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A Comparative Study on the Effect of Whole Body Vibration on DOMS, Depending on Time Mediation

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Abstract

The experiments were carried out during a total of nine sessions, that is, 3 sessions over 3 days. The CK levels decreased depending on the experiment session ($p \leq 0.05$), but there was no significant difference ($P \leq 0.05$) between the experimental group and the control group. Pressure threshold levels significantly decreased depending on the experiment session and the treatments had higher effects in the experimental group. VAS figures significantly decreased depending on the experiment session ($P \leq 0.005$) and the treatments had higher effects in the experimental group. The results of this study verified the contention that applying vibration treatment immediately after inducing DOMS is more effective in terms of pressure pain threshold (PPT) and VAS, but not CK levels, than applying the treatment 24 hours after inducing DOMS. In addition, the experimental group showed a statistically significant difference compared to the control group. Therefore, it was concluded that applying vibration treatment immediately after inducing DOMS can be used as a DOMS treatment method.

Keywords: *DOMS, whole body vibration, CK, Time mediation, pressure pain threshold*

1. Introduction

Rapid changes in work industries and the living environment in modern society have resulted in a significant decrease in physical activities and exercise, which in turn causes various diseases. To prevent such physical diseases, people are doing different types of sports activities and weight training to maintain their health and body shape regardless of age and gender. [1]

Many people, however, experience muscle soreness while doing exercise as a leisure activity, which interrupts continuous exercise, and thus it is difficult to expect normal and effective results and benefits from exercise programs.[2] Muscle soreness induced by exercise can be divided into acute muscle soreness, experienced immediately after exercise, and delayed-onset muscle soreness (DOMS) that occurs several hours later. [3] [4]

DOMS occurs after unaccustomed or strenuous resistance exercise of moderate or higher intensity, or after using muscles in a certain position. In particular, it is often experienced as one symptom of exercise-induced muscle injuries after doing exercise that requires a maximum eccentric contraction. [5] DOMS is perceived as an intermittent and temporary stiffness, decreased muscle strength, reduced range of motion and muscle

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swelling. [6] [7]

DOMS is felt in the first 8~24 hours after exercise, and it peaks from 24 to 48 hours. [8] It gradually subsides and disappears in 5~7 days after exercise. [9] One of the ways to reduce DOMS is doing warm-up and warm-down exercises of low intensity before and after exercise. [10] It can be also reduced by doing light stretch exercise before and after exercise, [11] or by gradually increasing the intensity and duration of exercise programs. [12] Kim[14] reported that doing anaerobic stretch exercises immediately after exercise is more effective for the recovery of slightly damaged muscle fibers and for blood circulation than doing the exercises 24 hours after exercise.

There are several studies on the treatment of DOMS, including electrical nerve stimulation and microcurrent electrical neuromuscular stimulation, [14] transcutaneous electrical nerve stimulation, [15] ultrasound treatment, [2] and massage. [16] It was also found that vibration exercises are effective for recovery from DOMS. [17] [18]

Recently, as whole body vibration (WBV) exercises have been gaining attention, many studies have been conducted on the effects of WBV exercises. They are reported to have a positive impact on improving various motor skills and increasing energy metabolism and the blood flow rate. [19] [20]

Vibration exercise is an isometric exercise in a passive form using the repetitive motions of an object that moves around a pivot. [21] [22] Its effect on the body differs depending on vibration frequency. [23] It was reported that vibration exercises at 15~50Hz are effective in increasing excitatory responses of the central nervous system and blood pressure. [24]

The short-term effects of WBV exercises include increasing EMG activity, [25] increasing the maximum leg press power, enhancing growth hormones and catecholamine, [26] and increasing oxygen consumption. [27] There are also long-term effects such as improving jumping ability, [28] and increasing isometric muscular strength. [29]

Against this backdrop, this study aimed to examine the impact of time-intervened vibration exercises, after inducing DOMS on the quadriceps femoris muscle, on recovery from DOMS, and changes in observed symptoms 24 hours before and after inducing DOMS.

2. Methods

1. Subjects

This study was conducted among 20 healthy male adults living in Changwon, Gyeongnam. They were selected among those who voluntarily consented to participate in this experiment, and met the following qualifications.

A. Those who have not done weight training regularly. B. Those who do not suffer from any diseases or have not had any surgery in the lower limbs. C. Those who have not experienced muscle soreness in the week before this experiment. D. Those who do not need to use the muscles to be observed during this experiment for work or job related purposes.

Subjects were instructed not to use the muscles much except for actions required for daily life for one week before this experiment, not to take any medicine, and not to do exercises arbitrarily to strengthen muscles or for other purposes.

2. Measurement tools and methods

Exercises to induce DOMS were performed on the N-K table, and a whole body vibration (WBV) machine was used to treat DOMS. The level of soreness was measured after the treatment using a visual analogue scale (VAS), and the pressure pain threshold (PPT) of the participants was measured for functional evaluation using an algometer. Their blood was sampled to measure the level of creatine kinase (CK) in the

blood, and their maximum isometric muscular strength was assessed using a dynamometer.

1)Visual analogue scale (VAS)

The level of soreness was assessed by the subjects themselves, and they were instructed to mark the level of soreness they felt on the graduated scale from 0 to 100.

2)Pressure pain threshold (PPT)

To measure the pressure pain threshold (PPT) of subjects, a digital algometer (MedicalTM Commander, JTECH 801-478-0680 AA 129 REV, China) was used. In the supine position, a straight line was drawn from the base of the patella to the anterior superior iliac spine, and their PPT was measured three times at the midpoint of the line at the same speed and angle using the algometer. The mean value of the obtained data was used for analysis. The PPT was defined as a point when people feel pain caused by the pressure of the algometer. To verify the intrarater reliability, the PPT was measured on the quadriceps femoris muscle three times prior to the experiment, and the intraclass correlation coefficient (ICC) was used. The level of reliability was 81.

3)Blood analysis

The blood of subjects was sampled prior to the experiment, and 24, 48 and 72 hours after the experiment respectively, and the level of CK in the blood was analyzed.

4)Data analysis

Statistics analysis was conducted using SPSS/window (version 18.0). Two-way ANOVA with repeated measurements was used to examine differences in the effect of the treatment discussed above in the experimental group and the control group depending on the time of measurement. Independent-samples t-test was conducted to examine differences between the groups, and the level of statistical significance (a) was 0.05.

5)Experimental methods

Vibration treatment was applied to the experimental group immediately after inducing DOMS on the quadriceps femoris muscle, and to the control group 24 hours after inducing DOMS. DOMS was induced using the N-K table, and the intensity was set at 60% of the maximum muscular strength. Based on the method suggested by Kim[11] The maximum concentric and eccentric contraction exercise was performed in 10 sets (10 repetitive motions per set), a total of 100 times. Subjects took a break for 60 seconds between sets. [30]

Using a whole body vibration (WBV) machine (Model No. HS-300FA), three sets of vibration treatment (10 minutes per set) were provided at 25Hz for the two groups, and subjects took a break for 3 minutes between sets. The treatment was provided for the experimental group immediately after the experiment, and 24 and 48 hours after the experiment respectively, and for the control group, 24, 48, and 72 hours after the experiment. The levels of CK, PPT and VAS were measured before the experiment, and 24, 48 and 72 hours after the experiment respectively.

3. Results

1.General characteristics of subjects

The number of subjects who participated in this study was a total of 20 adults, and there was no statistically significant difference in age, height and weight in the independent-samples t-test (Table 1).

Table 1. General characteristics of subjects (M±SD)

	Experimental Group (n=10)	Control Group (n=10)	t	p
Age	24	23.7±0.67	1.406	.09
Height	175.3±3.27	174.4±4.16	.00	.5
Weight	68.2±8.14	68.5±7.59	-.08	.46

2. Comparison of the CK level between groups depending on experimental period

The level of CK depending on the experimental period was compared between the two groups, but the results did not meet Mauchly's sphericity assumption (Table 2). For this reason, the within-subject effect was examined using the Greenhouse-Geisser test. There was a statistically significant difference depending on the measurement time (Table 3), but no statistically significant difference in the results of the time-group Greenhouse-Geisser test (Figure 1).

Table 2. Sphericity test for the level of CK

Within-subject effect	Mauchly's W	Chi square	Degree of freedom	P
Time	.181	28.59	9	.00

Table 3. Within-subject effect test for the level of CK

	TypeIII S	Degree of freedo	Mean square	F	P
Time Greenhouse-Geisser	63335579.1	1.558	4067184.2	29.16	.00
Time*Group Greenhouse-Geisser	42464.5	1.558	27260.48	.19	.76
Error (time) Greenhouse-Geisser	3909653.4	28.039	139435.47		

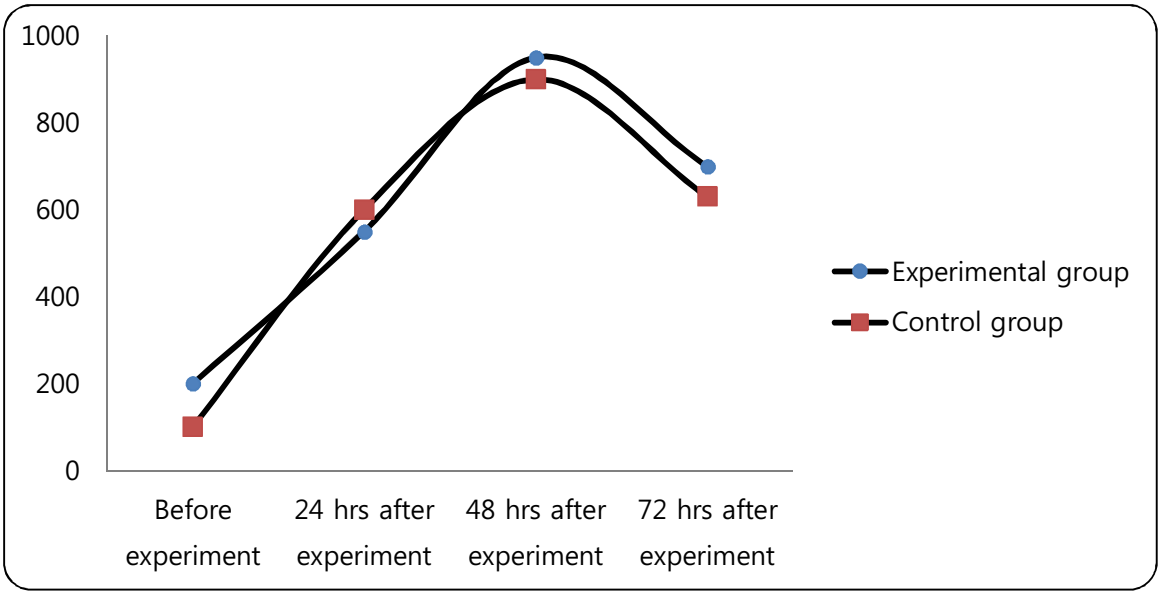

Figure 1. Interaction between measurement time and groups on the CK level

There was no statistically significant difference in the results of the between-subjects effect test in the two groups (Table 4). There was no statistically significant difference in the level of CK between the two groups before the experiment, and 24, 48, and 72 hours after the experiment (Table 5).

Table 4. Between-subjects effect test for the level of CK

	Type III SS	Degree of freedom	Mean square	F	P
Group	924.8	1	924.8	.00	.96
	8549993.2	18	474999.62		

Table 5. Comparison of the level of CK (M±SD) (unit: IU/L)

Measurement time	Experimental group	Control group	T	P
Before experiment	199±234	153±62	0.58	0.28
24 hrs after experiment	550±533	614±161	-0.36	0.35
48 hrs after experiment	947±509	916±442	0.14	0.44
72 hrs after experiment	746±569	786±485	-0.16	0.43
F	12.96	16.71		
P	0.0	0.00		

3. Comparison of the PPT level between groups depending on experimental period

The level of PPT depending on the experimental period was compared between the two groups, but the results did not meet Mauchly's sphericity assumption (Table 6). The within-subject effect was examined using the Greenhouse-Geisser test. There was a statistically significant difference depending on the measurement time (Table 7), but no statistically significant difference in the results of the time-group Greenhouse-Geisser test (Figure 2).

Table 6. Sphericity test for PPT

Within-subject effect	Mauchly's W	Chi square	Degree of freedom	P
Time	.348	17.66	5	.00

Table 7. Within-subject effect test for PPT

	Type III SS	Degree of freedom	Mean square	F	p
Time Green house-Geisser	18312.73	1.821	10055.33	329.341	.00
Time≠Group Green house-Geisser	92.63	1.821	50.866	1.666	.20
Error (Time) Green house-Geisser	1000.87	32.782	30.532		

There was no statistically significant difference in the results of the between-subjects effect test in the two groups (Table 8). In addition, there was no statistically significant difference in the level of PPT between the

two groups before the experiment, and 48 hours after the experiment, but there was a statistically significant difference between the groups 24 and 72 hours after the experiment (Table 9).

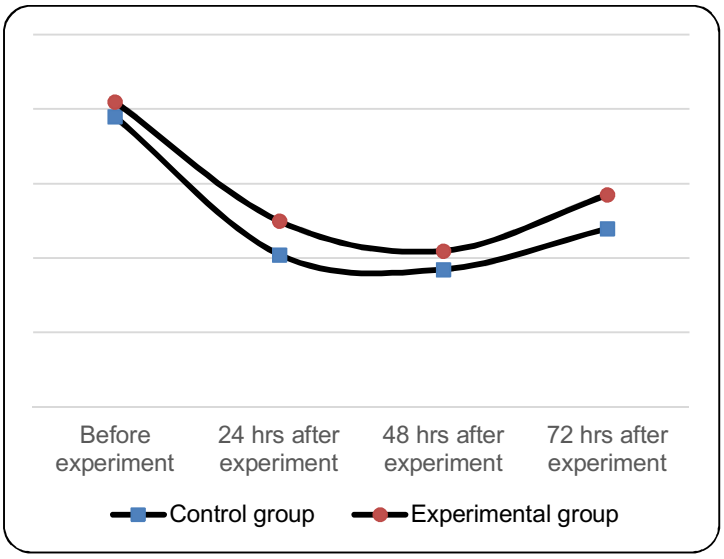

Figure 2. Interaction between measurement time and group on PPT

Table 8. Between-subjects effect test for PPT

	Type III SS	Degree of freedom	Mean square	F	P
Group	621.613	1	621.613	4.97	.03
Error	2247.625	18	124.868		

Table 9. Comparison on PPT (M±SD) (unit : lbf)

Measurement time	Experimental group	Control group	T	P
Before experiment	80±7	78±6	-.820	.21
24 hrs after experiment	48±7	41±5	-2.35	.01
48 hrs after experiment	43±6	38±5	-1.45	.82
72 hrs after experiment	56±6	48±4	-3.01	.00
F	134.42	205.25		
p	.00	.00		

4. Comparison of the VAS level between groups depending on experimental period

The level of VAS depending on the experimental period was compared between the two groups, and the results met Mauchly's sphericity assumption (Table 10). For this reason, the within-subject effect was

examined using the sphericity assumption. There was a statistically significant difference depending on the measurement time (Table 11), but no statistically significant difference in the results of the time-group sphericity assumption (Figure 3).

Table 10. Sphericity test for VAS

Within-subject effect	Mauchly's W	Chi square	Degree of freedom	P
Time	.959	8.685	5	.12

Table 11. Within-subject effect test for VAS

	Type II SS	Degree of freedom	Mean square	F	P
Time sphericity assumption	224.738	3	74.913	184.927	.00
Time group sphericity assumption	3.138	3	1.046	2.582	.06
Error (Time) sphericity assumption	21.875	54	.405		

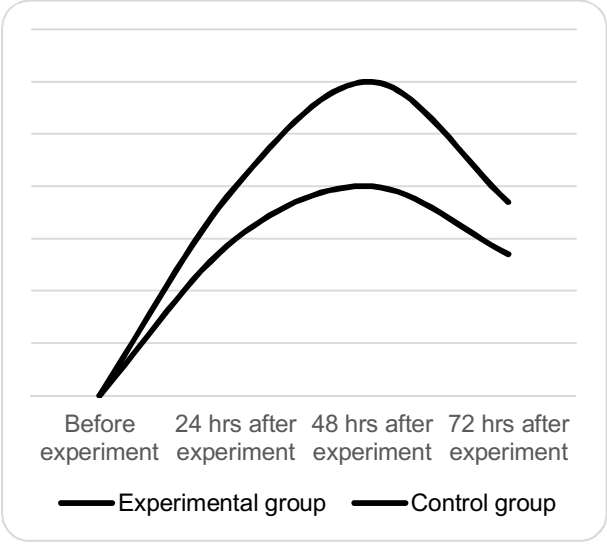

Figure 3. Interaction between measurement time and group on VAS

There was a statistically significant difference in the results of the between-subjects effect test in the two

groups (Table 12). In addition, there was a statistically significant difference in the level of VAS between the two groups 24 and 48 hours after the experiment, but no statistically significant difference between the groups 72 hours after the experiment (Table 13).

Table 12. Between-subjects effect test for VAS

	Type II SS	Degree of freedom	Mean square	F	P
Group	9.113	1	9.113	7.585	.01
Error	21.625	18	1.201		

Table 13. Comparison on VAS (M±SD) (unit : cm)

Measurement time	Experimental group	Control group	T	P
Before experiment	0	0		
24 hrs after experiment	3.0±0.6	3.9±0.5	-3.25	.00
48 hrs after experiment	4.0±0.6	5.0±1.1	-2.372	.02
72 hrs after experiment	2.7±0.4	3.5±1.4	-1.672	.06
F	120.001	82.471		
P	.00	.00		

4. Discussion

In this study, the delayed onset muscle soreness (DOMS) was induced on the quadriceps femoris muscle, and time-intervened vibration exercises were applied. After that, changes in the level of soreness (using a visual analogue scale, VAS), pressure pain threshold (PPT), and creatine kinase (CK) in the blood were measured. In the process of inducing and treating DOMS, the level of CK was measured to examine the objective level of DOMS.

CK is known as an indicator for injuries to the skeletal muscles, and it is reported that the level of CK in the blood significantly increases during strenuous exercise. For this reason, the activity of CK has been measured as an indicator to check the occurrence and extent of DOMS in many studies. [31]

CK is found in muscular tissues including brain tissues, and is affected by various factors such as inflammation, ischemic heart disease, muscle damage, drinking, the activity of sex hormones, exercise, environmental temperature, etc., and thus it is difficult to readily determine the type of a disease or the extent of a muscle injury based on the level of CK in the blood only. [32] [33]

CK enzyme is an isoenzyme that exists in the extensor and skeletal muscles, and an increase in the level of CK in the blood is indirect proof of a muscle injury. [33] [34] When the level of CK increases after exercise, it can be used as an indicator for muscle injuries. [35] CK liberated from the injured skeletal muscles is a general indicator for skeletal muscle injuries. [36] The activity of CK enzymes continues to increase within

the 1~3 days of eccentric exercises, which is a serious health issue associated with DOMS. [37]

For this reason, the activity of CK in this study began to gradually increase from 24 hours after exercise both in the experimental and control groups, and reached a peak after 48 hours. The activity began to decrease gradually from 72 hours after exercise, but there was no statistically significant difference between the two groups. Thus, vibration treatment was effective in reducing the activity of CK in DOMS, similar to the results of the study of, [17] but it is difficult to determine whether applying vibration treatment immediately after inducing DOMS would be more effective to reduce the activity of CK, or applying it 24 hours after exercise would be more effective.

The experimental group to which vibration treatment was applied immediately after DOMS was induced did not show any statistically significant difference in the level of VAS compared to applying the vibration treatment 24 and 48 hours after inducing DOMS. There was a statistically significant difference in the level of PPT when applying vibration treatment 24 and 72 hours after inducing DOMS. There was a numerical difference when applying the treatment 48 hours after inducing DOMS, but no statistically significant difference. The results indicated that vibration treatment was effective for the recovery of VAS and PPT in the experimental group. Beak and Shin [38] reported that vibration exercise at 20Hz in an upright position increases the temperature of the vibrated area, which expands peripheral blood vessels and increases blood circulation.

There are several studies on the effect of whole body vibration (WBV) exercise on muscle ischemia and hypoxia, which are some of the causes of DOMS. Among them, those on the increasing blood circulation in peripheral blood vessels and changes in aerobic metabolism. [39] [40] reported that vibration exercise increases the blood flow rate in muscles. In this study, the experimental group to which vibration exercise was applied immediately after inducing DOMS showed an increase in blood circulation on the treated area more than the control group, and a more significant decrease in soreness, which can be attributable to changes in the level of PPT. It seems that an increase in oxygen uptake after WBV exercise compensates for the shortage of oxygen right after inducing DOMS, thus having a more positive impact on the level of soreness and PPT in the experimental group.

There are some limitations in this study. First, subjects were not selected from those who have a similar body shape with a similar level of muscle mass since their BMI was not analyzed prior to this experiment. Second, this study was conducted among males in their 20s only, and thus it will be difficult to generalize the results of this study to females or those in middle age or older who display a relatively lower level of activity and muscle mass. Third, this study observed subjects up until 72 hours after inducing DOMS, and did not analyze the status until DOMS disappears completely.

5. Conclusions

This study aimed to examine the impact of time-intervened vibration exercise, after inducing DOMS on the quadriceps femoris muscle, on recovery from DOMS. To do so, vibration treatment was provided a total of 9 times for 3 days (3 times per day) for the experimental group (n=10) to which the first vibration treatment was applied immediately after inducing DOMS, and for the control group (n=10) to which the first vibration treatment was applied 24 hours after inducing DOMS, and the results are as follows.

1. The level of CK decreased statistically significantly depending on the experimental period, but there was no significant difference between the experimental and control groups.
2. The level of PPT also decreased statistically significantly depending on the experimental period, and vibration treatment was more effective in the experimental group in terms of PPT.

3. The level of VAS decreased statistically significantly depending on the experimental period, and vibration treatment was more effective in the experimental group in terms of VAS.

The results of this study indicated that vibration treatment immediately after inducing DOMS was more effective for the recovery of PPT and VAS, but not for the level of CK, than the treatment provided 24 hours after inducing DOMS, and that the experimental group showed a statistically significant difference compared to the control group. Therefore, it can be concluded that applying vibration treatment immediately after inducing DOMS is more effective to treat DOMS.

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