementation in male and fema le track athletes. *Medicine and Science in Sports and Exercise* 29: 145.

Knehans A, Bemben M, Bemen D, Loftiss D (1998). Creatine supplementation affects body composition and neuromuscular performance in football athletes. *Federation of the American Society for Experimental Biology Journal.* 12: 863.

Kreider RB (1999). Dietary supplements and the promotion of muscle growth with resistance exercise. *Sports Medicine* 27: 97-110.

Kreider R, Ferreira M, Greenwood M, Wilson M, Grindstaff P, Plisk S, Reinardy J, Almada A (2000). Effects of calcium ß- HMB supplementation during training on markers of catabolism, body composition, strength and sprint performance. *Journal of Exercise Physiology*, 59: 157-168.

Kreider R, Ferreira M, Wilson M, Almada A (1998). Effects of creatine supplementation with and without glucose on repetitive sprint performance in trained and untrained men and women. *International Journal of* Sport *Nutrition,* 8: 204-205.

Kreider R, Greenwood M, Melton C, Rasmussen C, Cantler E, Milner P, Almada A (2002). Long term creatine supplementation during training/competition does not increase perceptions of fatigue or adversely affect health status. *Medicine and Science in Sports and Exercise.* 34: 146

Kreider R, Klesges R, Harmon K, Grindstaff P, Ramsey L, Bullen D, Wood L, Li Y, Almada A (1996). Effects of ingesting supplements designed to promote lean tissue accretion on body composition during resistance training. *International Journal of Sport Nutrition*, 6: 234-246.

Kurosawa Y, Iwane H, Hamaoka T, Shomomitsu T, Katsumura T, Sako T, Kuwamori M, Kimura N (1997). Effects of oral creatine supplementation on high-and low-intensity grip exercise performance. *Medicine and Science in Sports and Exercise*, 29: 251.

Larson DE, Hunter G, Trowbridge C, Turk J, Harbin P, Torman S (1998). Creatine supplementation and performance during off-season training in female soccer players. *Medicine and Science in Sports and Exercise*, 30: 264.

Lefavi RG, Anderson RS, Keith RE (1992). Efficacy of chromium supplementation in athle tes: emphasis on anabolism. *International Journal of Sport Nutrition*, 2: 111-22.

Lefavi RG, McMillan JL, Kahn PJ, Crosby JF, Digioacchino RF, Streater JA (1998). Effects of creatine monohydrate on performance of collegiate baseball and basketball players. *Journal of Strength and Conditioning Research*, 12: 275.

Nelson A, Arnall D, Kokkonen J, Day R, Evans J (2001). Muscle glycogen supercompensation is enhanced by prior creatine supplementation. *Medicine and Science in Sports and Exercise*, 33(7): 1096–1100.

Nissen SL, Abumrad NN (1997). Nutritional role of the leucine metabolite ß-hydroxy-ß-methylbutyrate. *Nutrition and Biochemistry*. 8: 300-311.

Noonan B, French J, Street G (1998a). Creatine supplementation and multiple skating task performance in Division I hockey players. *Medicine and Science in Sports and Exercise* 30: 310.

Noonan D, Berg K, Latin RW, Wagner JC, Reimers K (1998b). Effects of varying dosages of oral creatine relative to fat free body mass on strength and body composition. *Journal of Strength and Conditioning Research* 12: 104-108.

Peyrebrune MC, Nevill ME, Donaldson FJ, Cosford DJ (1998). The effects of oral creatine supplementation of performance in single and repeated sprint swimming. *Journal of Sports Sciences* 16: 271-279.

Poortmans JR, Auquier H, Renaut V, Durussel A, Saugy M, Brisson G (1997). Effect of short term supplementation on renal responses in men. *European Journal of Applied Physiology*, 76: 566 – 567.

Powers ME, Arnold BA (1999). The effects of creatine supplementation and beta-hydroxy-beta-methylbutyrate supplementation on delayed onset muscle soreness. *Journal of Athletic Training* 34: 33.

Prevost MC, Nelson AG, Moris GS (1997). Creatine supplementation enhances intermittent work performance. *Research Quarterly for Exercise and Sport* 68: 233-240.

Slater GJ, Jenkins D (2000). Beta -hydroxy-beta -methylbutyrate (HMB) supplementation and the promotion of muscle growth and strength. *Sports Medicine.* 30(2):105-116.

Slater GJ, Jenkins D, Logan P, Lee H, Vukovich M, Rathmacher JA, Halin AG (2001). Beta -hydroxy-beta -methylbutyrate (HMB) supplementation does not affect changes in strength or body composition during resistance training in trained men. *International Journal of Sport Nutrition and Exercice Metabolism.* 11(3):384-396.

Smith CR, Ruthertord OM (1995). The role of metabolites in strength training. *European Journal of Applied Physiology*. 71: 332-336.

Smith DA, Perry PJ (1992). The efficacy of ergogenic agents in athletic competition. *Annals of Pharmacotherapy* 26: 653-659.

Smith RA (1992). A historical look at enhancement of pertormance in sport: Muscular moralists versus muscular scientists. *American Academy of Physical Education Papers.*25: 2-11.

Stone MH, Sanborn K, Smith L, O'Bryant HS, Hoke T, Utter A, Johnson RL, Boros R, Hruby J; Pierce K, Stone ME, Garner B (1999). Effects of in-season (5 weeks) creatine and pyruvate supplementation on anaerobic performance and body composition in American football players. *International Journal of Sport Nutrition,* 9(2): 146-165.

Stout JR, Echerson J, Noonan D, Moore G, Cullen D (1999). Effects of creatine supplementation on exercise performance and fat-free weight in football players during training. *Nutrition Research* 19: 217-225.

Thorensen E, McMillam J, Guion K, Joyner B (1998). The effect of creatine supplementation on repeated sprint performance. *Journal of Strength and Conditioning Research.* 12: 278.

Volek JS, Kraemer WJ (1996). Creatine supplementation: Its effect on human muscular performance and body composition. *Journal of Strength and Conditioning Research* 10: 200-210.

Williams MH, Kreider R, Branch D (1999). *Creatine the power supplement* : 1–213. Human Kinetics Books , Champign, IL.

Ziegenfuss T, Gales D, Felix S, Straehle S, Klemash K, Konrath D, Lemon PWR (1998). Performance benefits following a five day creatine loading procedure persist for at least four weeks. *Medicine and Science in Sports and Exercise,* 30: 265.