EFFECT OF L-CARNITINE INTAKE ON EXERCISE PERFORMANCE AMONG ATHLETES: A SCOPING REVIEW

MATIUSDAS S/O MARIADAS

SCHOOL OF HEALTH SCIENCE

UNIVERSITI SAINS MALAYSIA

2021

DECLARATION

I hereby declare that this dissertation is the result of my investigations, except where otherwise stated and duly acknowledged. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at Universiti Sains Malaysia or other institutions. I grant Universiti Sains Malaysia the right to use the dissertation for teaching, research and promotional purposes.

Matius Das Mariadas

Date: 29 July 2021

ACKNOWLEDGEMENTS

First of all, I would like to thank God for providing me strength, courage and patience to complete this study.

I would like to express my sincere appreciation to my Supervisor, Dr. Mohd Rahimi Che Jusoh for providing me the support and advice to complete this study. I am indeed very thankful for his dedication and knowledge with so much of patience, guidance, and encouragement towards me.

I would like to express my appreciation to Dr. Nur Syamsina binti Ahmad, for guiding and teaching the process on how to do the scoping review study. At this moment, not forgetting the supportive lecturers in Exercise and Sports Science who encouraged me throughout the journey of this study.

Finally, I am very grateful to have my parent as my pillar of strength throughout the journey in my life. My father, Mariadas Belamindas and my mother, Jabamalai Seenapan, have always been supporting and giving me love, care and concern not only during completing this study, but throughout the span of my study in Universiti Sains Malaysia, Kubang Kerian, Kelantan. Not forgetting my firiends and classmates who encouraged and cheered me during this study.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

KESAN PENGAMBILAN L-KARNITIN TERHADAP PRESTASI SUKAN: KAJIAN SKOP

ABSTRAK

L-karnitin adalah salah satu bahan ergogenik yang biasa digunakan dalam bidang sukan, dan keberkesanannya disokong oleh bukti-bukti kukuh yang menunjukkan pengambilan L-karnitin meningkatkan prestasi sukan terutamanya dalam aktiviti aktiviti aerobik. Kajian berkaitan dicari secara elektronik melalui pangkalan data berikut: EbascoHost, JSTOR, SpringerLink dan Cambridge. Analisis dilakukan sesuai dengan kriteria Item Pelaporan Pilihan untuk Ulasan Sistematik dan Analisis Meta (PRISMA). Dari 11 kajian yang dikaji, semua kajian dilakukan pada manusia. Skop kajian dari artikel yang diambil itu terutama mengenai kesan penggunaan L-karnitin terhadap prestasi sukan. Jumlah bilangan peserta untuk semua 11 artikel adalah 176 peserta. Rekabentuk kajian dalam semua artikel yang dikaji terdiri daripada percubaan terkawal plasebo secara rawak dan reka bentuk silang ‘double-blind’.

EFFECTS OF L-CARNITINE INTAKE ON SPORTS PERFORMANCE: A SCOPING REVIEW

ABSTRACT

L-carnitine is one of the most common ergogenic compounds used in sports, and its efficacy is supported by a strong body of evidence that demonstrated improvement in sport performance especially in aerobic activities. Therefore, this review aims to determine the effect of caffeine consumption on sports performance, types and dosage of caffeine consumed and the timing of its consumption among athletes and physically active individuals. Related studies were searched electronically using the following databases: EbascoHost, JSTOR, SpringerLink and Cambridge. The analysis was done in compliance with the criteria of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). From the 11 studies reviewed, all the studies were conducted on humans. The scope of study from those retrieved articles was primarily on the effects of L-carnitine consumption on sports performance. The total number of participants for all the 11 articles are 176 participants. The study design in these reviewed articles include randomised placebo-controlled trial and double-blind cross-over design.

CHAPTER 1

INTRODUCTION

1.1 Background of the Topic

L-carnitine is a naturally occurring amino acid derivative that is often taken as a supplement. It is derived from an amino acid which is found in nearly all cells of the body. It is used for weight loss and may have an impact on brain function. This occurs by transporting of long-chain fatty acids into the mitochondrial matrix for their conversion in energy, via β-oxidation process. However, popular claims about supplements do not always match up with the science (Mawer, 2018). It plays a crucial role in the production of energy by transporting fatty acids into the cells' mitochondria. The mitochondria act as engines within the cells, burning these fats, oxidizes them and changes it into usable energy. Besides that, the reaction of L-carnitine with acetyl-CoA and maintaining the acetyl-CoA/CoA ratio in the cell regulates pyruvate dehydrogenase activity. L-carnitine also plays an important role in the regulation of metabolic pathways involved in skeletal muscle protein balance: proteolysis and protein synthesis. Furthermore, L-carnitine acts as an anti-inflammatory compound; thus, it may attenuate the exercise-induced muscle damage. The body can produce L-carnitine out of the amino acid which is lysine and methionine. In addition to the L-carnitine produced in the body, it can be obtained in small amounts by eating animal products like meat or fish. Vegans or people whom practicing vegetation diet may be unable to produce or obtain sufficient amount of L-canitine

(Mawer, 2018). This makes L-carnitine a conditionally essential nutrient. L-carnitine, also known as levocarnitine plays a critical role in energy production, as it converts fat into energy. As well as supporting energy production, L-carnitine helps some other functions in the body, such as maintaining general brain function and reducing the risk of certain disorders (Wilson, 2020).

L-carnitine generally is used as a supplement by recreationally active, competitive and highly trained athletes because besides L-carnitine helps in transportation of long-chain fatty acids into the mitochondrial matrix for their conversion in energy, via beta-oxidation process, it also acts as an ergogenic aid to delay fatigue and improve physical performance (Sung. D. J., Kim, S., & Ahn, H., 2016).

L-carnitine is a more common form of carnitine which is produced in the body. There are also other forms of carnitine which include acetyl L-carnitine (ALCAR). This form of L-carnitine is the most effective form for human brain. It possesses neuroprotective properties that may help to protect the nervous system. L-tatrate is most common and widely used by athletes as supplements. Most of the scientific studies suggests that L-carnitine beneficial to minimize muscle soreness and aid recovery after exercise (Mawer, 2018).

L-carnitine can be found minimally in daily dietary intake. Some of the best recommended of L-carnitine sources are beef (81mg per 3 ounces or 85g), pork (24mg per 3 ounces or 85g), fish (5mg per 3 ounces or 85 mg), chicken (3mg per 3 ounces or 85 g), (8mg per 8 ounces or 227ml) and cheddar cheese (2mg per 2 ounces or 57g). As most of the food that contains L-carnitine are derived from animal or their product, people who are vegetarian may have deficiency of L-carnitine (Mawer, 2018).

L-carnitine has been investigated as ergogenic aid for enhancing exercise capacity in the healthy athletic population. Early research indicates its beneficial effects on acute physical performance, such as increased maximum oxygen consumption and higher power output. Later studies have pointed out the positive impact of dietary supplementation with L-carnitine on the recovery process after exercise. (Fielding, Riede, & Lugo, 2018). A previous study had shown a decrease in markers of purine catabolism and free radical generation and muscle soreness as a result of L-carnitine supplementation. Direct assessment of muscle tissue damage via magnetic resonance imaging also indicates the ability of L-carnitine to attenuate tissue damage related to hypoxic stress. L-Carnitine is regarded as a safe supplement for athletes and has been shown to positively impact the recovery process after exercise (Huang, & Owen, 2012). The variabilities of the studies vary by the dosage and timing protocol of the L-carnitine intake. Therefore, the aim of this review is to determine the effect of L-carnitine on sport performance among elite athletes, dosage of the supplementation and optimum timing to enhance sport performance among athletes.

Considering that carnitine is necessary for the transmembrane fatty acid transport, changes in the muscle free carnitine availability may contribute to the regulation of fatty acid oxidation. Generally, intramitochondrial acetyl-CoA can be generated by both fatty acid β-oxidation and by the activity of the multi-enzymatic complex of the pyruvate dehydrogenase, from the glycolytic pyruvate. Mitochondrial acetyl-CoA can be buffered by conversion in acetyl-carnitines by the ACS enzyme. When acetyl-CoA is generated over its metabolism in the tricarboxylic acid cycle, high amount of muscle free carnitine can be entrapped in the form of acetyl-carnitine thus decreasing the free carnitine pool (Gnoni, Longo, Gnoni, & Gludetti, 2020)

1.2 Problem Statement

To date, many scientific studies on L-carnitine have been designed and conducted with various staggering variables such as differences in sample size, dosage, training status, gender, sports, exercise performance testing. However, there are several issues in those studies that needed to be addressed such as sport performances involving aerobic and anaerobic exercises, dosage and timing of L-carnitine intake by the participants.

1.3 Objectives of the Review

Main objective:

The main objective of the review is to identify the effect of L-carnitine intake on sport performance among athletes.

Specific objective:

i. To identify the effect of L-carnitine intake on aerobic performances among athletes
ii. To identify the effect of L-carnitine intake on anaerobic performances among athletes
iii. To identify the optimum dosage and timing of L-carnitine intake to improve exercise performance among athletes.

1.4 Research Questions of the Review

i. What is the effect of L-carnitine intake on aerobic and anaerobic performances among athletes?

ii. What is the optimum dosage and timing of L-carnitine intake to improve the exercise performance among athletes?

1.5 Significance of the Review

L-carnitine is one of the supplements that has been generally taken by athletes from various sports to enhance the sports performance in various forms and dosages. In previous scientific studies on L-carnitine supplementation, the mixing of dosage and timing exerts different results in exercise performance variables. Thus, the information obtained from this review is important for elite athletes to determine the dosage and timing of L-carnitine to improve exercise performances.

CHAPTER 2

LITERATURE REVIEW

2.1 The effect of L-carnitine intake on aerobic and anaerobic performances among elite athletes

Previous studies have shown that carnitine supplementation may foster exercise performance. As reported in the majority of studies, an increase in maximal oxygen consumption and a lowering of the respiratory quotient indicate that dietary carnitine has the potential to stimulate lipid metabolism (Karlic, & Lohninger, 2004). Treatment with L-carnitine also has been shown to induce a significant decrease in plasma lactate after, aerobic exercises. Data from preliminary studies have indicated that L-carnitine supplementation can attenuate the deleterious effects of hypoxic training and speed up recovery from exercise stress. Recent data have indicated that L-carnitine plays a decisive role in the prevention of cellular damage and affects recovery from exercise stress.

Mitochondrial fatty acid oxidation represents an important energy source for muscle metabolism particularly during physical exercise. However, especially during high-intensity exercise, this process seems to be limited by the mitochondrial availability of free L-carnitine. Hence, fatty acid oxidation rapidly declines, increasing exercise intensity from moderate to high. Considering the important role of fatty acids in muscle bioenergetics, and the limiting

effect of free carnitine in fatty acid oxidation during endurance exercise, L-carnitine supplementation has been hypothesized to improve exercise performance (Gnoni, etc, 2020).

Muscle acetyl-CoA and acetylcarnitine contents increase dramatically at the onset of intense exercise. During prolonged exercise, acetyl-CoA and acetylcarnitine contents decrease in different proportions but are maintained above resting levels at exhaustion when muscle glycogen levels are depleted. As fatigue approaches, the carbohydrate-derived acetyl-CoA content decreases at a rate more rapid than the decrease in acetylcarnitine (Brass E.P., & Hiatt W.R., 1994). L-carnitine is taken by athletes because of its acyl- and acetyl-carrier properties. Plasma and urine carnitine concentrations before and 10 min after maximal treadmill ergometry in nine well-trained sportsmen with and without oral supplementation with 1 g L-carnitine. These variables were chosen because it will be observed first when there is a transition between aerobic and anaerobic exercise intensities occurs at a workload approximated by lactate threshold. In athletes without L-carnitine intake, plasma free carnitine concentration decreased significantly from 45.2 ± 5.3 to 41.6 ± 5.0 mumol/l ($p < 0.001$) 10 min after exercise compared with baseline. In athletes with oral L-carnitine supplementation, plasma free carnitine concentration at baseline was 71.3 ± 10.2 mumol/l and did not change after maximal exercise (71.8 mumol/l ±10.7 mumol/l). The elevated plasma concentration of free carnitine without decreases after maximal exercise in well-trained athletes taking L-carnitine could be important in view of the newly postulated direct vascular effects of L-carnitine in improving skeletal muscle performance. (Nuesh, Rosetto, & Martina, 1999).

2.2 The optimum dosage and timing of L-carnitine intake to improve the exercise performance among elite athletes

The standard dose of L-carnitine is 500–2,000 mg per day for a normal grown adult athlete depends on the metabolic rate and type of sports involved. The dosage also depends on the type of L-carnitine consumed. Generally, L-tatrate type is most used by athletes to enhance their sports performances. This form is most effective for exercise performance. Dosage is varying from 1,000–4,000 mg per day. Another type is acetyl-L-carnitine supplement which is best for brain health and function. The recommended dosage for acetyl-L-carnitine is from 600-2,500 mg per day. Next is propionyl-L-carnitine which is for improving blood flow in those with high blood pressure or related health conditions and recommended intake from 400-1,000 mg per day. As an overall recommendation up to 2,000 mg (2 grams) per day seems safe and effective in the long term (Mawer, 2018).

A previous study which involved six competitive walkers with daily oral dosage of 4g of L-carnitine for 14 days found that there was an increase in $VO_{2\ max}$ (Marconi, Sassi, & Carpinelli, 1985). VO_{2max} is the maximum rate at which the heart, lungs, and muscles can effectively use oxygen during exercise. In another study sixteen well-trained male athletes consumed oral dosage of 2 g of L-carnitine for 28 days and after the endurance athletes started a 4-week endurance training program. It was found that the VO_2max was improved after L-carnitine administration (Arenas, 1994). Moreover, another study used to load of the athletes with L-carnitine for 10 days before running a marathon. The time of marathon run was reduced by 3.2%, after loading of L-carnitine (Cooper, 1986).

2.3 Health uses of intake of L-carnitine

It is stated that the effectiveness of L-carnitine is high for serious kidney diseases. Most research suggests that taking L-carnitine by mouth or intravenously (by IV) can improve red blood cell counts during hemodialysis. The US Food and Drug Administration (FDA) has approved L-carnitine for the treatment and prevention of L-carnitine deficiency in people with serious kidney disease who are undergoing hemodialysis.

Besides that, L-carnitine is said to be possibly have health benefits on chest pain (angina). Taking L-carnitine by mouth or by IV seems to improve exercise tolerance in people with chest pain. Taking L-carnitine along with standard treatment also seems to reduce chest pain and improve exercise ability in people with cardiac syndrome. People with this condition have chest pain but not blocked arteries.

Other than that overactive thyroid (hyperthyroidism). Taking L-carnitine seems to improve symptoms such as rapid or pounding heartbeat, nervousness, and weakness in people with high thyroid hormone levels.

Next conditions in a man that prevent him from getting a woman pregnant within a year of trying to conceive (male infertility). Most research shows that taking L-carnitine, alone or in combination with acetyl-L-carnitine, increases sperm count and sperm movement in men with fertility problems. Some research shows that this increases the chance of pregnancy.

CHAPTER 3

METHODOLOGY

3.1 Data Sources

Previous studies to be reviewed were searched electronically from the following databases: EBSCOHost, JSTOR, ScienceDirect, Scopus, SpringerLINK, Taylor & Francis, WILEY Online Library, Annual Reviews Journal and Annual Reviews Journal. . The selected studies were hand searched using the same eligibility criteria as mentioned below. Furthermore, to obtain additional details, cross-referencing of similar previous studies was carried out. Articles peer-reviewed in English were used in the period from 1985 to 2020. There were no attempts to approach the authors for more information.

3.2 Study Selection

The analysis was done in compliance with the criteria of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). #L-CARNITINE AND #SPORT PERFORMANCE (#aerobic performance or #anaerobic performance) were the keywords used throughout the search. The use of L-carnitine as intervention and sport performance as outcome measures were screened. This analysis included controlled trials and laboratory tests on humans. The interventions comprised of L-carnitine with placebo control and L-carnitine with other dietary supplements while the exercise performance were described as aerobic and anaerobic performances.

The initial search was from the databases from 357 potential articles where another two of them found cross refencing. After duplicates were removed 350 articles were assessed based on the titles, abstract and introduction. 341 articles were then excluded as they did not cover both L-carnitine and sport performance area in their research. After a detailed analysis of full-text articles, 14 were included to be reviewed.

3.3 Data Extraction

Using the parameters stated, the titles and abstracts of retrieved articles were assessed to determine whether full texts were available for further study. A full-text report was systematically reviewed according to the research: objectives, study characteristics (design of the study, participants and sample size), intervention content (types of intervention, duration

of intervention or mode of exercise measured, targeted outcomes and expected outcomes.

3.4 Search Results

The initial search from the databases identified 357 potential articles while another 2 were found through cross referencing. After removing duplicates, 350 articles were assessed based on titles and abstracts against the selection criteria. A total of 341 articles were excluded because they did not investigate on L-carnitine and sports performance. After detailed analysis of full-text articles, only 11 were included.

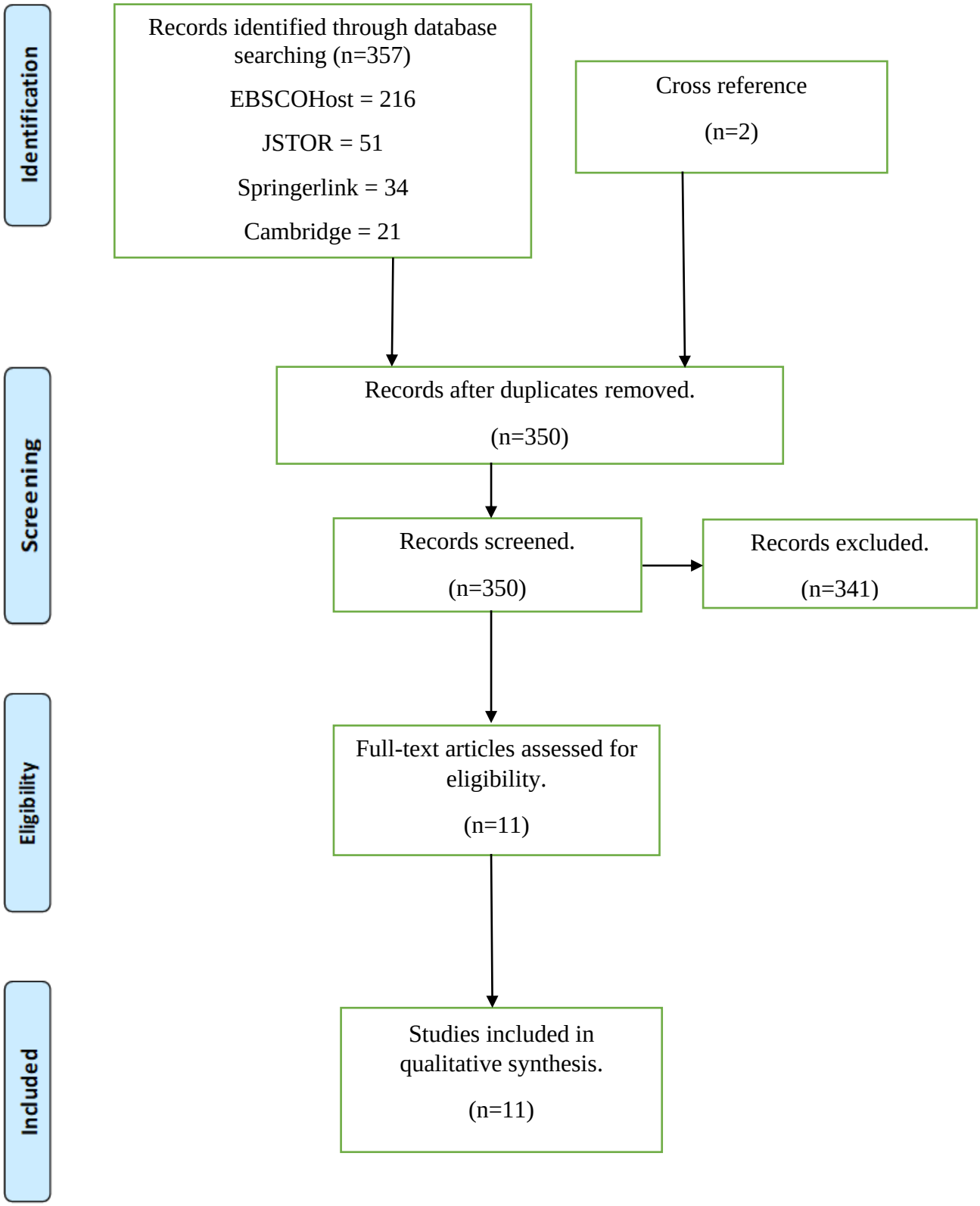

Figure 1: The PRISMA flow diagram for the study selection.

List of Papers that will be Analysed in Chapter 4

1. Balashov V., Balykova L., Khutorskaya I., Bystrova E., Shaymardanova G., Ivyanskiy S., Krasnopolskaya A., & Kotlyarov A. (2020). Potential for L-carnitine application in sports practice. Procedia Computer Science. 169, 821-828.

2. Swart I., Rossouw J., & Loots J.M., & Kruger M. C. (1997). The effect of L-carnitine supplementation on plasma carnitine levels and various performance parameters of male marathon athletes. Nutrition Research. 17(3), 405-415.

3. Watcher S., Vogt M., Kreis R., Boesch C., Bigler P., Hoppeler H., Krahenbuhl S. (2002). Long-term Administration of L-carnitine to Humans: Effect on Skeletal Muscle Carnitine Content and Physical Performance. Clinica Chimica Acta 318(1-2), 51-61.

4. Cha Y., Choi S., Suh H., Lee S., Cho D & Lim K., (2001). Effects of Carnitine Coingested Caffeine on Carnitine Metabolism and Endurance Capacity in Athletes. Journal of Nutritional Science and Vitaminology, 47(6), 378–384.

5. Broad, E. M., Maughan, R. J., & Galloway, S. D. R. (2005). Effects of Four Weeks L-Carnitine L-tartrate Ingestion on Substrate Utilization during Prolonged Exercise. International Journal of Sport Nutrition and Exercise Metabolism, 15(6), 665–679.

6. Broad, E. M., Maughan, R. J., & Galloway, S. D. R. (2011). Effects of Exercise Intensity and Altered Substrate Availability on Cardiovascular and Metabolic Responses to Exercise after Oral Carnitine Supplementation in Athletes. International Journal of Sport Nutrition and Exercise Metabolism, 21(5), 385–397.

7. Leelarungrayub J., Pinkaew D., Klaphajone J., Eungpinichpong E., & Bloomer R. (2016). Effects of L-Carnitine Supplementation on Metabolic Utilization of Oxygen and Lipid Profile among Trained and Untrained Humans. Asian J Sports Med. 2017; 8(1): e38707

8. Burrus B., Moscicki B., Matthew T., & Paolone V. (2018). The Effect of Acute L-carnitine and Carbohydrate Intake on Cycling Performance. Int J Exerc Sci. 2018; 11(2): 404–416.

9. Jacobs., Patrick L., & Erica R. (2010). Long-term glycine propionyl-l-carnitine supplemention and paradoxical effects on repeated anaerobic sprint performance. Journal of the International Society of Sport Nutrition. 7.

10. Marconi C., Sassi G., Carpinelli A., Cerretelli P. (1985). Effects of L-carnitine Loading on the Aerobic and Anaerobic Performance of Endurance Athletes. European Journal of Applied Physiology and Occupational Physiology 54(2), 131-135.

11. Vecchiet R., Di Lisa F., Pieralisi G., Ripari P., Menabo R., Giamberardino M R., & Siliprandi R. (1990). Influence of L-carnitine Administration on Maximal Physical Exercise. European Journal of Applied Physiology and Occupational Physiology. 61(5-6), 486-490.