

## Editorial

# Carnitine as an Ergogenic Aid in Health and Disease

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Athletes are particularly vulnerable to the lure of improved performance via supplementation. Various nutritional strategies have been employed in an effort to improve endurance and some, like carbohydrate loading, are proven to be beneficial for many [1]. Similarly, those with chronic diseases may seek nutritional remedies which allow them to function on a higher level during daily activities.

The publication by Brass and coworkers in this issue of the *Journal of the American College of Nutrition* [2] summarizes the current body of knowledge regarding the effects of carnitine supplementation on exercise performance. Carnitine is required for fatty acid oxidation, and therefore many studies have evaluated its potential as an ergogenic aid during exercise. The review is a concise treatise of carnitine's effects in both healthy individuals and in those with health limitations, specifically in renal and peripheral arterial disease.

Brass et al argue that carnitine supplementation is unlikely to be an effective enhancer of exercise performance in healthy individuals. Five studies are cited which evaluated carnitine's effect upon maximal oxygen consumption [ $VO_{2max}$ ] in healthy men. Although there may have been methodological flaws in some of these studies, three of the five did show an increase in  $VO_{2max}$ . None of the studies which evaluated changes in  $VO_{2max}$  included women in the test populations.

Maximum oxygen consumption, the surrogate indicator of training used by Brass et al, is determined by cardiac output and the arterial to venous oxygen difference. Metabolic efficiency or substrate utilization is not a primary determinant of maximum oxygen consumption. Further, it is clear that performance in largely aerobic events is dependent upon factors such as oxygen consumption or work load at the anaerobic threshold, sparing of substrate [glycogen], and economy of movement [3]. Cumulatively these variables will determine how long a given workload can be maintained. Additionally, prolonged exercise performance is dependent to a great degree on the ability to metabolize fat [4–6], and this is where carnitine metabolism may become more important. The review by Brass and colleagues is limited in giving serious consideration only to those studies which measured  $VO_{2max}$  as an indicator of carnitine's ergogenic effects. It may be premature, therefore, to render an opinion regarding carnitine's potential to improve exercise performance in healthy humans. Clearly the need for adequate periods of supplementation, randomization and double blinding

are of paramount importance in evaluating any role carnitine may have in submaximal aerobic exercise performance.

Carnitine's role in certain disease states is intriguing. In renal disease carnitine handling is perturbed, and carnitine status may be particularly impaired in dialysis patients. Many of the metabolic deficiencies of chronic dialysis patients are poorly understood and unrecognized. A few studies have indicated an improvement in muscle function in hemodialysis patients following supplementation. The review by Brass et al indicates that carnitine supplementation may also be of use in patients with peripheral arterial disease [PAD], a condition estimated to effect 12% of the population [7]. Four studies are cited which demonstrated improved treadmill performance or improved function during daily activities in PAD patients following carnitine supplementation. Notably, the maximal capacity of these patients is typically limited by pain long before they attain a physiological, vis-à-vis volitional, maximum oxygen consumption.

Carnitine's role in oxidative metabolism makes it attractive as a possible ergogenic aid. As Brass and colleagues point out in their review, previously conducted studies in healthy individuals have often been methodologically flawed. Further research is indicated which includes more heterogenous test populations and which examine other performance measures, such as time to fatigue at submaximal workloads. The review does not present information regarding the safety of carnitine supplementation in the typically prescribed dosage of 1 to 3 g/day [8], and it is not clear if this issue has been adequately addressed in the scientific literature. Nonetheless, the possibility of carnitine supplementation as a relatively inexpensive, convenient and safe means of improving exercise tolerance and quality of life in chronically ill patients is promising. The research that has been done thus far in PAD and dialysis patients is limited and more studies are needed to confirm the ergogenic potential of carnitine in populations with these and similar afflictions.

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