

Carnipure™ for exercise and recovery

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Sports nutritionals have gained wide acceptance as an essential component of any committed athletic lifestyle. Additionally, increasing numbers of consumers who aren't necessarily health club devotees are also turning to sports nutrition products, often in lieu of traditional beverages and snacks. This represents a significant opportunity for food and drinks marketers to take advantage of a fast-growing category trend.

The ingredients of those sports nutritionals, however, have to be chosen with efficacy, quality and safety in mind. There is evidence for a beneficial effect of Carnipure™ supplementation in sports nutrition regarding optimization of performance, delaying the onset of fatigue and improving recovery from strenuous exercise both in bodybuilders, athletes and in untrained people. Carnipure™ can thus be considered to be a winning ingredient, helping functional food and supplement manufacturers to capitalize on a healthy, growing market.

What is Carnipure™?

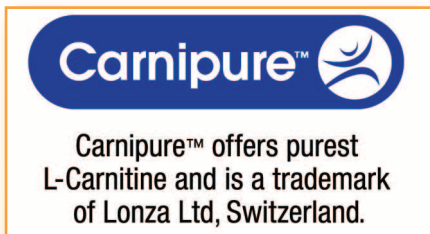
Carnipure™ is a special grade of L-Carnitine, manufactured by the Swiss life sciences company Lonza. Thanks to a unique production process based on fermentation, Lonza is the only L-Carnitine manufacturer capable of producing L-Carnitine in the same way as nature. Products carrying the Carnipure™ quality seal on the packaging show the consumer that they contain pure Lonza L-Carnitine.

What is L-Carnitine?

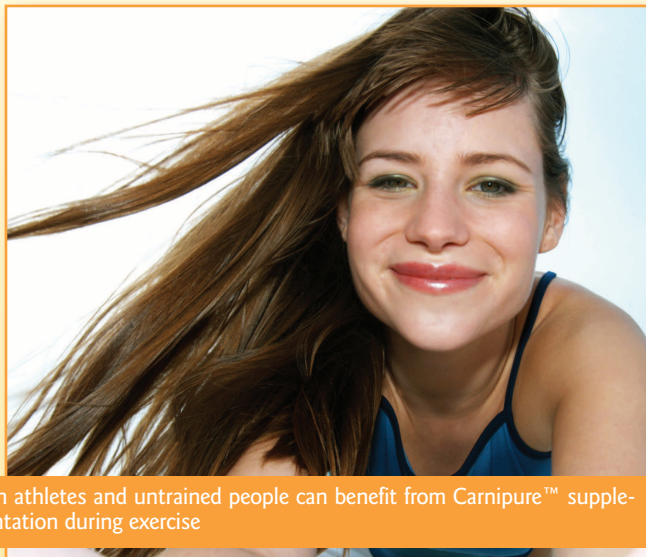
L-Carnitine, the biologically effective isomer of carnitine, is found ubiquitously in mammalian tissues and plays a key role within several cellular energy producing pathways¹. By way of example, L-Carnitine acts as a transport vehicle shuttling long chain fatty acids across the inner mitochondrial membrane. Once inside the mitochondria, L-Carnitine releases these fatty acids and they are broken down through a process called beta-oxidation for the production of ATP or energy. L-Carnitine is also important for the removal of potentially toxic acyl-CoAs from the mitochondria by forming acyl-L-Carnitines and serves as a temporal acetyl group buffer in the oxidation of carbohydrates during periods of augmented pathway flux. Not surprisingly, given its key role within carbohydrate and particularly fat metabolism, the functional role of L-Carnitine has been the subject of great scientific interest to date.

L-Carnitine metabolism during exercise

According to a recent report on the Sport nutrition market, people are buying more sports nutrition products than ever before, either in form of drinks and bars or as dietary supplements. Not only for athletes sports nutritionals are a substitute from other snacks, drinks and energy providing products. This also has consequences on



the normal diet: athletes wishing to consume a carbohydrate-rich diet often omit meat, which is the most reliable dietary source of L-Carnitine. Thus they do not get sufficient L-Carnitine with the diet. Researchers observed that triathletes on a predominantly vegetarian diet had the lowest plasma levels of L-Carnitine. Supplementation with L-Carnitine for 6 weeks increased free L-Carnitine from 10 µmol/L to 85 µmol/L. This considerable increase also improved the ratio of free L-Carnitine to acetylated L-Carnitine, which is



Both athletes and untrained people can benefit from Carnipure™ supplementation during exercise

an indicator of the supply of functionally active L-Carnitine.

High performance athletes such as triathletes have been shown to have lower than normal plasma levels of L-Carnitine even when following an omnivorous diet, as they have a higher excretion of esterified L-Carnitine via the kidneys and via perspiration². This loss may be followed by a decrease of L-Carnitine in the active muscles which may not always be rapidly replenished by the normal processes, thus Carnipure™ supplementation may be warranted³.

It has been demonstrated that with increasing exercise intensities, the concentration of acyl-L-Carnitine within the muscle is increased and the availability of free L-Carnitine is decreased⁴. Decreased availability of free L-Carnitine in the mitochondria means decreased capacity of all energy generating pathways. Supplementation with L-Carnitine can increase the amount of free L-Carnitine inside the mitochondria and thus ensure energy generating processes to continue.

Optimizing performance with Carnipure™

Although it has been known for many years that long-chain fatty acids are important sources of energy in the contracting muscle especially in endurance exercise, the mechanisms controlling fatty acid uptake and oxidation during the exercise are still not completely elucidated⁵.

Studies in athletes have shown that Carnipure™ supplementation aids in exercise performance⁶. $VO_2\max$ is the maximum amount of oxygen that an individual can utilize during exercise in a set period of time and often used as a predictor of potential in endurance sports. The positive effect of L-Carnitine supplementation on $VO_2\max$ has been subject of many research studies involving athletes of various disciplines such as top rowers⁷, marathon runners⁸, competitive long distance walkers⁹ and trained cyclists^{10,11}.

Both an increase in maximal oxygen consumption and a lowering of the respiratory quotient indicate that L-Carnitine has the potential to stimulate lipid metabolism¹². In humans it was shown that fat oxidation and muscle L-Carnitine concentration were tightly coupled during incremental exercise. In healthy adults, Carnipure™ supplementation has been shown to stimulate *in vivo* long chain fatty acid metabolism even without exercise training^{13,14}, and in exercise trained rats L-Carnitine supplementation also was found to change the flux of substrates through the Krebs cycle, increasing the oxidation of fatty acids and decreasing that of glucose^{15,16,17}.

Any "sparing" of glucose, however, can be regarded as highly beneficial since carbohydrate stores in the body can be exhausted following 1-2h of intense exercise, assuming that the ultimate goal of prolonged exercise is to maintain glycogen stores as long as possible¹⁸.

Delaying the onset of fatigue with Carnipure™

Fatigue during exercise is undesirable as it ultimately compromises performance. It can have a central origin, by reducing cognitive performance or lowering excitation of motoneurons. Various mediators are in question (serotonin, moduline, dopamine). On the metabolic level, the most-often evoked changes are reduced pH and increased intracellular lactate level. However, that "lactic acid hypothesis" has been seriously challenged in recent years. During endurance activities, the limiting factors are glycogen reserves and levels of oxidative enzymes.

Intense activities that demand a high output of energy in a short time frame, such as sprinting, quickly deplete glycogen stores¹⁹. If the use of fat as an energy source can be increased during exercise, this may spare muscle glycogen, thereby delaying the onset of fatigue. Again, there is

research to indicate that L-Carnitine may be beneficial in this respect. In endurance trained athletes, L-Carnitine supplementation (2 g/day for 28 days) led to a significant reduction in Respiratory Quotient (RQ) during a 45 minute cycling exercise, as compared to placebo. This decrease in RQ indicates a glycogen sparing effect and ultimately, should be associated with improved performance²⁰.

A consequence of high-intensity training is hypoxia, which increases the concentration of ammonia in blood. Also superimposed heat stress is postulated to augment systemic ammonia response²¹. Ammonia accumulation has been associated with fatigue. Carnipure™ tartrate supplementation in male cyclists has

been found to decrease ammonia levels in a well-controlled study²². As there has not been any change in amino acid metabolism, this effect may be explained by reduced AMP deamination.

Improving recovery processes with Carnipure™

Exercise places oxidative stress on the body derived from two different stimuli. First, the mechanical forces associated with exercise cause cellular structural damage, and subsequently, chemical responses related to muscle damage and the muscle repair process cause tissue alterations that can be observed for up to ten days post-



Carnipure™ – purity you can trust

session²⁴. The study results indicated that supplementation with Carnipure™ tartrate prior to high intensity exercise can attenuate the biochemical and structural stress responses to high-intensity squat exercise and is significantly effective in assisting recovery. More specifically, Carnipure™ supplementation allows for decreased production of free radicals, less tissue damage, reduced muscle soreness and better utilization of fat as an energy source during recovery.

Potentially, Carnipure™ may improve blood flow during and following exercise, and optimize the signals supporting tissue repair processes. A speedy and less painful recovery is important for all people who exercise, whether professionally or recreationally, as recovery affects how quickly a person can return to exercising optimally. These results are in line with previous findings^{25, 26}, and have important practical applications for athletes, as performance after damaging exercise bouts is primarily affected by strength loss and pain.

Most interestingly, latest research shows that this amelioration of post-exercise metabolism increases in response to the daily dosage of Carnipure™ tartrate, however that it is already statistically significant at a dosage of 1g L-Carnitine/day²⁷.

And so to conclude

The physiological function of L-Carnitine in facilitating the production of energy from fat is crucial during exercise, especially endurance exercise, because fat is one of the main fuels used to provide energy for physical activity. An increasing body of scientific evidence illustrates the favourable effects of Carnipure™ for athletes and recreationally physically active people with regard to optimizing performance, delaying the onset of fatigue and improving the recovery process. The growing interest in Carnipure™ can be attributed to a number of factors including its basic function in helping convert fat into energy, its efficacy, its excellent safety profile and, of course, its suitability for processing.



Athlete taking a sports drink for improved recovery

exercise²³. This sensation of discomfort or pain in the skeletal muscles frequently occurs following unaccustomed muscle exertion and is commonly referred to as DOMS (Delayed Onset Muscle Soreness).

The findings by researchers at the University of Connecticut, USA, however, have opened new avenues with regard to a role for Carnipure™ apart from its classical muscle energetic function: Using a balanced, placebo-controlled, cross-over design, ten healthy active men volunteered taking either a placebo or an Carnipure™ tartrate supplement (equivalent to 2 g L-Carnitine/day) for 3 weeks prior to the performance of a controlled exercise

References

- Steiber A, Kerner J et al (2004). Carnitine: a nutritional, biosynthetic, and functional perspective. *Mol Aspects Med* 25(5-6):455-473
- Föhrenbach R et al (1993). Der Einfluss von L-Carnitin auf den Lipidstoffwechsel von Hochleistungssportlern. *Dtsch Z Sport Med* 8:349 (In German)
- Cerretelli P et al (1990). L-Carnitine supplementation in humans. The effects on physical performance. *Int J Sports Med* 11:1
- LeBlanc PJ et al (2004). Effects of 7 wk endurance training on human skeletal muscle metabolism during submaximal exercise. *J Appl Physiol* 97:2148
- Kiens B et al. (2003). Utilization of long-chain fatty acids in human skeletal muscle during exercise. *Acta Physiol Scand* 178:391
- Karlic H et al (2004). Supplementation with L-Carnitine in athletes: Does it make sense? *Nutrition* 20:709
- Dragan G et al (1987). Studies concerning chronic and acute effects of L-Carnitine on some biological parameters in elite athletes. *Physiologie* 24(1):23-28
- Swart I et al (1997). The effect of L-Carnitine supplementation on plasma Carnitine levels and various performance parameters of male marathon athletes. *Nutr Res* 17:405
- Marconi C et al (1985). Effects of L-Carnitine loading on the aerobic and anaerobic performance of endurance athletes. *Eur J Appl Physiol* 54:131
- Angelini C et al (1986). Use of Carnitine in exercise physiology. *Adv Clin Enzymol* 4:103
- Vecchiet L et al (1990). Influence of L-Carnitine administration on maximal physical exercise. *Eur J Appl Physiol* 61:486
- Aoi W, Naito Y et al. (2006). Exercise and functional foods. *Nutr J* 5:15-22
- Müller DM et al (2002). Effects of oral L-Carnitine supplementation on in vivo long-chain fatty acid oxidation in healthy adults. *Metabolism* 51(11):1389
- Wutzke KD et al (2004). The effect of L-Carnitine on fat oxidation, protein turnover, and body composition in slightly overweight subjects. *Metabolism* 53(8):1002
- Dragan AM et al. (1987). Studies concerning some acute biological changes after endovenous administration of 1 g L-carnitine, in elite athletes. *Physiologie* 24(4):231-234
- Siliprandi N et al (1990). Metabolic changes induced by maximal exercise in human subjects following L-Carnitine administration. *Biochim Biophys Acta* 1034:17
- Bacurau RFP et al. (2003). Does exercise training interfere with the effects of L-Carnitine supplementation? *Nutrition* 19:337
- Spiet LL et al (2003). Regulatory mechanisms in the interaction between carbohydrate and lipid oxidation during exercise. *Acta Physiol Scand* 178:443
- Burke ER (1999). *Optimal Muscle Recovery*, New York
- Gorostiaga EM et al (1989). Decrease in respiratory quotient during exercise following L-Carnitine supplementation. *Int J Sports Med* 10:169
- Mohr M et al. (2006). Environmental heat stress, hyperammonemia and nucleotide metabolism during intermittent exercise. *Eur J Appl Physiol* 97(1):89-95
- Galloway SDR et al (2004). Effect of 2 weeks supplementation with L-Carnitine L-tartrate on plasma ammonia response to exercise. *FASEB J* 18(4-5):502.5
- Kraemer WJ et al (2005). L-Carnitine supplementation: A new paradigm for its role in exercise. *Chem Month* 136:1383
- Volek JS et al. (2002). L-Carnitine L-tartrate supplementation favorably affects markers of recovery from exercise stress. *Am J Physiol Endocrinol Metab* 282:E474
- Giamberardino MA et al (1996). Effects of prolonged L-Carnitine administration on delayed muscle pain and CK release after eccentric effort. *Int J Sports Med* 17:320
- Maggini S et al (2000). L-Carnitine supplementation results in improved recovery after strenuous exercise: A preliminary study. *Ann Nutr Metab* 44(2):86
- Spierring BA, Kraemer WJ et al (2007). Responses of criterion variables to different supplemental doses of L-Carnitine L-Tartrate. *J Strength Cond Res* 21(1):259-264

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