

Effect of Acupuncture on Carnitine for Skeletal Muscle Fatigue

Shizuo Toda

Department of Health Sciences, Kansai University of Health Sciences, Osaka, Japan
Email: toda@kansai.ac.jp

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ABSTRACT

Skeletal muscle fatigue is a common symptom in various diseases, works and exercises. These were generally induced by neuron, metabolic conditions, overused muscle, and stress. But, there have been few principles about it. Many researchers have reported that acupuncture therapy has been useful to skeletal muscle fatigue on various diseases and conditions. However, it has never been shown why acupuncture therapy has the effect on skeletal muscle fatigue. The deficiency of carnitine induces fatigue, weakness, and disorder of skeletal muscle. It has showed that acupuncture induces the increase of carnitine in skeletal muscle. These findings demonstrated that acupuncture on skeletal muscle fatigue could increase carnitine as a possible affection mechanism.

Keywords: Acupuncture; Carnitine; Skeletal Muscle Fatigue

1. Introduction

Skeletal muscle fatigue is a common symptom experienced in various diseases, works and exercises. These were generally induced by neuron, metabolic conditions, overused muscle, and stress. But, there have been few principles about it. The study of muscle fatigue has been stated about the syndrome. Recently, many studies have reported a lot of factors. Those are calcium, potassium, phosphate, lactate, central nervous system, H^+ , ATP, Mg^{2+} and reactive oxygen species. Fatigue has been caused by such factors within the muscle cells and diminished activation from the central nervous system [1]. However, we have never been able to state why we experience skeletal muscle fatigue. The discussion following the work of Angelo Mosso stated that skeletal muscle fatigue involved the production of toxic substances such as carbonic acid on his collective studies [2].

Many researchers have reported that acupuncture therapy has been useful to muscle fatigue on various diseases and conditions. On multiple sclerosis, acupuncture showed the great improvement of Multiple Sclerosis Impact Scale 29 psychological subscale [3]. However, it has never been shown why acupuncture therapy has the effect on muscle fatigue.

The purpose of this review is to demonstrate the effect of acupuncture on skeletal muscle fatigue.

2. Acupuncture on Skeletal Muscle Fatigue

Acupuncture has therapeutic effects on the skeletal muscle

fatigue on various diseases and conditions. It has been showed that acupuncture reduces perceived pain arising from exercise-induced muscle soreness on randomized, controlled, observer and subjective-blinded trail. Pain perception 72 hours after acupuncture was significantly lower than control group [4]. Fibromyalgia has various symptoms as pain, debilitating fatigue, sleep disturbance, and joint stiffness. The one of them is skeletal muscle fatigue. The performance of acupuncture for 114 participants diagnosed with fibromyalgia has been carried out on a single-site, single-blind randomized trail. Acupuncture improvement in pain, fatigue and physical function were highly codependent in fibromyalgia [5].

We have often experienced skeletal muscle fatigue as low back pain. On systematic review of acupuncture for low-back pain, acupuncture has moderately effects, pain relief, and improvement of function from short-term. Acupuncture was moderately superior for long term pain relief [6-8]. Pain tolerance in the masticatory muscles increased significantly more with acupuncture. Acupuncture reduces significantly in face pain neck pain, and headache. Acupuncture peripheral stimulus can act as modular mechanism of muscle activity and was possible to verify correspondence of the auricular acupoint with the trapezius muscle [9]. Acupuncture was efficacious for improving isometric quadriceps strength in recreational athletes in a double-blind crossover trial. Acupuncture might have implications not only for athletes, but also for rehabilitation programs aimed at restoring neuromuscular function [10].

Acupuncture may become an additional therapeutic strategy to improve the exercise tolerance of patients with congestive heart failure, potentially by improving skeletal muscle function. Acupuncture partially prevented skeletal muscle atrophy. This effect might be due to an increase in protein synthesis and a decrease in protein degradation [11].

These data showed that acupuncture have effects on the performance, strength, and fatigue of skeletal muscle.

3. Carnitine of Skeletal Muscle

On energy production, fatty acid has a main role. Mitochondria produce energy by uptake of fatty acid. But fatty acid arrives at the surface of mitochondria, it is impossible to transport into mitochondria membrane. Fatty acid consists on the activation to acyl CoA. This transport is accompanied by carnitine. Carnitine is a transporter of acetyl CoA into mitochondria.

An acute increase in human skeletal muscle total carnitine content results in an inhibition of carbohydrate oxidation in conditions of high carbohydrate availability. It is possibly due to a carnitine-mediated increase in fat oxidation. They have important implications for our understanding of the regulation of muscle fat oxidation, particularly during exercise. These results showed that carnitine availability may limit fat oxidation, and in obesity and type 2 diabetes [12,13].

Carnitine has an important role in energy production and modulation of the intramitochondrial coenzyme A (CoA)/acyl-CoA ratio in the skeletal muscle. The deficiency of carnitine might induce an energy deficit and abnormality of the intramitochondrial condition in the skeletal muscle. These results show in general fatigue, myalgia, muscle weakness, and postexertional malaise in patients with chronic fatigue syndrome [14].

Intracellular mechanism regulating fat oxidation has been investigated in human skeletal muscle during exercise. The availability of free carnitine may limit fat oxidation during exercise with high muscle glycogen [15].

L-carnitine supplementation improves muscular performance. That is based on the role of L-carnitine in regulating aerobic metabolism. L-carnitine delays muscle fatigue by the reducing oxidative damage. The delay of muscular fatigue was evident from mean frequency, 50% peak force of contraction, peak force of contraction. These results demonstrated that L-carnitine delays muscle fatigue by the reducing oxidative damage of intermittent hypoxia [16].

Carnitine has been used to enhance human exercise performance., Brass et al studied that the fatigue of isolated rat skeletal muscle strips was studied in vitro, on the hypothesis that carnitine directly modify skeletal muscle function. As the incubation with propionyl-L-carnitine maximal contractile force, carnitine directly im-

proves the fatigue characteristics of muscle enriched in type I fibers directly [17].

Carnitine deficiency may be an important factor of dialysis-associated muscular symptom. Acetylcarnitine and propionylcarnitine showed beneficial effects on muscular fatigue of dialysis. Acetylcarnitine had main effect on mental fatigue and propionylcarnitine on general fatigue [18].

L-carnitine has an important role to cellular energy metabolism. Prolonged low-dose L-carnitine treatment can improve dialysis-associated muscle symptoms by restoring carnitine tissue levels and washing out acyl moieties [19]. Levocarnitine induced a reduction of total fat mass, increases total muscular mass, and facilitates an increased capacity for physical and cognitive activity by reducing fatigue and improving cognitive function [20].

These results demonstrated that the deficiency of carnitine induces fatigue, weakness, and disorder of skeletal muscle.

4. Acupuncture on Carnitine

Skeletal muscle disease are associated with contractures, cramps muscle stiffness and deep muscle aching. These phenomena relate to skeletal muscle fatigue [21].

The pathogenesis of fatigue in skeletal muscle condition has the relation carnitine. Carnitine appears to improve force of skeletal muscle while stimulated in situ. This effect of carnitine is acute and stereospecific [22]. In energy metabolism, carnitine has a major role in the translocation of long-chain fatty acids into the mitochondrial matrix for subsequent β -oxidation, and in the regulation of the mitochondrial in skeletal muscle [23]. Acupuncture can protect cells from injury of acute spots and maintain the functions of mitochondria so as to delay fatigue, prolong working time of skeletal muscles [24].

Toda has reported the effect of acupuncture on carnitine in skeletal muscle [25]. The mice of acupuncture group by inserting 3 mm deep at right Zusanli (ST36) and Jixi (ST41) with sterilized disposable stainless steel acupuncture needles were fixed in the animal cage. The right Zusanli (ST36) and Jixi (ST41) were punctured, allowed for 15 minutes. The mice of normal control group were not both punctured and stimulated. Carnitine level in muscle tissue of acupuncture group was significantly higher than normal control group (**Table 1**).

Table 1. Effect of acupuncture on carnitine in skeletal muscle (mean \pm standard error, $\mu\text{mol/g}$).

Carnitine	
Acupuncture group	$654.17 \pm 50.52^*$
Normal control group	$346.67 \pm 53.41^*$

* $p < 0.001$.

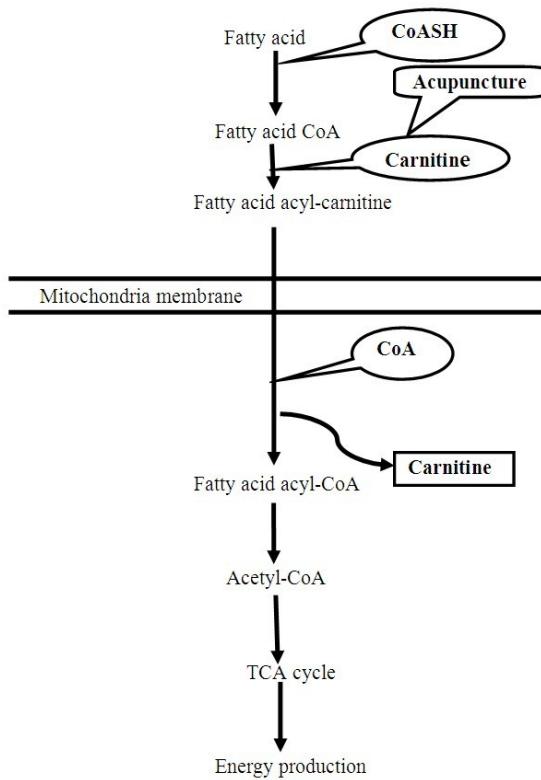


Figure 1. A model of acupuncture on carnitine and energy production.

Acupuncture at ST36 and ST41 has been shown to be a better therapeutic effect for muscle fatigue, problems of constriction and myofacial pain of leg muscle [26]. Acupuncture at these acupoints reduces the tibialis anterior electromyography muscle activity [27].

Acupuncture leads to analgesia and improvement in other somatic symptoms of fibromyalgia on a single-site, single-blind, randomized trial [28]. Acupuncture has been useful therapy on muscle symptoms. Carnitine therapy is effective in ameliorating fatigue in celiac disease on randomized double-blind versus placebo parallel study [29]. Carnitine can directly improve the fatigue characteristics of muscles enriched in type I fiber [30]. More than 95% of carnitine in the body exists within skeletal muscle tissue [31]. Carnitine transfer fatty acids to the mitochondria, and involves energy metabolism. Carnitine deficiencies induce muscle fatigue and myopathy [32]. Carnitine in blood and brain showed to be increased by acupuncture [33].

These following findings showed that the effects of acupuncture may be related with carnitine. Acupuncture may be able to improve skeletal muscle fatigue by increasing carnitine in skeletal muscle (**Figure 1**).

5. Conclusion

Skeletal muscle fatigue is a common symptom experienced in various diseases, works and exercises. The defi-

ciency of carnitine induces fatigue of skeletal muscle. It has showed that acupuncture induces the increase of carnitine in muscle. These findings demonstrated that acupuncture on skeletal muscle fatigue could increase carnitine as a possible affection mechanism.

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