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Original Article

The Effects of Aerobic Exercise and Strengthening Exercise on Pain Pressure Thresholds

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Abstract. [Purpose] We assessed the effects of aerobic exercise and strengthening exercise on pain pressure thresholds (PPTs) over time. [Subjects and Methods] Fifteen healthy participants were recruited and randomly divided into 3 groups: aerobic exercise, strengthening exercise, and control. The subjects in the aerobic group walked on a treadmill for 40 min at 6.5 km/h. The subjects in the strength group performed circuit training that included bench press, lat pull down, biceps curl, triceps extension, and shoulder press based on the perceived exertion for 40 min. The subjects in the control group rested without any exercise in a quiet room for 40 min. The PPTs of 5 potential muscle trigger points before exercise, and immediately after 10 and 40 min of exercise or rest were measured using an electronic algometer (JTECH Medical, USA). The Friedman's, Kruskal-Wallis, and Mann-Whitney tests were performed using SPSS 18.0 (IBM, Korea). [Results] The PPTs of all subjects decreased after 10 min of exercise, but the difference was not statistically significant. The PPTs of the control group decreased after 40 min. Furthermore, the PPTs of 3 muscles increased after 40 min of aerobic exercise and of 6 muscles after 40 min of strengthening exercise. No significant difference in PPTs was noted among the groups. [Conclusion] The results show that 40 min is a more appropriate exercise time, although the efficacy of controlling pain did not differ between strengthening exercise and aerobic exercise.
Key words: Aerobic exercise, Strengthening exercise, Pain pressure thresholds

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INTRODUCTION

The pain threshold (PT) is the minimum amount of pain or unpleasant feeling experienced by an individual, and it may be changed by continuous stimulation[1–3)]. A patient with chronic pain may have a high PT[4)] or a low PT[5)]. Three different theories of pain symptoms have been proposed by researchers[5–16)]. The neurophysiological theory proposes that continuous stimulation will induce a high PT because pain will inhibit pain by inhibiting neurons in the dorsal horn of the spinal cord. Second, The cognitive theory, an adaptive theory, proposes that if a subject often experiences uncomfortable sensations, their ability to perceive pain improves, which leads to a chronically increased PT, and, the hypersensitivity theory suggests that the PT will decrease due to exaggerated reactions in patients with chronic pain[6)].

A trigger point is a tender point in the muscle fibers that divides active and potential trigger points. An active trigger point is a point which moves during the performance of activities of daily living, while a potential trigger point is that one that is not felt until it is stimulated, e.g. by the application of pressure on the skin[3, 7, 8)]. Most people have similar potential trigger points despite having different lifestyles, which may be the main reason for pain[1)]. Therefore, physiotherapists must consider the potential trigger points when they create exercise plans for healthy people as well as patients.

Aerobic exercise increases oxygen consumption and induces pain relief by activating endocannabinoid receptors that can easily pass the blood vessel barrier[9)]. Sparing et al.[10)] reported that college students running on a treadmill or pedaling on a stationary bike at 79–80% of the maximum heart rate exhibited sedation and analgesia via activation of the endocannabinoid system. Hoffman et al.[11)] also found that pain perception changed after a minimum of 10 min of aerobic exercise with a 75% maximal oxygen uptake (VO_{2max}). Koltyn et al.[12)] suggested that an acute bout of exercise induced a lower systolic blood pressure, a higher heart rate, and changed the pain perception. However, isometric exercise increased blood pressure, but it is not related to pain perception[13)]—i.e., neurotransmitter and blood pressure levels were changed and then changes in pain perception were induced.

Muscle strength exercises have a positive effect on PT; however, some exercises such as weightlifting can worsen pain[14)]. Kolton and Arbogasr[15)] reported that the PT increased after 5 min of strengthening exercise with 75% of one-repetition maximum, and returned to normal after 15 min of strengthening exercises. Bartholomew et al.[16)] reported that pain tolerance increased after 20 min of self-

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selected exercise, indicating an analgesic response after exercise. Koltyn et al.[17] found that the PT of women increased and the PT of men did not change after isometric strengthening exercise.

As mentioned above, the analgesic effect of aerobic exercise requires a minimum of 10 min; however, strengthening exercise did not require the same amount of time. Furthermore, most studies selected an exercise intensity associated with maximum resistance, and the time for which exercise was performed differed among studies. Hence, a study of the effect of exercise duration using mild intensity of exercise was required. Moreover, in most previous studies, it was unclear whether a potential or active trigger point was used. Studies of the potential trigger point are essential, since it could lead to disease progression if it is not treated. Therefore, in the present study, we aimed to elucidate the manner in which aerobic and strengthening exercises affect PTs over time, and to identify appropriate exercises that clinicians can use for managing pain in patients.

SUBJECTS AND METHODS

Fifteen healthy participants were recruited and randomly divided into 3 groups. One participant dropped out of the study during the second test for personal reasons. All the subjects provided their written informed consent to participation in the experiment in accordance with the ethical principles of the Declaration of Helsinki. This study also excluded subjects who took any medication for musculoskeletal pain, in order to eliminate interference effects.

The pain pressure thresholds (PPTs) were measured using an electronic algometer (JTECH Medical, USA) over potential trigger points. The examiner identified a trigger point by palpating and exerting vertical pressure on the skin. The examiner increased the pressure at the rate of 1 kg/s until the subject experienced a pain or an unpleasant feeling, and the PPT values were measured 3 times for each muscle[1]. The participants were instructed to verbally express their first perception of pain or an unpleasant feeling, at which point the application of pressure was stopped[18]. The PPT has been proven to be a reliable measure (interclass correlation, 0.78–0.93)[19].

The subjects in the aerobic group walked on a treadmill for 10 and 40 min at 6.5 km/h. The subjects in the strength group performed 10 and 40 min of circulate training exercises that included a bench press, lat pulldown, biceps curl, triceps extension, and shoulder press based on the perceived exertion. The subjects in the control group rested in a quiet room without exercising for 10 and 40 min.

The PPTs were measured before exercise as well as immediately after 10 and 40 min of exercise using an electronic algometer at the potential trigger points of 5 muscles. The measurements were recorded at 2-day intervals to minimize fatigue-related errors and the mean values were then calculated.

The 5 muscles examined were the trapezius, supraspinatus, teres major, rhomboid, and levator scapulae. Most individuals experience problems, such as sudden muscle pain, in these muscles due to computer work and sedentary lifestyles, and therefore, these muscles were selected.

Table 1. General characteristics of the subjects (n=14) (M(SD))

Groups Characteristics	AG*	SG**	CG***
Height (cm)	176±7.7	174.5±3.7	176.8±3.1
Weight (kg)	75± 13.9	78±10.2	78±10.2
Age (year)	25.2± 0.8	71.2±05.3	24.3±0.5

* AG: Aerobic exercise Group, ** SG: Strengthening exercise Group, ***CG: Control Group, **** M: Mean, SD: Standard Deviation

Frequency analysis was performed to analyze the patients' general characteristics. Friedman's test was used to identify the change in the PPTs according to time, and the Kruskal-Wallis test was used to confirm differences among the 3 groups. The Mann-Whitney test was performed using SPSS 18.0 (IBM, Korea). A significance level of 0.05 was chosen for the Friedman's and Kruskal-Wallis tests and 0.001 for the Mann-Whitney test.

RESULTS

The participant's mean age was 25.2 years, their mean height was 176 cm, and their mean weight was 75 kg (Table 1).

The PPTs of all the muscles of all the subjects decreased immediately after 10 min of exercise or rest, although no significant differences in these values were noted. The PPTs of all the muscles decreased immediately after 40 min only in the control group, and significant differences were observed in the right trapezius and left levator scapulae muscles (Table 2).

Although the PPTs of both the trapezius and left supraspinatus muscles increased immediately after 40 min of exercise in the aerobic exercise group, the differences were not significant. Furthermore, in the strengthening exercise group, the PPTs of the left trapezius, left levator scapulae, left and right teres major, and left and right supraspinatus muscles increased; however, significant differences were only noted for the left trapezius, left levator scapulae, and left teres major muscle (Table 2). Moreover, no significant differences in the change of the PPTs were observed among the groups.

DISCUSSION

PPTs can be measured by electrical stimulation or pressure[1]. In the present study, we used a digital pressure algometer to measure the PPTs. We aimed to elucidate whether exercise changes pain perception at potential trigger points. Exercise-induced analgesia is useful in clinical settings. The endorphins induced after exercise decrease pain. In particular, pain perceptions are changed by exercise in patients with chronic low back pain; however, the effect of anesthesia differs according to the type of exercise[20]. Most of the previous studies have examined aerobic exercise, whereas only a few studies have focused on strengthening exercise, therefore, we also focused on strengthening exer-

Table 2. The changes of PPTs with time and different exercise types (M(SD))

Times Types	AG (n=5)	CG (n=5)	SG (n=5)	χ^2
R Tra baseline	28.4±2.3	31.6±3.6	29.6±5.4	2.2
10 min	24.6±4.2	25.3±4.3	23.8±1.4	0.2
40 min	29.6±5.4	23.9±5.1	23.3±3.9	0.2
χ^2	1.5	7.6*	6.0*	
L Tra baseline	28.0±2.3	27.9±3.2	30.5±5.1	1.0
10 min	24.7±2.9	26.4±4.2	23.9±5.8	0.4
40 min	25.3±2.4	23.6±5.2	24.1±4.7	0.5
χ^2	2.0	5.2	6.5*	
R Lev baseline	32.0±1.1	29.6±3.4	34.8±4.3	4.4
10 min	28.5±2.9	28.9±5.4	27.0±7.3	0.6
40 min	26.4±6.3	26.0±4.9	25.9±3.8	0.3
χ^2	7.6*	5.2	6.0*	
L Lev baseline	32.7±2.2	34.1±3.1	33.1±4.5	0.7
10 min	30.9±2.7	30.7±5.7	26.5±4.6	2.4
40 min	29.4±4.2	27.8±4.4	28.1±6.1	0.3
χ^2	5.2	8.4*	6.0*	
R Tere Maj baseline	25.2±5.8	22.4±2.3	24.1±5.0	1.0
10 min	21.7±3.7	22.0±6.1	19.8±4.9	0.5
40 min	20.8±6.4	21.7±5.0	21.3±6.2	0.04
χ^2	6.4*	0.7	3.5	
L Tere Maj baseline	22.9±6.2	23.3±3.6	26.5±7.2	0.7
10 min	20.8±5.0	21.8±6.2	19.4±6.0	0.2
40 min	20.1±5.7	21.9±5.6	20.8±5.7	0.5
χ^2	1.6	1.2	6.5*	
R Rom baseline	30.1±6.5	26.6±3.8	27.0±2.2	1.2
10 min	26.2±6.2	25.5±6.5	25.8±4.2	0.1
40 min	26.0±8.2	24.8±6.1	25.8±6.0	0.03
χ^2	4.8	1.4	1.5	
L Rom baseline	30.6±6.0	27.5±5.1	29.5±4.1	0.3
10 min	28.0±6.0	26.8±7.3	26.7±7.8	0.3
40 min	25.5±8.3	25.8±5.6	25.6±6.1	0.1
χ^2	7.6*	2.8	2.0	
R Supra baseline	30.2±5.0	31.5±4.3	33.7±3.2	1.7
10 min	29.4±3.5	30.4±6.7	28.8±7.3	0.5
40 min	28.4±6.1	29.3±6.2	29.0±8.6	0.3
χ^2	1.2	0.4	1.5	
L Supra baseline	30.3±2.5	31.7±4.0	31.5±1.7	1.9
10 min	28.6±5.1	30.5±6.2	27.5±7.7	0.8
40 min	29.4±4.4	29.8±5.1	29.7±10.9	0.5
χ^2	1.2	0.7	2.0	

* $p<0.05$, ** AG: Aerobic exercise Group, *** SG: Strengthening exercise Group, ****CG: Control Group, ***** M: Mean, SD: Standard Deviation
Tra: trapezius, Lev: Levator scapulae, Tere Ma: Teres Major, Rom:Romboid major, Supra: Supra spinatus, R: right, L: left

cise in the present study.

In the present study, treadmill walking was chosen as the aerobic exercise mode and circuit exercise was chosen as the strengthening exercise mode, because these forms of exercise are frequently chosen as self-exercise. The same testing method was employed for the 2 tests that differed in duration (10 min and 40 min), and it was repeated at a 2-day interval. Hoffman et al.[21] suggested that PPT reproducibility did not evoke a significant stress-induced analgesic effect, therefore, they did not measure potential trigger points. However, in the present study, PPT reproducibility at potential trigger points was measured.

Droste et al.[22] reported that the PPTs of 3 groups (cycle ergometer, naloxone, and placebo groups) did not change significantly, whereas Hoffman et al.[11] found that pain ratings were decreased 5 min after 30 min of exercise at 75% VO_{2max}, but had returned to baseline by 30 min after 30 min of exercise in healthy people.

Hoffman et al.[21] reported that PPTs were decreased after 30 min of aerobic exercise, consisting of leg cycling, among patients with chronic low back pain. However, Koltyn et al.[12] showed that the PPTs of a cycle ergometer group increased after 15, 20, and 30 min of exercise due to lowered systolic blood pressure and a higher heart rate. Kosek et al.[23] found that the PT of healthy subjects was increased after isometric exercise at a reading of 21% on a peak flow meter; however, the PT remained unchanged in patients with fibromyalgia. Koltyn and Arbogast[15] suggested that the PT after 45 min of strengthening exercise did not significantly differ between a strengthening exercise group and a control group.

In the present study, the PPTs had decreased immediately after 10 min of exercise or rest in the aerobic, strengthening exercise, and a control groups decreased after 10 min, although the differences between the values were not statistically significant among the groups.

There are several potential reasons for this. First, the patients' pain perceptions were changed and they could recognize the pain due to the application of pressure over the skin by the examiner—i.e., the subjects recognized potential pain after the examiner exerted pressure on the skin, and the potential trigger point was changed to an activating trigger point. When these subjects performed exercise, they still experienced the pain as they had already identified the trigger point. In fact, the subjects may have remembered the trigger point during short duration of the exercise.

Second, the measurements were made repeatedly and may have represented the summation of findings at the trigger points. The subjects repeatedly experienced pain at the trigger points, and may have easily remembered the pain at the time of exercise completion. This would indicate that pain is a sensory experience, involving a summation of psychological experience and cognitive experience.

The PPTs of 3 muscles in the aerobic exercise group and 6 muscles in the strengthening exercise group increased immediately after 40 min of exercise, but none of these values indicated a significant difference, except for the PPTs of the left trapezius, left levator scapulae, and left teres major in strengthening exercise group. Therefore, 40 min of exercise was more effective than 10 min of exercise, although the change in the PPTs was mild. This may be explained by the intensity of the exercise. Although we used mild intensity exercise in the present study, most previous research has used maximum intensity exercise. Maximum intensity exercise may increase the blood supply to the muscle, sufficiently enough to control pain. However, the intensity of the exercise used in the present study was perhaps in sufficient to ensure adequate blood supply to the muscles for pain control.

The PPTs of all of the muscles in the control group decreased immediately after 40 min of rest, but no significant differences were noted. This finding may be explained the fact that the subjects could easily perceive the trigger points after the examiner exerted pressure at these points. The subjects remembered the pain that was caused by the pressure applied by the examiner, and were continuously aware of the pain during the rest period. This may have been one reason why the subjects responded quickly when an examiner measured the pain threshold again.

Physiotherapists may need to treat patients who complain of a greater amount of pain after therapy in the clinic, because a potential trigger point may have changed to an active trigger point in these patients. The results of the present study indicate the potential for change in the condition of the trigger points after therapy. Therapists need to determine whether pain originates from an activated or potential trigger point.

We believe that the measurement of PPTs in the sitting position is a limitation of this study, as the examiner needs to apply a greater amount of pressure when the subject is in the sitting position than when the subject is lying on a table. Moreover, the sample size was small, and therefore, the findings are difficult to generalize.

In conclusion, PPTs decreased immediately after 10 min of exercise or rest, but the PPTs of some muscles were increased immediately after 40 min of exercise. Moreover, no significant differences in these values were noted according to the type of exercise. Therefore, both strengthening exercise as well as aerobic exercise of mild intensity were unable to effectively control pain. Hence, we suggest that 40 min is an effective exercise time, but that an increased intensity of exercise is required to control pain.

Thus, more specific exercises need to be developed in the future, including exercises with varying intensity and duration. Moreover, the transition of a potential trigger point to an activated trigger point should be identified to prevent potential disease

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