Effect of muscle fatigue by laser irradiation in rat skeletal muscle – Preliminary study

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Abstract

We investigated whether the laser therapy can reduce muscular fatigue during 20Hz stimulation in rats. Three male Wistar rats were randomly assigned into two groups receiving the laser therapy group or a no-treatment control group. In both of groups, constant low-frequency stimulation of 20 Hz was applied intermittently (4 sec “ON”/16 sec “OFF”). This procedure was repeated 20 times, and had a rest for 2 minutes; after that, the intermittent stimulation was done 20 times again. In the laser group, the laser therapy was performed during down period (two-minute rest), irradiated 0.67J/cm² (pulse laser). The electrical stimulation was used to induce tetanic muscle contraction in the gastrocnemius muscle. The muscle force after total stimulation cycle, the laser group was tending to be strong at the maximum muscular force (under fatigued condition). The results of this study suggest that pulse-low-level-laser may be able to be preventing development of muscular fatigue in rats during repeated tetanic contractions.

1 Introduction

Functional electrical stimulation (FES) is the technology of restoring voluntary control of movement in patients who have central nervous system (CNS) dysfunction and for whom no normal recovery is expected. When FES restored the functions of the lower extremities, muscle fatigue usually occurred much earlier than under normal physiological conditions. In restoration of standing and walking, muscle fatigue leads to knee buckling, thus hindering restorative efforts.

Several tools have been used to preventing muscle fatigue in healthy subjects as well as in pathological conditions such as nutritional supplements, fluid reposition, and so on. Laser therapy is a novel therapy form that have been used to treat muscular pain, but the biological mechanisms behind observed beneficial results in clinical trials remain unclear. We decided to use the experimental model of electrical stimulation to induce fatigue by tetanic gastrocnemius muscle contraction in rats and test whether pulse-low-level-laser therapy (PLLLT) could prevent the reduction of muscle fatigue.

2 Methods

Surgical procedure. The medial gastrocnemius muscles of adult male Wistar rats were used. Each the rats were deeply anaesthetized with an intraperitoneal injection of 30 mg per kg body weight of pentobarbital sodium. The animal was then mounted in a rigid frame that securely immobilized the right leg and pelvis. The skin over the posterior leg and popliteal space was reflected and the sciatic nerve and the medial gastrocnemius were exposed. A commercially available bipolar cuff electrode (MD Giken, Japan) was attached to the sciatic nerve at the center of the femur. The medial gastrocnemius was severed at the tendon near the attachment site to the calcaneus. A transducer (ORIENTEC Co., Japan) was attached to the end of the medial gastrocnemius and fixed with a load of approximately 1N next to the stump. The animal care protocol for this study was approved by our Akita University’s Institutional Animal Care and Use Committee and the guidelines of the National Institutes of Health.

Experimental protocol. Three adult male Wistar rats were randomly assigned into two groups receiving the laser therapy group (N=1) or a no-treatment control group (N=2). In both of groups, constant low-frequency stimulation of 20 Hz was applied intermittently (4 sec “ON”/16 sec “OFF”). This procedure was
repeated 20 times, and had a rest for 2 minutes; after that, the intermittent stimulation was done 20 times. In the laser group, the laser therapy was performed during down period (two-minute rest), irradiated 0.67J/cm². The electrical stimulation was used to induce tetanic muscle contraction in the gastrocnemius muscle (Fig.1).

Data management and analysis. We measured the initial maximum force \(a\) and each force of stimulation \(b\). To ascertain the time course of muscle fatigue, the percentage of initial force was calculated using the formula

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\text{Percentage of initial force} = \frac{b}{a} \times 100
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The number of the animals was few now, it was impossible to analyze those data.

3 Results

The muscle fatigue of the rat that had the laser therapy was tending to be smaller than control muscles (Fig 3).

4 Discussion and Conclusions

There are several papers that demonstrated low-level laser therapy (LLLT) is effective for clinical field. Improved circulation due to LLLT is considered to be one of the possible mechanisms of the clinical effectiveness of LLLT for the treatment of pain or to promote the healing of wounds. However, we found few reports regarding to the muscle fatigue; especially there no studies have been performed using PLLLT. It is explained that the difference between LLLT and PLLLT is the temperature change and PLLLT is smaller than LLLT on that. In this trial, our result showed the tendency that the PLLLT reduced muscle fatigue. One possibility is that pulse-low-level laser makes vascular flow of the muscle increased and the muscle condition was improved, in the result, the muscle fatigue was reduced. We are increasing the number of animals and need further consideration.

References