J. Phys. Ther. Sci.
25: 1093–1095, 2013

Effects of Vibratory Stimulations on Maximal Voluntary Isometric Contraction from Delayed Onset Muscle Soreness

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Abstract. [Purpose] The aim of this study was to investigate the effect of vibratory stimulation on maximal voluntary isometric contraction (MVIC) from delayed onset muscle soreness (DOMS). [Subjects] Sixty healthy adults participated in this study. The exclusion criteria were orthopedic or neurologic disease. [Methods] The researchers induced DOMS in the musculus extensor carpi radialis longus of each participant. Subjects in the control group received no treatment. The ultrasound group received ultrasound treatment (intensity, 1.0 W/cm$^{2;}$ frequency 1 MHz; time, 10 minutes). The vibration group received vibration stimulation (frequency, 20 MHz; time, 10 minutes). Maximal voluntary isometric contraction (MVIC) was recorded at baseline, immediately after exercise, and 24, 48, and 72 hours after exercise. [Results] MVIC measurements showed statistically significant differences in the vibration group compared with the control group. [Conclusion] Vibratory stimulation had a positive effect on recovery of muscle function from DOMS.

Key words: Vibratory stimulation, Ultrasound, Isometric contraction

(This article was submitted Mar. 6, 2013, and was accepted Apr. 19, 2013)

INTRODUCTION

Isometric contraction or phasic movement that expresses power can induce muscular pain. Muscular pain that starts 12–24 hours after unaccustomed exercise, serious resistance exercise, or excessive use of specific muscles, is known as delayed onset muscle soreness (DOMS)[1)]. DOMS increases during the first 24 hours after exercise and, peaks 24–48 hours later. It is characterized by oppressive pain to tactile perception and on movement, which disappears within 5–7 days, and is accompanied by decreased flexibility and maximum voluntary force production[2)].

The effects of whole body vibration exercise are influenced by numerous factors including amplitude, frequency, exercises performed, intensity, and volume[3)]. There is considerable evidence from studies that whole body vibration exercise increases physical strength, improves muscle performance, and improves balance[4)]. Kawanabe et al.[5)] showed that whole body vibration exercise improves knee extensor strength, jumping power, chair-rising time, timed up and go, body balance, chronic back pain, and hip bone mineral density, and increases the levels of serum testosterone and growth hormone.

Vibration has also been shown to increase lower body bone density in postmenopausal women and thus may be useful for rehabilitation and prevention of osteoporosis[5)]. Thus, vibration exercise induces additional neural adaptation by stimulating the muscular system and enhances morphological functional development of the muscular fiber, thereby improving overall muscle function[6)].

There is a lack of evidence on the optimal treatment approach for effective recovery of muscle function. This study aimed to examine the effects of vibration exercise on the recovery of muscle function after induction of DOMS and to determine its potential as a clinical treatment.

SUBJECTS AND METHODS

Sixty college students were assigned to a control group, an ultrasound treatment group, or a vibration treatment group. The average age and height of the participants were 21.72 ± 2.16 years and 168.35 ± 7.26 cm. The averages weight and body mass index of the participants were 62.42 ± 10.35 kg and 21.87 ± 2.21 kg/m^2 (Table 1). The researcherS measured maximal voluntary isometric contraction (MVIC). Measurements were performed immediately

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Table 1. General characteristics of subjects

	Control group (n=20)	Ultrasound group (n=20)	Vibration group (n=20)
Gender (M/F)	10 / 10	10 / 10	10 / 10
Age (year)	22.10 ± 1.97	21.25 ± 2.29	21.80 ± 2.24
Height (cm)	168.02 ± 7.18	167.82 ± 6.69	169.22 ± 8.14
Weight (kg)	62.77 ± 11.03	61.77 ± 8.96	62.71 ± 11.40
BMI (kg/m^2)	22.05 ± 2.23	21.84 ± 2.09	21.73 ± 2.42

Values are means ± SD

Table 2. The changes in MVIC before and after inducing DOMS between groups (units: %)

	Pretest	Immediately after	After 1 day	After 2day	After 3 day
Control group	17.05 ± 3.03	14.41 ± 3.19	11.37 ± 2.60	12.22 ± 2.71	12.83 ± 2.93
Ultrasound group	16.86 ± 2.48	14.09 ± 2.53	11.27 ± 2.66	12.71 ± 3.23	14.21 ± 3.50
Vibration group	16.95 ± 3.28	14.23 ± 3.20	11.97 ± 3.67	14.16 ± 3.49	16.02 ± 3.46*

Values are means ± SD, *Significantly greater change compared with the control group (p<0.05)

before and after the induction of DOMS and, 24 hours, hours, and 72 hours after induction of DOMS. Changes in the measurements over time were compared between group subjects.

The researchers induced DOMS in the musculus extensor carpi radialis longus in each study participant. An isokinetic dynamometer (CS200 Dynamometer, JLW Instruments Inc., Chicago, IL, USA) was used for all the testing and exercise. Three sets of eccentric contractions were carried out 12 times using 70% maximum voluntary contraction based on 1 RM (repetition maximum) for the induction of DOMS; this was based on when the eccentric contraction could not be performed continuously three times, because the point of induction of muscular pain varies among individuals.

Ultrasound was applied to the nondominant musculus extensor carpi radialis longus portion of the wrist of participants in the ultrasound group for 10 minutes at a time, at a frequency of 1 MHz and an intensity of 1.0 W/cm^2. Ultrasound was carried out in the most comfortable state once a day for three days after the commencement of DOMS.

Vibration stimulation was applied to the nondominant musculus extensor carpi radialis longus portion of the wrist of participants in the vibration group. A research worker used a vibration massager for 10 minutes at a frequency 20 Hz. Applying the vibration stimulation to the partcipants was carried out in the most comfortable state once a day for three days after DOMS induction.

The researcher measured the maximum isometric physical strength of the musculus extensor carpi radialis longus of the wrist extensor muscle in the nondominant arm. The upper side of the participants' arms and the antebrachial bottom stanchion were supported, and the wrist was maintained parallel to the stanchion by keeping the palm of the hand towards the ground or surface of the earth. An isokinetic dynamometer (CS200 Dynamometer, JLW Instruments, Inc., Chicago, IL, USA) was used to measure the maximum voluntary isometric contraction of the nondominant wrist extensor. A research worker calculated the average of 3 measurements for the maximum power of voluntary isometric contraction, and included resting time to prevent the muscle fatigue between the measurements[7]. SPSS version 12.0 (ICC, Chicago, IL, USA) was used for data analysis. Descriptive statistics are reported as means ± standard deviation (M ± SD). A one-way analysis of variance (ANOVA) was used to determine the difference between the groups. Repeated measure analysis of variance was used to verify the mean difference in time variation (pretest, immediately after commencement of DMOS and, 1, 2 and 3 days after the commencement of DOMS) within each group, and Tukey's test was used to analyze post- verification differences between the groups. Statistical significance was set at p<0.05 for all the analyses.

RESULTS

Analysis with descriptive statistics showed that the MVIC decreased in all three groups immediately after induction of DOMS and the next day, while it increased in the ultrasound and vibration groups compared with the control group on the second day after induction. One-way ANOVA showed that there was a statistically significant difference on the third day after the induction of DOMS (p<0.05) in the vibration group compared with the control group in terms of the Tukey posteriori tests (p<0.05). No significant difference in MVIC values was observed between the vibration group and ultrasound group (p>0.05) (Table 2).

DISCUSSION

In this study, the researchers applied vibration exercise to examine its effects on DOMS through the measurement of MVIC. Delayed onset muscle soreness begins with muscle overload or excessive or unaccustomed tension exercise, bringing pain ranging from stiffness and mild discomfort to incapacitating pain that limits normal activity. There can be various reasons for damage to muscle tissue, but eccentric contraction seems to be the main cause[8]. After eccentric exercise, muscle cells undergo ultra-minute changes including rupture of muscle fiber segmentation, such as popping, Z-band flow, injury of T-tubules and the sarcoplasmic reticulum, and injury to the muscle fiber. This rupture induces an increase in the flow of CA calcium outside the cells into the tissue, leading to inflammation with increased protein serum activity. In addition, the inner muscle cell contents, such as creatine kinase and myoglobin flow to the area of inflammation and into the blood; these degenerative changes are connected with DOMS[9]. Power decreases step by step during ongoing isometric maximum voluntary contraction[10]. Warren et al.[11] showed that decreased muscle strength is the most valid and reliable guideline of direct muscle injury in humans. Saxton et al.[12] measured the maximum voluntary contraction power to investigate the effects of muscle injury induced by eccentric exercise in the vibration of neuromuscular functions and proprioceptor factors[13]. They observed that MVC decreased after induction of DOMS but gradually recovered. In our study, it was decreased one day after the induction but gradually recovered over 3 days, with significant differences in the ultrasound and vibration groups compared with the control group. This result indicates that vibration stimulates muscle spindles to activate γ motor neurons for muscle contraction. This study researched the effect on maximal voluntary isometric contraction of vibration stimulation exercise for the wrist extensor muscle after inducing DOMS.

In the above research results, the effects of vibration stimulation on muscle function after inducing DOMS were revealed, and as more studies are carried out on the properties of the mechanism of vibration stimulation, it will be possible to use vibration stimulation as a new therapeutic approach in rehabilitation areas.

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