Science & Sports (2016) 31, 177—188

Disponible en ligne sur ScienceDirect www.sciencedirect.com

Elsevier Masson France EM|consulte www.em-consulte.com

REVIEW

Role of L-carnitine in sports performance: Focus on ergogenic aid and antioxidant

Rôle de la L-carnitine dans la performance sportive : focus sur ergogène et antioxydant

D.J. Sung[a], S. Kim[b], J. Kim[c], H.S. An[d], W.-Y. So[e,*]

[a] *Division of Sport Science, College of Science and Technology, Konkuk University, Chung-Ju, Republic of Korea*
[b] *Deparment of Physical Education, Global Campus, Kyung Hee University, Suwon, Republic of Korea*
[c] *Health and Rehabilitation Major, College of Physical Education, Kookmin University, Seoul, Republic of Korea*
[d] *School of Health, Physical Education and Recreation, University of Nebraska at Omaha, Omaha, NE, USA*
[e] *Sports and Health Care Major, College of Humanities and Arts, Korea National University of Transportation, Chungju-si, Republic of Korea*

Received 8 October 2015; accepted 17 February 2016
Available online 2 May 2016

KEYWORDS
L-carnitine;
Sports performance;
Reactive oxygen species;
Oxidative stress

Summary
Objectives. — The purpose of this review is to examine the antioxidant effects of L-carnitine (LC) and to highlight its potential application in sports nutrition and exercise performance.
News. — The benefits of exercise include reduced mortality and decreased prevalence of diseases including cardiovascular disease, diabetes, cancer, and metabolic disease. However, exercise can induce overproduction of reactive oxygen species (ROS) through diverse pathways that decrease skeletal muscle contraction. In addition, overproduction of ROS can negatively affect physical performance by inversing force production of skeletal muscles, initiating quick prompting of fatigue, and causing oxidation-induced damage by lipid and protein peroxidation.
Prospect. — LC is an endogenous substance that is necessary for the β-oxidation of fatty acids, and has mainly been studied in the field of sports nutrition because of its glycogen-sparing effect. LC achieves this effect by promoting inhibition of glycolysis, increasing fatty acid metabolism, and acting as an ergogenic aid to delay fatigue and improve physical performance. Results from a recent study suggested that LC consumption was advantageous in inhibiting oxidative stress and activating endogenous antioxidant activity through its role as an antioxidant. However, research on the antioxidant role of LC in the field of exercise science and sports nutrition is currently insufficient.

* Corresponding author. Office: 82 43 841 5993; Fax: +82 43 841 5990.
E-mail address: wowso@ut.ac.kr (W.-Y. So).

http://dx.doi.org/10.1016/j.scispo.2016.02.005

Conclusion. — This review discusses research findings on ROS regulation of LC from both basic and sports science fields. It will highlight the role of LC as an antioxidant and ergogenic aid to improve physical performance and control oxidative stress.

MOTS CLÉS
L-carnitine ;
Performance sportive ;
Espèces réactives de l'oxygène ;
Stress oxydatif

Résumé
Objectifs. — Le but de cette étude est d'examiner les effets antioxydants de la L-carnitine (LC) et de mettre en valeur son potentiel d'application dans la nutrition sportive et de la performance de l'exercice.
Actualités. — Les bienfaits de l'exercice se traduisent par une réduction de la mortalité et une diminution de la prévalence de maladies, notamment les maladies cardiovasculaires, le diabète, le cancer et les maladies métaboliques. Toutefois, l'exercice peut induire une surproduction d'espèces réactives de l'oxygène (ROS) à travers diverses voies qui diminuent la contraction du muscle squelettique. En outre, la surproduction de ROS peut affecter négativement la performance physique en modifiant les qualités des muscles squelettiques et en causant des dommages induits par l'oxydation des lipides et la peroxidation des lipides.
Perspectives. — LC est une substance endogène qui est nécessaire pour l'oxydation des β-acides gras, et a été principalement étudiée dans le domaine de la nutrition sportive en raison de son effet d'épargne du glycogène. LC réalise cet effet par la promotion de l'inhibition de la glycolyse, en augmentant le métabolisme des acides gras, et agissant comme une aide ergogénique au retard de la fatigue et à l'amélioration des performances physiques. Les résultats d'une étude récente suggèrent que la consommation de LC était avantageuse dans l'inhibition du stress oxydatif et l'activation de l'activité antioxydante endogène grâce à son rôle d'antioxydant. Cependant, la recherche sur le rôle antioxydant de LC dans le domaine de la science de l'exercice et la nutrition sportive est actuellement insuffisante.
Conclusion. — Cette revue présente les résultats de recherche sur la réglementation des ROS LC dans les domaines des sciences fondamentales et sportives. Elle mettra en évidence le rôle de la LC comme un antioxydant et ergogène pour améliorer la performance physique et contrôler le stress oxydatif.

1. Introduction

Regular exercise has many health benefits, including reduced mortality and decreased prevalence of diseases such as cardiovascular disease, cancer, and diabetes. Paradoxically, exercise can promote producing oxidative stress [1—3]. Oxidative stress to cells induced by an increase of reactive oxygen species (ROS) is associated with cancer, diabetes, and neurological disorders [4—7]. Various tissues can generate ROS during exercise. Skeletal muscle in particular is the main contributor to the generation of ROS and free radicals [8]. ROS and oxidative stress are closely associated with skeletal muscle contraction, force production, and fatigue. ROS generation induced by skeletal muscle contraction causes reduced force production [9] and increased fatigue [10,11]. As a result, excessive ROS generation can have a negative effect on physical performance. This can be prevented by antioxidative effects of endogenous antioxidants and exogenous ergogenic aids. Various candidates including vitamin A, vitamin C, vitamin E, nitrate, and flavonoids have been studied as useful antioxidants. Although L-carnitine (3-hydroxy-4-trimethylammoniobutheic acid; LC) has been considered as an antioxidant candidate, the specific role of LC in combatting oxidative stress has not been investigated in the field of sport science. This review aims to illuminate the antioxidant role of LC, clarify its effects on physical performance, and provide insight for its application in the field of sports nutrition.

2. Overview of L-carnitine and exercise performance

LC was discovered in 1905. It was characterized by its white color and water solubility [12]. LC is endogenous, and controls the oxidation of long-chain fatty acids (LCFAs). The precursor of LC, ε-N-trimethyllysine, is formed from essential amino acids lysine and methionine. It is synthesized in the liver and kidneys with coenzymes including vitamin C, vitamin B3, vitamin B6, folic acid, and iron [13]. The accumulation of LC within the body occurs mainly (approximately > 95%) in the muscles [14]. Individuals without LC deficiencies have about 20—25 g of accumulated LC. Daily levels of LC excreted from the body require supplementation of 200—500 mg of LC per day [13] that can be sufficiently achieved through intake of red meat like beef [15].

The main functions of LC established through sports science research include increased fat oxidation, glycogen-sparing effects through acceleration of β-oxidation by LCFAs, and delayed fatigue accumulation [16]. LC increases the energy dependence of fatty acids by suppressing enzymes that influence the dissolution of glucose and