



# L-CARNITINE

RESEARCH & REVIEW

A publication from Lonza – The world's leading raw material supplier of L-Carnitine

Issue 3

## From Optimal Performance to Optimal Recovery

### INTRODUCTION

L-Carnitine has been used by sports enthusiasts since the early 1980's. 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. Clinical research indicates that supplemental L-Carnitine is beneficial in terms of optimizing performance, delaying the onset of fatigue and enhancing the recovery process. Scientists have also observed that exercise actually leads to increased losses of L-Carnitine in urine<sup>1</sup>. 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 L-Carnitine supplementation may be warranted<sup>2</sup>. Supplemental L-Carnitine is also helpful in assuring that the heart receives the extra energy it needs during exercise. The positive effects of L-Carnitine are not restricted to endurance athletes; "weekend warriors" can also benefit. Lets take a closer look...

### L-Carnitine and Exercise Performance

*Clinical data indicates that L-Carnitine supplementation may be of value in optimizing exercise performance.*

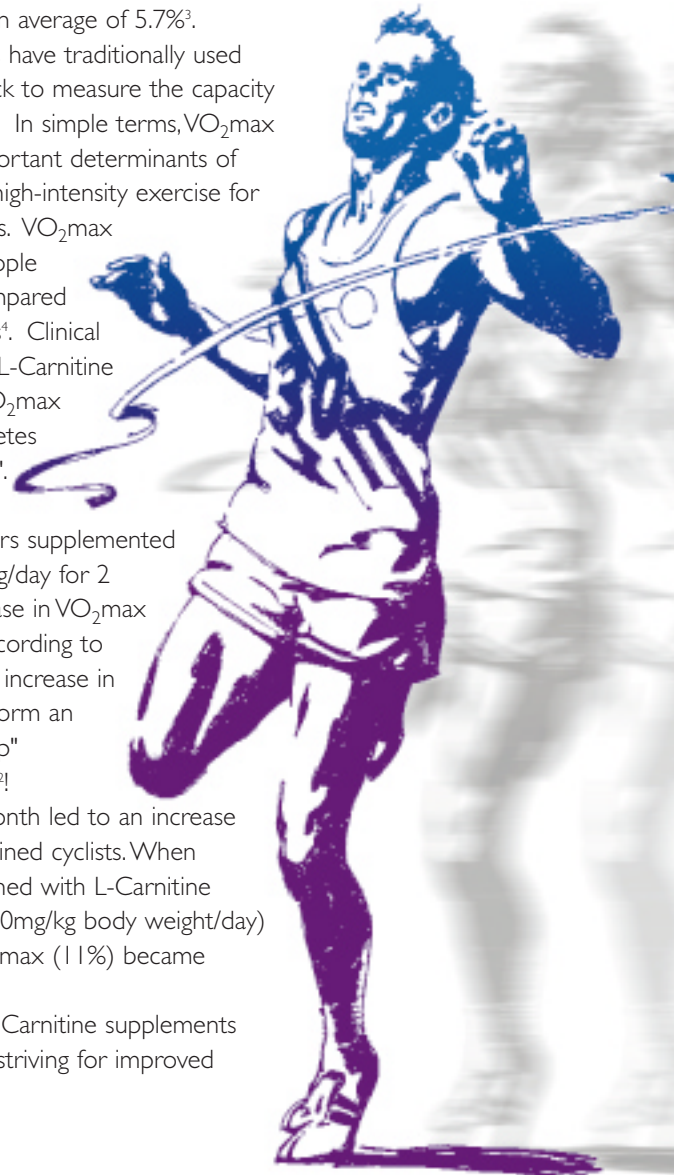
Whether you are in training for a competition or simply exercising to keep fit, the key lies in reaching the ultimate goal of optimized performance. A number of research reports indicate that L-Carnitine may be of value in enhancing exercise performance.

- In 1997, researchers reported that marathon runners who supplemented with L-Carnitine (2g/day for 6 weeks) increased their peak treadmill running speed by an average of 5.7%<sup>3</sup>.

Exercise physiologists have traditionally used  $VO_2max$  as the yardstick to measure the capacity for endurance exercise. In simple terms,  $VO_2max$  is one of the most important determinants of one's ability to sustain high-intensity exercise for longer than 4-5 minutes.  $VO_2max$  values are higher in people who are trained as compared to sedentary individuals<sup>4</sup>. Clinical research indicates that L-Carnitine can help to increase  $VO_2max$  in both endurance athletes and "weekend warriors".

- When competitive long distance walkers supplemented with L-Carnitine (4g/day for 2 weeks), a 6% increase in  $VO_2max$  was observed<sup>5</sup>. According to experts, even a 5% increase in  $VO_2max$  can transform an "average" into a "top" competitive athlete<sup>2</sup>!
- Training for one month led to an increase in  $VO_2max$  in untrained cyclists. When training was combined with L-Carnitine supplementation (50mg/kg body weight/day) the increase in  $VO_2max$  (11%) became significant<sup>6</sup>.

The bottom line – L-Carnitine supplements may be of value when striving for improved exercise performance!





## L-Carnitine and Exercise-Induced Fatigue

*Research suggests that L-Carnitine supplementation may help with delaying the onset of fatigue during exercise.*

It doesn't take a rocket scientist to realize that fatigue during exercise is undesirable as it ultimately compromises performance. Two key causes of fatigue during exercise are lactic acid accumulation and glycogen depletion.

**L-Carnitine and Lactic Acid:** During exercise, a substance known as lactic acid accumulates in the muscles and can eventually diffuse into the bloodstream. This is significant because fatigue is associated with the accumulation of lactic acid in the muscles and blood. The amount of lactic acid produced depends upon the exercise intensity and duration, as well as the person's level of fitness. For example, exercise involving high intensity legwork, such as running<sup>7</sup> or prolonged high intensity exercise such as a 20 km racewalk can lead to the accumulation of lactic acid and fatigue. Obviously a reduction in lactic acid accumulation during exercise is desirable, since this will delay the onset of fatigue. In this respect, various researchers have found promising results with L-Carnitine.

- In a double-blind crossover trial, ten moderately trained volunteers took 2g of L-Carnitine or placebo one hour prior to an intense cycling exercise. The rise in blood lactate was significantly reduced by L-Carnitine and was accompanied by an astounding 22.5% increase in working capacity<sup>8</sup>.
- In a similar study, researchers reported significantly decreased blood lactic acid levels, a significantly increased work output and a 7% increase in VO<sub>2</sub>max. They concluded that under the conditions of their experiment, L-Carnitine favors aerobic processes thereby resulting in a more efficient performance<sup>9</sup>.
- In a double blind placebo-controlled study involving elite rowers, L-Carnitine administration (3g/day for 3 weeks) resulted in significantly decreased lactic acid levels and significant increases in VO<sub>2</sub>max and strength index<sup>10</sup>.

**L-Carnitine and Glycogen Depletion:** Fat and carbohydrate are the two main fuels used to provide the energy required for exercise. Fat sources comprise of fatty acids derived from fat stores in muscle and adipose tissue while carbohydrate sources consist of blood glucose and muscle glycogen (many glucose molecules linked together). Depletion of muscle glycogen results in fatigue<sup>7</sup>. Intense activities that demand a high output of energy in a short time frame, such as sprinting, quickly deplete glycogen stores<sup>11</sup>. During prolonged exercise, e.g. a marathon, muscle glycogen stores can also become depleted<sup>4</sup>. 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 (2g/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 increased utilization of fat and a possible carbohydrate (glycogen) sparing effect and ultimately, should be associated with improved performance<sup>12</sup>.
- Similarly, in marathon runners who took L-Carnitine (2g/day for 6 weeks) a decline in the Respiratory Exchange Ratio was observed, again indicating a greater dependence upon fat utilization during endurance exercise<sup>3</sup>.

In summary, there is data to indicate that L-Carnitine is helpful in delaying the onset of fatigue. And remember: minimizing fatigue is one step toward maximizing performance<sup>11</sup>.

### Ideal for Sports Nutrition:

**L-Carnitine Magnesium Citrate (US Patent 5,071,874 and other international patents) is a non-hygroscopic, white powder which contains L-Carnitine, Magnesium (Mg) and Citrate. Mg is critical during exercise as it activates enzymes needed to release energy in the body. Low blood levels of Mg are implicated in muscle spasms and cramps, while supplementation has been shown to improve aerobic capacity and increase strength<sup>13</sup>. L-Carnitine Magnesium Citrate is highly stable, free from harmful D-Carnitine and combines L-Carnitine and magnesium in an ideal ratio!**

**L-Carnitine L-Tartrate (US Patent 5,073,376 and other international patents) is the most stable and preferred form of L-Carnitine in the marketplace. This non-hygroscopic, white crystalline powder is perfect for tablets and capsules. It contains 68% L-Carnitine USP and 32% tartaric acid (Generally Recognized as Safe by the FDA), has a pleasant fruity taste and is guaranteed to be completely free from harmful D-Carnitine, hence the brand name and sign of quality assurance, L-CARNIPURE<sup>®</sup>.**

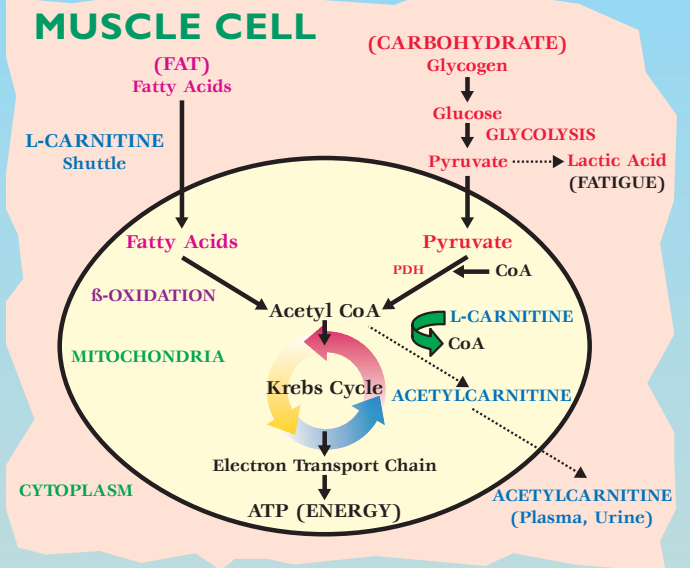
### DEBBI LAWRENCE: World's Fastest Walker!

Debbi Lawrence is a two-time U.S. Olympian and holds world and U.S. records in the sport of racewalking. A firm believer in L-Carnitine, during training Debbi takes 2.5 to 3 g of L-Carnitine L-Tartrate every morning. She increases the daily dose to 5g before a competition. Her reasons for supplementing are two-fold. Firstly, Debbi explains "with L-Carnitine I feel I have more energy, can exercise longer during my workouts and can see less body fat". Secondly, she is aware that as a vegetarian, she consumes lower than 'normal' levels of this nutrient. Here's wishing Debbi every success as she prepares for the 2000 Olympics!



Two-time Olympian Debbi Lawrence supplements daily with 2.5 - 3 g L-Carnitine L-Tartrate marketed under the brand name L-CARNIPURE<sup>®</sup>.

## How L-Carnitine Helps During Exercise



**Figure 1: Proposed Mechanism of Action of L-Carnitine during Exercise.**

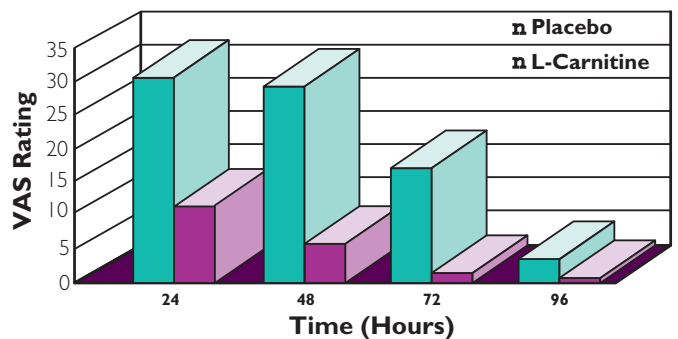
Muscle cells require a constant supply of high energy molecules (i.e. ATP) to provide the energy needed for exercise. The breakdown of fat ( $\beta$ -oxidation) and carbohydrates (glycolysis) ultimately results in the generation of ATP. According to scientific literature, L-Carnitine has a number of key roles in energy metabolism.

- L-Carnitine's primary function is to "shuttle" fatty acids into the mitochondria (energy producing organelles in the cell) where they can be broken down. Data from the studies discussed above<sup>3,12</sup> suggest that supplemental L-Carnitine can increase the rate of fatty acid breakdown during exercise, thereby causing a decrease in carbohydrate breakdown, i.e. glycogen can be spared. Sparing glycogen can potentially delay the onset of fatigue.
- L-Carnitine's secondary function affects the acetyl CoA/CoA ratio within the mitochondria. Acetyl CoA is a two carbon compound; CoA is a vitamin B derivative<sup>4</sup>. Supplemental L-Carnitine can react with some of the excess acetyl CoA groups which accumulate during strenuous exercise, thereby producing acetylcarnitine. This lowers the acetyl CoA/CoA ratio which in turn activates the enzyme pyruvate dehydrogenase (PDH). PDH causes some pyruvate to be converted to acetyl CoA as opposed to lactic acid<sup>8,9</sup>. This is a good effect because less lactic acid production can mean delayed fatigue.
- When supplemental L-Carnitine reacts with the excess acetyl CoA groups to form acetylcarnitine, free CoA is released. Free CoA is necessary for continuous operation of the Krebs cycle. Furthermore, stimulating PDH enhances flow through the Krebs cycle and consequently  $VO_{2max}$  (the capacity for aerobic regeneration of ATP<sup>9</sup>) is increased<sup>2,5</sup>. Recall an increased  $VO_{2max}$  can mean increased performance.

## L-Carnitine and Recovery

We all know the feeling – enthusiastically you set out for a hike in hilly countryside or your first step aerobics class and the next day your legs are so tender and stiff that you can barely hobble! What you are actually suffering from is called Delayed Onset Muscle Soreness (DOMS). DOMS is the sensation of discomfort or pain in the skeletal muscles that occurs following unaccustomed muscle exertion and appears to be due to tissue injury caused by excessive mechanical forces exerted upon muscle and connective tissue. The muscle soreness normally increases in the first 24 hours after exercise, peaks in 1-3 days and then subsides<sup>14</sup>. According to clinical research, L-Carnitine may be of assistance in alleviating the pain and tenderness following exercise.

- In untrained subjects, L-Carnitine supplementation (3g/day for 3 weeks) as compared to placebo, significantly reduced muscle pain (Figure 2) and tenderness after exercise and decreased muscle damage<sup>5</sup>.



**Figure 2: Post-exercise Visual Analogue Scale (VAS) following L-Carnitine or placebo supplementation (3g/day for 3 weeks). A lower VAS rating indicates less spontaneous pain<sup>15</sup>.**

### Proposed Mechanism of Action of L-Carnitine

The protective effect of L-Carnitine has been partly ascribed to its ability to deliver more blood and consequently more oxygen to the muscle during the early stages of exercise, thereby improving energy metabolism. This property of L-Carnitine is also important when the muscle has actually been damaged as it will help in the repair process and in washing out the substances responsible for producing the painful symptoms<sup>15</sup>.



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## L-CARNITINE

### and so to conclude...

Not only is L-Carnitine an important supplement for the heart, it also holds promise in terms of exercise performance, fatigue and recovery for both the well-trained athlete, who can possibly be at risk of L-Carnitine deficiency due to increased urinary losses and the untrained "weekend warrior". In fact, it may be suggested that L-Carnitine has a "training-like" effect in "weekend warriors" as it can help to enhance performance, delay fatigue and even alleviate a painful recovery. So, whether or not you are in training for the Olympics, L-Carnitine has something for everyone!

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**Lonza**, the leading manufacturer and supplier of the bulk dietary supplement L-Carnitine, is the only supplier who can guarantee 100% pure, natural L-Carnitine - totally free from toxic D-Carnitine. Our L-Carnitine is Kosher certified and is found in infant formula, multivitamins and a wide variety of health products.

#### Lonza offers the following four forms of L-Carnitine:

L-Carnitine USP Free Base, our unique and patented L-Carnitine L-Tartrate (US Patent 5,073,376 and other international patents), L-Carnitine Magnesium Citrate (US Patent 5,071,874 and other international patents) and Acetyl-L-Carnitine.

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This newsletter has been reviewed by **Dr. William Kraemer, Director, Human Performance Laboratory, Ball State University, IN, USA.**