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Original Article

Effects of integrated treatment with LED and microcurrent on muscle tone and stiffness in the calf muscle during moderate aerobic exercise

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Abstract. [Purpose] This study aimed to investigate the effects of the therapeutic device combined with LED and microcurrent (MC) on muscle tone and stiffness in the calf muscle after its application during moderate aerobic exercise. [Subjects and Methods] Twenty healthy adult subjects were randomized to either the test group of the therapeutic device combined with LED and MC or the control group, and they walked on a 10%-sloped treadmill with a 5 km/hr speed for 30 minutes. Each of the subjects in the test group performed treadmill exercise with the therapeutic device attached to the edge of his or her calf muscle. After the exercise, the muscle tone and stiffness at the edge of the calf muscle were measured. [Results] With respect to the muscle tone, a statistically significant difference was found between the two groups only 5 minutes after the exercise. Concerning muscle stiffness, significant differences were shown between the two groups right after the exercise and 5 minutes after the exercise. [Conclusion] Integrated treatment with LED and MC on is considered helpful for lowering the muscle tone 5 minutes after the exercise, and for lowering the muscle stiffness right after the exercise and 5 minutes after the exercise.

Key words: Light-emitting diode, Microcurrent, Muscle tone

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INTRODUCTION

Repeated exercise and long-distance walking may cause fatigue in the skeletal muscles. During intensive aerobic exercise, muscular fatigue can occur, lowering the muscle power due to the limited energy supply or increased metabolite concentration in the muscle[1]. The fatigue level in the muscles of the lower limbs increases as a person walks for a longer time, and the calf muscle contracts continuously while a person is walking to maintain the center of gravity in the basal facet. In the case of various lower-limb exercises, the continuous contraction of the calf muscle while a person is walking plays the role of ensuring sufficient muscle power for maintaining the stability of the body and its movements[2]. It is essential for the prevention of calf muscle damage or for recovery from muscular fatigue, to improve one's walking and daily life[3].

The treatment with microcurrent uses microampere (μA) current to treat the muscle damage without any adverse effect, and for such treatment, a small and handy device has been developed[4, 5]. Curtis et al.[4] reported that the level of pain of the 35 healthy adult subjects in their study due to the delayed onset muscle soreness (DOMS) that occurred in them after they performed eccentric exercise was alleviated by the 20-minute treatment with microcurrent. Recently, multiple studies on muscle functions using light-emitting diode therapy (LEDT) was reported, and LEDT showed the effects of expediting muscle recovery and overcoming muscle power damage and fatigue caused by exercise[6, 7]. In addition, it has a bigger spot size than laser diode, with a lower manufacturing cost, and the therapeutic efficacy was reported to be related with the wavelength and strength rather than with the light source[8]. Baroni et al.[9] reported the durable efficacy on exercise capacity

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of LEDT application to fatigue in the quadriceps femoris caused by intensive exercise, and Hemmings et al.[10] reported a positive therapeutic effect on exercise capacity of the application of LEDT to the quadriceps femoris for 60–120 seconds before eccentric leg extensions. Likewise, the therapies using LED and microcurrent have been reported to be effective for the treatment of muscle fatigue or pain, but few studies have been conducted to date on treatment with LED and microcurrent during physical activity or exercise. Therefore, this study aimed to investigate the effects of integrated treatment with LED and microcurrent on the muscle tone and stiffness after exercise by applying them to the muscle during exercise.

SUBJECTS AND METHODS

The subjects of this study were 20 students of G University. After sufficient explanation of the purpose and procedures of the study the participants were provided a written informed consent form in accordance with the ethical standards of the Declaration of Helsinki, and those without any orthopaedic, internal medicine, or neurosurgical disease that might affect the knees and muscles near the ankle, and the walking capacity.

Twenty adult males were randomized to either the control group or the integrated-treatment group with LED and microcurrent (10 per group). The general characteristics of the subjects are shown in Table 1. The muscle functions of the study subjects, including the muscle tone and stiffness, were measured using Myoton®PRO (MyotonAS, Estonia), a device for measuring the biodynamics and mechanical characteristics of soft tissue such as the muscles and tendons[11]. The intra-class correlation coefficients (ICC) were 0.99 (95% CI:0.98 to 0.99) for natural oscillation frequency (i.e. tension), 0.99 (95% CI: 0.98 to 1.00) for stiffness[11]. For all the subjects, the muscle tone was measured before the test, and stretching for the muscles in the thigh and calf was done for 5 minutes.

Then the control group walked on the treadmill with a 10% slope at the speed of 5 km/hr for 30 minutes. The integrated-treatment group did the same exercise as was done by the control group, and walked on the treadmill with the integrated-treatment device (LOC-MC01, Linkoptics, Kwangju, South Korea) attached to their calf muscle. The leg that was selected as the one to which the device was to be attached was the one that would kick a football.

The integrated-treatment device consists of microcurrent and LED with a 830 nm wavelength, 10 Hz frequency, 90 mW (3 × 30 Mw) average power, 0.2 cm^2 spot size (number of points=3), and 9.7 J treatment dosage[12]. For the microcurrent therapy, a pulsed current with a 30 HZ frequency and 100 µA intensity was used.

The measurement was done twice, and additional measurement was done if the coefficient of variation was over 3%. The mean value obtained from the two-time measurement with a coefficient of variation of 3% or less was recorded. The measurement was done before the exercise, right after the exercise, and 5 and 20 minutes after the exercise, under a constant room temperature (23 °C). The same physical therapist performed all the interventions and measurements. Statistical analysis was done using by SPSS 19.0 for Windows. An independent t-test was conducted to determine the difference in muscle function between the two groups at each time point. The statistical significance level of the data was 0.05.

RESULTS

A significant difference in muscle tone was found between the control and integrated-treatment groups only 5 minutes after the exercise ($p<0.05$). The muscle tone in the integrated-treatment group with LED and microcurrent was lowered more than in the control group only 5 minutes after the exercise. Significant differences in muscle stiffness were found between the control and integrated-treatment groups right after the exercise and 5 minutes after the exercise ($p<0.05$). The muscle stiffness in the integrated-treatment group with LED and microcurrent was lowered more than in the control group right after the exercise and 5 minutes after the exercise (Table 2, 3).

DISCUSSION

The results of the test involving moderate aerobic exercise on a sloped treadmill with the application of the therapeutic device for LEDT and microcurrent showed that the tone of the calf muscle was lowered more only 5 minutes after the exercise in the integrated-treatment group with LED and microcurrent than in the control group. The dynamic stiffness of the muscle was shown to have been lowered more right after the exercise and 5 minutes after the exercise in the integrated-treatment group with LED and microcurrent than in the control group.

Curtis et al.[4] reported that 20-minute microcurrent therapy decreased the DOMS in the subjects of their study. Kim[13] pointed out that excessive muscle tension caused muscular tissue damage through temporary oxygen deficiency and ischemia in the muscle, resulting in muscular diseases such as myofascial pain syndrome. In fact, an intervention using microcurrent among a variety of interventions for lowering muscle tension was reported to be effective for relieving the pain due to myofascial pain syndrome that could occur due to excessive muscle tension[14]. As the stiffness (S) in the Myoton measurements increases together with the muscle tone (F), the muscle power also increases. Proper interventions are required as an excessive increase of muscle power can develop into muscular diseases[3]. The normal range of muscle stiffness, a biodynamic characteristic, has been known as 220–320 N/m, and inefficient joint movement is generated as the value increases[15]. The results of this study showed that both muscle tone (F) and stiffness (S) were lowered right after the exercise and 5 minutes

Table 1. General characteristics of the subjects

	Control group (n=10)	Integrated-treatment group (n=10)
Age (yrs)	22.1 ± 1.4	23.3 ± 1.5
Height (cm)	172.7 ± 4.7	175.2 ± 5.7
Weight (kg)	75.1 ± 13.1	68.0 ± 5.2

Table 2. Changes of muscle tone (unit: Hz)

Group	Before exercise	Right after exercise	5 minutes after exercise	20 minutes after exercise
CON	17.07 ± 1.40	17.12 ± 2.57	16.71 ± 1.63	15.44 ± 1.30
COM	16.29 ± 1.53	15.70 ± 1.33	15.36 ± 0.55	15.34 ± 1.00
t (p)	1.189 (0.250)	1.550 (0.138)	2.473 (0.024)	0.415 (0.683)

The values are the means ± SD.
CON: control group; COM: combined therapy group (light-emitting diode therapy and microcurrent therapy).

Table 3. Changes of muscle stiffness (unit: N/m)

Group	Before exercise	Right after exercise	5 minutes after exercise	20 minutes after exercise
CON	311.8 ± 41.5	321.9 ± 75.5	298.4 ± 38.6	270.6 ± 26.9
COM	285.5 ± 40.8	265.4 ± 35.7	262.8 ± 24.1	264.6 ± 37.0
t (p)	1.429 (0.170)	2.139 (0.046)	2.474 (0.024)	0.415 (0.683)

The values are the means ± SD.
CON: control group; COM: combined therapy group (light-emitting diode therapy and microcurrent therapy).

after the exercise in the integrated-treatment group with LED and microcurrent. These results demonstrate that integrated therapy with LED and microcurrent during moderate exercise can effectively prevent DOMS and muscular diseases such as myofascial pain syndrome right after the exercise. Therefore, the integrated therapy applied in this study can be considered to assist the dilation of the muscle to the extent possible by lowering the muscle tension and dynamic stiffness, which are increased by physical activities. Also, these results can be utilized as the fundamental data for the development of a method of expediting recovery from muscle fatigue caused by physical activities involving the application of LED and microcurrent for those who walk or stand up for a long time during the performance of physical activities. The limitation of this study is that the subject was healthy normal adults.

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Conflict of interest

None.

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