Scientific Review & Overview

"Podium Gold™"
(Beta-Creatine)

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Summary of Podium Gold Benefits

The following are the primary benefits of Podium Gold:

More soluble than creatine monohydrate- Mixes easier and less GI distress

Synergistic buffering - as creatine allows for greater regeneration of the bodies immediate energy source ATP, for both high intensity exercise and recovery/adaptation β-alanine increases carnosine, an important and highly concentrated fast twitch muscle fiber buffer.

Strength Increases - Creatine increases strength up to 30% in 10 weeks

Increases Fast Twitch Muscle Buffering - β-alanine increases fast twitch muscle fiber carnosine content by 80% in just 10 weeks

Research - Over 30 primary research papers on creatine and β-alanine supplementation

Increases Buffering Capacity - Increases buffering capacity of the fast twitch muscle cells

Greater Per Gram Dosage - More creatine and β-alanine per gram than any other supplement

Podium Gold White Paper

Abstract

A proprietary dietary supplement that contains creatine ionically bound to β-alanine and is employed to synergistically enhance muscle energetics, buffer hydrogen ion, increase muscle creatine, and increase muscle carnosine to enhance exercise capacity. The following compound takes advantage of the optimum dosage of creatine to increase its levels in muscle and optimum dosage of β-alanine to increase muscle carnosine content.

Background

Recent advances in the understanding of muscle energetics has allowed for the identification of new compounds that improve performance. Largely this understanding has allowed for the advancement of improving the internal milieu of the cell for both short term and long term increases in performance, muscle mass, and strength for athletic purposes. Creatine is an important intermediate in maintaining cell energy status and plays a vital role in regeneration of ATP and cell signaling. Creatine is hypothesized in part to work by effectively increasing muscle creatine content and thus increasing flux through the well-established creatine kinase reaction assisting in the maintenance of ATP homeostasis and the energy charge of the cell (Casey *et al.*, 1996). Additionally the shortening of muscle reaction time seen after creatine loading for several weeks can assist in strength generation (Van, Vandenberghe, & Hespel, 1999). Muscle anabolism is then increased indirectly through the increased workload the athlete is able to sustain in workouts and subsequent gains in lean body mass ensues if adequate energy is consumed by the athlete. From review of the literature the average individual can expect a 40% increase in strength over a 10-week time period compared to those receiving placebo.

Creatine supplementation, while effective in increasing muscle strength and gains in lean body mass, as shown above, creates additional metabolic acid in the form of H+ as flux through the creatine kinase reaction increases. This is where the ionically bonded β-alanine assists synergistically to allow greater metabolic flux and higher muscular power outputs. As creatine supplementation allows for performance of more work, generating more acid, that additional acid may be buffered by the elevated carnosine content that is facilitated by the β-alanine intake.

β-alanine is a non-essential amino acid that constitutes the rate-limiting step in carnosine synthesis an important intracellular buffer of hydrogen ions. As metabolic flux increases pH inside the cell reaches levels much more intense than the blood. The fatigue caused by this acidity reduces force production in short term, explosive sports such as repeated sprints or heavy exertion. By increasing muscle carnosine content via β-alanine supplementation the pH driven reduction in force production is delayed. Over 10 weeks of supplementation with β-alanine muscle carnosine content can be increased by 80% (Hill *et al.*, 2007). Higher carnosine concentration in muscle has been shown experimentally to be associated with prevention of fatigue, such as that exemplified by higher mean power from a 30-second maximal sprint (Suzuki *et al.*, 2002)

Creatine and β-alanine work together to provide an energetic advantage to athletes and like minded individuals in enhancing muscle energetics and optimizing short term performance and long term muscle strength and gains in lean body mass.

Recommended Dosages:

Whether put into a powder, liquid, or tablet form the recommended dosage for a 200lb individual is 5 grams twice daily. The athlete may "load" with the product at 10 grams twice daily, however ours and other research has shown that after 8 weeks of supplementation the results do not differ between loading and non-loading groups.

References:

β-alanine

Dunnett, M., & Harris, R.C. (1999). Influence of oral beta-alanine and L-histidine supplementation on the carnitine content of the gluteus medius. Equine Veterinary Journal Supplement, 30, 499-504

Abe, H. (2000). Role of histidine related compounds as intracellular proton buffering constituents in vertabrate muscle. Biochemistry (Moscow) 65, 757-765.

Tallon, M.J., Harris, R.C., Boobis, L.H., (2005) The carnosine content of vastus lateralis is elevated in resistance-trained bodybuilders. Journal of Strength and Conditioning Research, 19, 725-729.

Hill C. A., Harris, R.C., Kim, H.J., Harris, B.D., Sale, C., Boobis, L.H (2007). Influence of beta-alanine supplementation on skeletal muscle carnosine concentrations and high intensity cycling capacity. Amino Acids, 32, 225-233.

Suzuki, Y., Ito, O., Mukai, N., Takahashi, H., & Takamatsu, K. (2002) High level of muscle carnosine contributes to the latter half of exercise performance during 30-second maximal ergometer sprinting. Japanese journal of Physiology, 52, 199-205.

Stout, J.R. Cramer, J.T., Zoeller, R.F., Torok, D., Costa, P,. Hoffman, J.R. et al. (2007) Effects of beta-alanine supplementation on the onset of neuromuscular fatigue and ventilatory threshold in women. Amino Acids, 32, 381-386.

Creatine

Harris, R.C., Soderlund, K., & Hultman, E,. (1992) Elevation of creatine in resting and exercised muscle of normal subjects by creatine supplementation. Clinical Science, 83, 367-374.

Skare, O.C., Skadberg, O,. Wisnes, A.R., (2001) Creatine supplementation improves sprint performance in male sprinters. Scandinavian Journal of Medicine and Science in Sports, 11, 96-102.

Delecluse, C., Diels, R., & Goris, M. (2003). Effects of creatine supplementation on intermittent sprint performance in highly trained athletes. Journal of Strength and Conditioning Research, 17, 446-454.

Glaister, M,. Lockey, R.A., Abraham, C.S., Staerck, A,. Goodwin, J.E., & McInnes.

(2006) Creatine supplementation and multiple sprint running performance. Journal of Strength and Conditioning Research, 20, 273-277.

Mujika, I., Padilla, S., Ibanez, J., Izquierdo, M., & Gorostiaga, E. (2000). Creatine supplementation and sprint performance in soccer players. Medicine and Science in Sports and Exercise, 32, 518-525.

Terjunget, R. L., Clarkson, P., Eichner, E.R., Greenhaff, P.L., Hespel, P.J., Israel, R.G. (2000). American College of Sports Medicine Roundtable: The physiological and health effects of oral creatine supplementation. Medicine and Science in Sports and Exercise, 32, 706-717.

Casey, A., Short, A.H., Curtis, S., & Greenhaff, P.L. (1996). The effect of glycogen availability on power output and the metabolic response to repeated bouts of maximal, isokinetic exercise in man. European Journal of Applied Physiology and Occupational Physiology, 72, 249-255.

Hespel, P,. Op't, E.B., Van, L.M,. Urso, B., Greenhaff, P.L., Larbarque, V. et al., (2001). Oral creatine supplementation facilitates the rehabilitation of disuse atrophy and alters the expression of muscle myogenic factors in humans. Journal of Physiology, 536, 625-633.

Volek, J.S., Kraemer, W.J., Bush, J.A., Boetes, M., Incledon, T., Clark, K.L. (1997) Creatine Supplementation enhances muscular performance during high-intensity resistance exercise. Journal of American Dietetic Association, 97, 765-770.

Creatine Athletic Background

Creatine is one of most commonly used supplements among athletes, especially in speed and strength intensive sports. It is available in the market in the form of powder, capsules, and gels. Creatines are usually classified as either creatine monohydrate or creatine salts (creatine citrate or creatine pyruvate). The effects may vary within individuals. Creatine is naturally present in muscle tissues such as meat, fish, and other animal products. It is also endogenously synthesized in the liver, the kidneys, and the pancreas from arginine, glycine, and methionine.

In strength exercises, utilization of intramuscular adenosine triphosphate (ATP) is the main pathway to generate energy (Brooks, 2005). In order to generate more energy, through ATP for muscle contraction, creatine supplementation is thought to accelerate and/or replenish the supply of muscle creatine and phosphocreatine (PCr) to prevent fatigue that occurs due to ATP depletion. Creatine is used to recover faster after exercise. Due to delayed fatigue, athletes are able to train harder and longer which may contribute to muscle hypertrophy.

What Creatine Does

Trained Athletes

In a "trained" athlete they can expect a 1-2 kg gain in muscle mass over an 8 week period and a 10% to 30% increase in strength for a given exercise (Izquierdo et al.). Taking creatine with carbohydrates and protein after the exercise may have even more potent effect in creatine supplementation because higher insulin concentration will assist the uptake of both protein and creatine into the muscle tissues (Tipton, 2007); for some "non-responders" there is anecdotal evidence that it helps assist them.

Example Studies

In an 8 week study rugby players were either given creatine supplementation or placebo (blinded fashion) and then parameters of both strength and performance were measured. The creatine group showed better gains in strength (6% more) and increases in muscle mass (2 lbs more) and decreased body fat (5lbs) at the end of the 8 week study in comparison to the placebo (Chilibeck, et al).

A 50 week study looked at American Football players taking either a placebo, creatine, pyruvate, or creatine and pyruvate as a supplement. After the 50 week study only the groups using creatine or creatine with pyruvate showed a statistically higher increases for body mass, lean body mass, 1 repetition maximum (RM) bench press, combined 1 RM squat and bench press, and static vertical jump (SVJ) power output. Peak rate of force development for SVJ was also higher in the creatine supplemented groups. The pyruvate only group did not show any differences in comparison to placebo leading to the conclusion that creatine caused the positive effects in both creatine only and creatine with pyruvate groups (Stone, et al).

Elderly

Human aging is associated with a significant reduction in muscle mass (sarcopenia) resulting in muscle weakness and functional limitations in the elderly. Sarcopenia has been associated with mitochondrial dysfunction and the accumulation of mitochonrial DNA deletions. Resistance training increases muscle strength and size and can ameliorate deletions to mitochondrial DNA by causing recruitment of muscle precursor cells with undamaged mitochondrial DNA. As well, resistance training increases mitochondrial capacity and decrease oxidative stress in older adults. Creatine monohydrate has biological effects that enhances some of the beneficial effects of resistance training in older adults. Several studies have found that creatine supplementation enhanced the resistance exercise mediated gains in fat-free mass and strength. (Tarnopolsky 2008). Not only for the purpose of retaining the muscle mass, pharmaceutical usage of creatine is emerging.

Example Studies

Age related disease such as Gyrate atrophy, Parkinson's, Duchenne muscular dystrophy, and congestive heart failure etc. Gyrate atrophy (GA) is a genetic defect in which fast twitch muscle (type II muscle) decreases significantly. Sipila et al. supplemented seven patients with 1.5 g of creatine per day for one year. The diameters of Type 2 muscle fibers increased 45% (Persly, 2001). This indicates that the creatine supplementation can result in retaining the muscle mass which elderly tend to loose as they age.

Church et al assessed thirty men with an average age of 70.4 +/- 1.6 years old for effect in creatine supplementation in randomized double blind fashion. The treatment group had creatine supplementation (0.3g creatine per kg of body weight as loading phase and 0.07g per kg of body weight), and the other group received the placebo. Both of the groups were assigned to resistance training (36 sessions, 3 times per week). Creatine supplementation group had 250 % increases (compare to the placebo group) in the lean tissue mass, 160 % increases in maximum leg press, 140% increase in maximum knee press (Church et al, 2001).

Creatine supplementation is usually followed by the dosage regiments:

- Initial loading phase: 12-20g/ day for 4-7 days Maintenance phase: 2-5g/ day
- However recent evidence shows no need to use the loading phase, in fact a loading phase in not recommended at this time

Health Claims and Common Usage

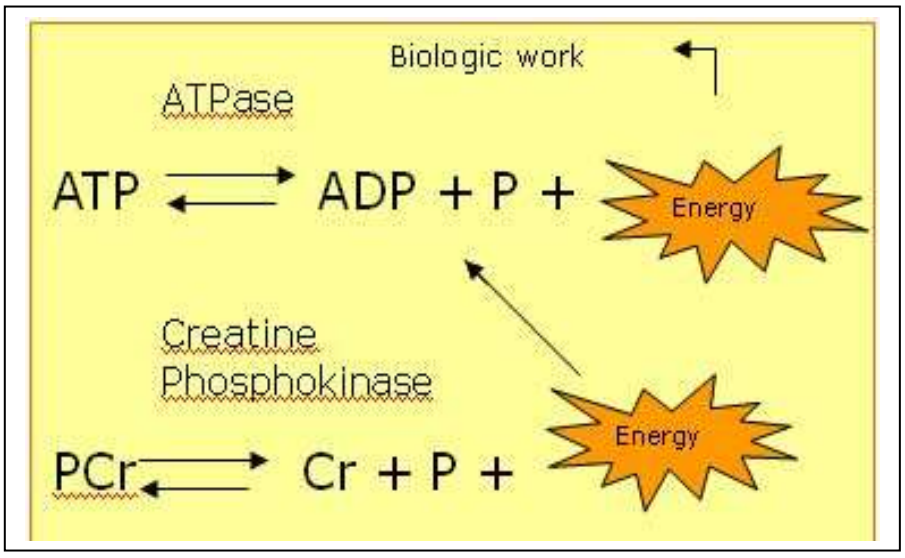
The common uses of creatine are the following:

- Muscle fiber hypertrophy
- Improved recovery
- Increased power output
- Decreased fatigue

Scientific Evidence

- **Increased gene expression in muscle fibers:** Several studies demonstrated that supplementation of creatine and resistance exercise increase mRNA expression of type I and II myosin heavy-chain (proteins that function in muscle contraction, as well as enzymes that are needed for generation of energy.

- **ADP rephosphorylation:** In the skeletal muscle, both ATP and PCr are limited. Supplementing creatine is thought to increase total creatine concentration in the muscle which can facilitate PCr production leading to more production of ATPs for energy release. The following illustration is the general overview of physiological mechanism of energy generation through ATPs.



- **Increased glycogen storage:** Some experiments have illustrated increased glycogen storage with creatine supplementation. Creatine is known to increase intracellular water which may influence glycogen storage in the body.

Side Effects

There are several known potential side effects; however, there are many controversies in the reasons and mechanisms of the causes of such side effects.

- Muscle Cramping
- Dehydration
- Diarrhea (minimized/eliminated without loading phase)
- GI discomfort (minimized/eliminated without loading phase)

References

George A. Brooks, Thomas D. Fahey, Kenneth M. Baldwin. (2005) *Exercise Physiology: Human Bioenergetics and Its Application*. 4th ed. 766-767. McGraw-Hill Co, NY

Kevin D. Tipton, Asker E. Jeukendrup, Peter Hespel. (2007) Nutrition for the sprinter. Journal of Sports Sciences; 25(S1): S5 - S15

Melvin H. Williams, J. David Branch. (1998) Creatine Supplementation and Exercise Performance: An Update. *Journal of the American College of Nutrition, Vol. 17, No. 3, 216-234*

Jeff S. Volek, Eric S. Rawson. (2004) Scientific Basis and Practical Aspects of Creatine Supplementation for Athletes. *Nutrition Volume 20, Numbers 7/8*

Adam M. Persky, Gayle A. Brazeau. (2001) Clinical Pharmacology of the Dietary Supplement Creatine Monohydrate. *The American Society for Pharmacology and Experimental Therapeutics 121/89905. Pharmacol Rev 53:161-176*

Izquierdo M, Ibañez J, González-Badillo JJ, Gorostiaga EM. Med Sci Sports Exerc. 2002 Feb;34(2):332-43. Effects of creatine supplementation on muscle power, endurance, and sprint performance.

Tarnopolsky MA, Safdar A. Appl Physiol Nutr Metab. 2008 Feb;33(1):213-27. The potential benefits of creatine and conjugated linoleic acid as adjuncts to resistance training in older adults.

Brose A, Parise G, Tarnopolsky MA. J Gerontol A Biol Sci Med Sci. 2003 Jan;58(1):11-9. Creatine supplementation enhances isometric strength and body composition improvements following strength exercise training in older adults.

Murray J Chrusch. (2001) Creatine supplementation combined with resistance training in older men. *Medicine & Science in Sports & Exercise. 33(12):2111-2117, December 2001*

Chilibeck PD, Magnus C, Anderson M. Appl Physiol Nutr Metab. 2007 Dec;32(6):1052-7. Effect of in-season creatine supplementation on body composition and performance in rugby union football players.

Stone MH, Sanborn K, Smith LL, O'Bryant HS, Hoke T, Utter AC, Johnson RL, Boros R, Hruby J, Pierce KC, Stone ME, Garner B. Int J Sport Nutr. 1999 Jun;9(2):146-65. Effects of in-season (5 weeks) creatine and pyruvate supplementation on anaerobic performance and body composition in American football players.

β-Alanine Background

When supplementing with β-alanine, the main goal is to use it to increase the amount of an important intracellular buffer of H+ (acid) in fast twitch muscles called carnosine. β-alanine is the rate-limiting precursor for synthesizing muscle carnosine; meaning that the level of β-alanine consumed in the diet or supplements is a large determinant of the amount of carnosine synthesized in muscle cells.

Carnosine is a physiological buffering agent in the skeletal muscles, especially in type II muscle (fast-twitching muscle) which is essential to power and strength exercise. It is a di-peptide (2 amino acids) which consists of β-alanine and L-histidine. There are numerous dietary supplements for carnosine in forms of capsules, powder, and pills in the market; however, research shows that supplementing with carnosine does not have an effect on muscle carnosine levels most likely due to enzymatic activity in the blood to inactivate the compound before it gets into the muscle cells.

While increases in performance are multi factorial; increases in buffering capacity is one method of delaying muscle fatigue, therefore improving exercise performance. Many drugs used in sports such as erythropoietin (EPO), a peptide hormone that is produced in the kidneys which stimulates the production of red blood cells, is thought to work by increased buffering capacity of the blood for endurance athletes (Brooks, 2005).

Additionally supplementing with bicarbonate (major buffer in human blood) has shown to increase performance of swimmers (Tipton).

Ingesting the sodium bicarbonate such as baking soda (200mg per kg of body weight) one to two hours prior to the performance is popular for middle distance athletes; however, this will only enhance the extracellular (outside of the cell) buffering capacity, rather than the intracellular (inside of the cell, such as muscle) buffering system which is important for fast and intense exercise. Both erythropoietin and bicarbonate were well studied for endurance exercise. However finding an explosive strength sport specific buffer (such as in fast twitch fibers) has eluded scientists until β-alanine was found to increase intracellular carnosine levels in fast twitch (type II) fibers by 80% in untrained individuals. Despite the fact that L-histidine is the buffering component in carnosine, it seems that supplementing with L-histidine does not have as much effect as β-alanine does leading to the conclusion that β-alanine is the rate limiting compound in carnosine synthesis.

Health Claims and Common Usage

The common usage of the product is:

- Improved buffering capacity in muscle
- Antioxidant
- Enzyme regulator
- Skeletal muscle regulation

Scientific Evidence

During intensive exercise, H+ production increases which results in acidosis that is a component of muscle fatigue. Carnosine will buffer the H+ that is generated from muscle contraction caused by intensive exercise. In sprint athletes increased muscle carnosine levels are associated with faster sprint times. Additionally supplementing with β-alanine in football players has shown to increase training volume and decrease perceived fatigue when compared to placebo (Hoffman et al).

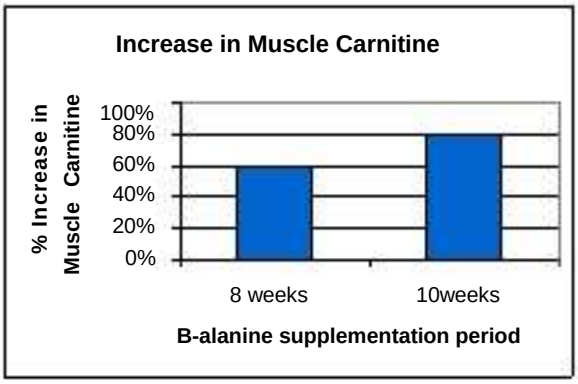


Figure 1: β-alanine supplementation and muscle carnitine increase
Modified from Hill et al., 2007

Research shows that carnosine may have antioxidant properties (Hill et al). Oxidative stress due to increase in exercise training is well documented and recognized, and it is a concern because it may cause DNA and cell damage. Antioxidants will scavenge the free radicals in the body which may attack the cells to result oxidative damage. Supplementation of β-alanine to increase carnosine levels may prevent oxidative damage that are done due to the exercise and is unique because it is fast twitch muscle specific.

Regulating ability of carnosine in enzymatic activities is also proposed in several studies including myosin ATPase (ATP generating enzyme in the muscle) (Begum, et al 2005). ATPase is the key player in generating ATP which can give a rise to energy for muscle contraction.

Carnosine is also thought to have an effect in stimulating muscle contraction though activating calcium channel (ryanodine receptor/ RyR) in muscle fibers. Calcium release is a vital signaling mechanism for the muscle to be stimulated for the action. Reduction in calcium release in the muscle will result in fatigue and impaired ability in muscle contraction (Begum, et al 2005, et al 2005). Thus, to summarize, supplementation with

β-alanine may protect muscles from fatigue caused by acidosis, fatigue caused by impaired calcium handling, and from overtraining due to oxidative damage to muscle fibers.

Side Effects

It is generally well tolerated despite several potential side effects that are extremely rare but have been named in several studies with high dosages.

- Nausea
- Vomiting
- Diarrhea
- Abdominal cramps

References

Gulshanara Begum, Adam Cunliffe, Michael Leveritt., (2005) Physiological Role of Carnosine in Contracting Muscle. *International Journal of Sport Nutrition and Exercise Metabolism*, 15, 493-514

Hill, C. A., Harris, R. C., Kim, H. J., Harris, B. D., Sale, C., Boobis, L. H. et al. (2007). Influence of beta-alanine supplementation on skeletal muscle carnosine concentrations and high intensity cycling capacity. *Amino Acids*, 32, 225 -233.

Jay R. Hoffman, Nicholas A. Ratamess, Avery D. Faigenbaum. (2008) Short-duration β-alanine supplementation increases training volume and reduces subjective feelings of fatigue in college football players. Nutrition Research 28. 31-35

Kevin D. Tipton, Asker E. Jeukendrup, Peter Hespel. (2007) Nutrition for the sprinter. Journal of Sports Sciences; 25(S1): S5 - S15

Stout, J. R., Cramer, J. T., Zoeller, R. F., Torok, D., Costa, P., Hoffman, J. R. et al. (2007). Effects of beta-alanine supplementation on the onset of neuromuscular fatigue and ventilatory threshold in women. *Amino Acids*, 32, 381 - 386.

Iain P. Kendrick. Roger C. Harris. Hyo Jeong Kim. Chang Keun Kim. et al. (2008) The effects of 10 weeks of resistance training combined with *b*-alanine supplementation on whole body strength, force production, muscular endurance and body composition. *Amino Acids* 34:547-554