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The Effect of L-Carnitine Supplementation on Sportive Performance

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Abstract: L-carnitine is a derivative of two essential amino acids synthesized in the liver and kidneys that our body needs for energy. In the bioenergetics of skeletal muscle, carnitine plays crucial roles. A severe reduction in muscular activity is associated with skeletal muscle carnitine insufficiency. Since L-carnitine supplement is known as a fat burner, its use among athletes has become more common in recent years. This review's objective is to assess the potential mechanistic effects of L-carnitine supplementation on athletic performance. In this context, the literature in the SportDiscus, EMBASE, PubMed and Google Scholar databases was scanned during a 15-year period to gather the data from the publications screened within the scope of SCI, SCI-Expanded, and ESCI. Consequently, it may be argued that taking carnitine supplementation improves athletic performance through a number of processes; including the maintenance of glycogen.

Keywords: Fat burner, L-carnitine, Exercise

Introduction

Dietary supplements are frequently used by competitors to preserve health and improve their performance in sports. There are many claims about L-carnitine, especially among sports supplements. Following rumors that it assisted the Italian national soccer team in winning the world championship in 1982, L-carnitine gained popularity. It is frequently referred to as a "fat burner" because it is said to increase the aerobic capacity by increasing fat oxidation and muscle mass while decreasing fat mass (Karlic & Lohninger, 2004). L-carnitine ß-hydroxy-gamma-trimethyl amino butyric acid is a derivative of two essential amino acids synthesized in the liver and kidneys that our body needs for energy (Mohammadi et al., 2016). Carnitine, synthesized from the amino acids lysine and methionine, has two forms: L-carnitine (biologically active) and D-carnitine (inactive). Carnitine is necessary for the transport of fatty acids to the mitochondria to be used in ATP synthesis. Since excess carnitine is stored in the body, it is always present in sufficient amounts in the muscles, and its deficiency is not possible (Roseiro & Santos, 2019).The largest source of L-carnitine in the body is found in skeletal muscles, where levels are typically around 50 and 200 fold greater than in the bloodstream (41 µM/L for females and 50 µM/L for males) (Ramsay et al., 2001). L-carnitine is also present in a variety of meals, although red meats like beef and lamb are the finest sources of carnitine. Besides meat, fish, poultry, and milk are also acceptable sources of carnitine (Pekala et al., 2011). Solely the bile and urine, where it has been shown that long-chain acyl derivatives congregate, are capable of excreting carnitine from the body (Ramsay et al., 2001).

Additionally, glycine propionyl-l-carnitine (GPLC), a new form of propionyl-l-carnitine (PLC) with diverse biological effects, has lately been used as a nutritional supplement (Mingorance et al., 2011). L-carnitine research in active, healthy populations has produced conflicting findings. More data supported by science are required to fully understand how L-carnitine can improve sportive performance (Koozehchian et al., 2018). For that, the aim of this review is to explain the mechanisms through which L-carnitine supplementation contributes to athletic performance.

Increasing Effect on the Use of Fatty Acids

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Muscle metabolism uses mitochondrial fatty acid oxidation as a substantial source of energy, especially while performing exercise. Unfortunately, it seems like there is a limited amount of free L-carnitine available in the mitochondria throughout this process, particularly during intense activity. Thus, as exercise intensity increases from moderate to high, fatty-acid oxidation considerably declines. Given the significance of fatty acids in muscle bioenergetics and free carnitine's limiting effect on the oxidation of fatty acids during endurance exercise, supplementing with L-carnitine has been suggested as a way to enhance athletic performance (Muscella et al., 2020).

The main function of L-Carnitine is to transport long-chain fatty acids to the mitochondria for use in energy production. The cytosolic fatty acid form is long chain Acyl co-A (GovindShukla et al., 2019). L-carnitine acts as a substrate for the enzyme carnitine palmitoyltransferase and the production of acetylcarnitine, both of which are important for preserving a viable reserve of free coenzyme A (CoA) and sustaining flow through the tricarboxylic acid cycle (Wall et al., 2011). A group of enzymes known as carnitine acyltransferases (CATs) regulates the pool of acetyl-CoA and long-chain acyl-CoA in various sections, which is essential for maintaining energy homeostasis and fat metabolism (Colucci & Gandour,1988).Both the outer mitochondrial membrane (CPT I) and the matrix of mitochondria (CPT II) include carnitine palmitoyltransferases (CPT), which favor long chain acyl-CoAs as a type of substrate (Van der Leij et al., 2000). CPT1 converts long chain Acyl co-A to Acyl carnitine. Free L-carnitine is restricting the CPT1 reaction as a result of its buffering function (GovindShukla et al., 2019).

The passage of acyl carnitine across the mitochondrial inner membrane is mediated by mitochondrial translocase enzymes. Acyl Carnitine is converted into free carnitine and acyl-CoA by CPT2 (carnitine palmitoyl transferase II). Acyl-CoA undergoes beta oxidation, the resulting acetyl-CoA is included in the Krebs cycle. The energy is produced as a result of a series of reactions. Carnitine also helps convert pyruvate into citric acid in the mitochondria. It also regulates the activities of the pyruvate dehydrogenase enzyme and the adenine nucleotide translocase enzymes that control the ATP/ADP exchange within the mitochondria. Free carnitine then returns to the plasma and can react with a new long chain acyl-CoA. Based on this information, it has been reported that L-carnitine improves muscle endurance capacity by increasing fatty acid oxidation and energy consumption. (GovindShukla et al., 2019).

Glycogen Sparing Effect

The primary substrates for sustaining extended muscular contractions during endurance exercise are known to be carbohydrates and fat (Cermak & van Loon, 2013).Although carnitine is famous for its fat-burning properties, emerging evidence shows that it is also important in carbohydrate metabolism. It is clear that there is a strong correlation between muscle carnitine and the activity of the Krebs cycle, a very important in carbohydrate metabolism. The concentration of carnitine in muscle has been found to be directly proportional to muscle glycogen stores. Carnitine can act as a catabolic agent due to its 'glycogen sparing' effect to improve energy production from fats, effectively reducing the need to burn glycogen (Mojtaba et al., 2009). Simply put, a glycogen sparing effect makes more glycogen available later in physical activity, preserving plasma glucose availability and transport to the muscle to satisfy the CHO oxidation rates essential for maintaining the required activity (Jeukendrup et al., 1997). As a result of the first in vivo study**,** by modifying the acyl-CoA/CoA ratio, L-carnitine, regulates the activity of pyruvate dehydrogenase. Additionally, it inhibits the metabolism of carbohydrates, which eventually has the effect of sparing glycogen (Huelsmann et al., 1964).

Preventing Effect on Lactate Accumulation

L-carnitine is crucial for transferring long-chain fatty acids over the mitochondrial membrane and into the cells. Thus, it causes fatty acid oxidation to rise. High-intensity exercise can result in the production of acetyl-CoA and carnitine, which can combine to form acetyl L-carnitine and lower the acetyl-CoA to CoA ratio. It might lead to a reduction in the levels of lactate and a rise in pyruvate dehydrogenase activity. The transformation of acetyl-CoA to free CoA ratio rises during vigorous exercise, which causes more lactate to accumulate. Acetyl L-carnitine is created when L-carnitine and acetyl-CoA combine to adjust this proportion, resulting in less lactate buildup (Karlic & Lohninger, 2004).

Logically increased pyruvate dehydrogenase complex flux during intense activity would be anticipated to decrease blood lactate buildup, which may possibly protect glycogen stores and delay exhaustion (Spriet & Heigenhauser, 2002). Additionally, it's thought that L-carnitine could lessen lactate generation by preserving the pyruvate dehydrogenase complex’s enzymatic activity via a buffering process, lowering the acetyl-CoA/CoA balance (Barnett et al., 1994). Due to the steady pyruvate dehydrogenase complex flux and stable acetyl CoA/CoA ratio, L-carnitine has been found to minimize lactate buildup (Siliprandi et al., 1990).

Briefly, the main substrate in anaerobic activity is carbohydrate, and pyruvate is converted to lactate by lactate dehydrogenase, which affects sportive performance. The ratio of CoA to acetyl-CoA in mitochondria causes increased activity of the enzyme pyruvate dehydrogenase and eventually reduces lactate production. Carnitine increases pyruvate dehydrogenase activity and reduces lactate density, preventing fatigue (Arazi & Mehrtash, 2017).

Antioxidant Effect

The muscles in the skull are thought to have a major role in the oxidative stress brought on by exercise. This is while exercise increases the production of reactive oxygen species (ROS) and free radicals since movement is created by the skeletal muscles contracting continuously (Powers & Jackson, 2008). The primary factor contributing to the reduction in the NADH/NAD ratio in mitochondria appears to be contraction activity, which alters the redox state of muscles to one that is more oxidative (Sakellariou et al., 2014). Multiple ways that carnitine can support the body's antioxidant defenses. First, directly scavenging free radicals. It manifests this function by forming complexes with Fe^{+2}, which accelerates the synthesis of reactive oxygen species, reducing iron levels and preventing lipid peroxidation (Powers & Jackson, 2008).

Second, by avoiding the creation of free radicals by blocking specific enzymes that produce free radicals or by preserving the integrity of the electron-transport chain in stressed mitochondria.The capacity of L-carnitine to control free radical-producing enzymes like NADPH oxidase, an oxidoreductase that produces ROS by transferring electrons from NADPH to molecular oxygen, is what gives it its antioxidant effects (Carillo et al., 2020).According to studies, L-carnitine inhibits Protein Hinase C (PKC) in a dose-dependent manner, which in turn transforms NADPH's phosphorylation state to that of a significant cytosolic component (Martins et al.,2002 ;Pignatelli et al., 2003).

Finally, by actively stimulating a variety of antioxidant enzymes and non-enzymatic antioxidants, mostly through transcription factors like Nrf2 and NF-B, to contribute to the preservation of the cell's ideal redox status.(Powers & Jackson, 2008). Currently, it has been established that the antioxidant activity of carnitine appears to be caused by the cellular control of antioxidant enzymes through the stimulation of the NF-B/IB system. According to an animal study examining the antioxidant effect of carnitine supplements, in the renal cortex of hypertensive rats compared to control rats, Nrf2, PPAR, and NF-kB expression were shown to be lower (0.3, 0.8, and 13-fold, respectively), but NF-kB expression was higher (Zambrano et al., 2013).

Method

The literature in the SportDiscus, EMBASE, PubMed and Google Scholar databases was scanned during a 15-year period to gather the data from the publications screened within the scope of SCI, SCI-Expanded, and ESCI for this review with ‘’l-carnitine’’AND ‘’sportive performance supplements’’AND ‘’carnite use’’ keywords. The selected research were carefully reviewed, and an attempt was made to describe the ergogenic effects of L-Carnitine.

Conclusion

L-carnitine is a physiologically diverse component of an amino acid that comes in a variety of forms (Mingorance et al., 2011). In line with the research, it has been reported that carnitine supplementation can contribute to sports performance through mechanisms such as the maintenance of glycogen reserves, prevention of lactate buildup, increased antioxidant activity, and the utilization of fatty acids (GovindShukla et al., 2019). All of these factors suggest that -L-carnitine intake may have diverse impacts on various physiological and metabolic pathways, enhancing athletic performance during both medium and intense workouts (Pekala et al.,2016). To more fully examine L-carnitine’s potential role in sportive performance, however, more research is necessary.

Recommendations

To begin with, even though L-carnitine is not technically a "banned" supplement, it is essential to confirm compliance with current WADA guidelines before a top athlete utilizes any supplement. The recommended L-carnitine dosage to improve exercise performance appears to be between **1 and 5 g**. L-Carnitine is non-toxic up to 15 g and has no side effects. Excessive amounts of L-carnitine (over 15 g) supplementation causes diarrhea. It has been reported that the bioavailability of L-carnitine is higher when taken naturally from foods compared to supplement form. Shortly, L-carnitine plays a role in energy synthesis and use; as such, it can be used as a sportive supplement for endurance during athletic competition.

Scientific Ethics Declaration

The author declares that the scientific ethical and legal responsibility of this article published in EPHELS journal belongs to the author

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