Synergistic effect of a rehabilitation program and treadmill exercise on pain and dysfunction in patients with chronic low back pain

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Abstract. [Purpose] The present study examined the influence of treadmill exercise added to a low back pain rehabilitation program on low back extensor strength, pain, and dysfunction in chronic low back pain patients. [Subjects and Methods] Twenty men aged 22–36 years with chronic low back pain were randomly divided into experimental and control groups of 10 patients each. Both groups underwent a low back pain rehabilitation program lasting 30 min each, thrice/week for 8 weeks. The experimental group was prescribed an additional 30 min of treadmill exercise without a slope at a speed of 3.0–3.5 km/h, at which patients could walk comfortably. Low back extensor strength was tested using the Medx lumbar extension machine, pain level was tested, using the visual analog scale, and dysfunction was tested, using the Oswestry Low Back Pain Disability Questionnaire. [Results] Changes in low back extensor strength by angle showed significant interaction effects between measurement time and group at 12°, 24°, and 36°. The results of the visual analog scale and Oswestry Questionnaire showed a decreasing trend after the experiment in both groups. However, there was no interaction effect of the additional treadmill exercise in the experimental group. [Conclusion] The combination of a low back pain rehabilitation program and treadmill exercise has a synergistic effect, to some extent, on the improvement of low back extensor strength and should be considered for treatment and rehabilitation of low back pain patients.

Key words: Low back pain, Rehabilitation, Treadmill exercise

INTRODUCTION

Over 70% of the population in developed countries experiences low back pain, and its incidence is increasing in developing countries as well; low back pain is therefore a global problem. As varied and complex psychological and social factors are involved, the pain has no definite cause in about 85% of patients. Low back pain is divided into acute or chronic according to its duration; if the pain lasts for over 12 weeks, it is defined as chronic low back pain, and 5–10% of all acute low back pain patients develop chronic low back pain.

Once low back pain becomes serious, physical activities are restricted, and ultimately muscle atrophy occurs as the muscles remain unused for long durations. Particularly in chronic low back pain patients, the worsening of low back pain caused by reduction in the muscle area and muscular atrophy leads to secondary damage and relapse. Many low back pain patients develop recurring low back pain due to lumbar instability caused by muscular weakness around the spine and soft tissue damage in the trunk. Finally, the reduction in muscular strength, muscular endurance, and flexibility in the lumbar spine and limited range of motion of joints cause relapse of chronic low back pain. In particular, chronic low back pain patients have more severe atrophy of low back extensors than of flexors. Additionally, the aerobic exercise capacity tends to decrease in patients with chronic low back pain owing to the limitation on motion—this must be considered in rehabilitation exercise.

The reasons for low back pain are still under discussion, and over many years, various exercise methods have been suggested for treating low back pain, including flexion exercise, isometric flexion exercise, extension exercise, passive extension exercise, and intensive dynamic back exercise. Although these exercise programs have been recommended and developed over several years in low back pain discussions and rehabilitation centers, a satisfactory outcome has not yet emerged. Despite greatly differ-
ent opinions on the pathogenesis of low back pain among researchers, therapeutic exercise is known to be effective in general. In addition, therapeutic exercise in which patients participate actively is effective for low back pain after the acute phase, and in particular, different types of exercises applied by physiotherapists show very positive outcomes.

Rehabilitation programs for the relief of low back pain include complex exercises such as selective exercises involving control of trunk muscles, muscle strengthening, muscle stretching, and aerobic exercises. Recent studies report that aerobic exercise is effective in reducing depression, pain, and dysfunction in low back pain patients. However, some studies report that aerobic exercise combined with traditional physical therapy has no additional effect on pain and dysfunction. Therefore, there are conflicting results concerning the effects of aerobic exercise in low back pain patients, and there is also a lack of clear evidence on this matter. Therefore, the purpose of this study was to determine the additional effect of treadmill exercise combined with a low back pain rehabilitation exercise program on low back extensor strength, pain, and dysfunction in patients with chronic low back pain.

SUBJECTS AND METHODS

This study involved 20 men aged 22–36 years with chronic low back pain who visited a hospital rehabilitation medicine department; they were randomly divided into experimental group and a control group, with 10 patients in each group. Patients who complained of low back pain lasting for over 3 months were selected as subjects, and patients with musculoskeletal diseases that impaired gait, heart diseases, neurological disorders, or structural spine deformity were excluded. All the subjects of this study signed the consent form for this study voluntarily after the variation (Δ) between baseline measurements and measurements after 8 weeks of exercise was calculated (Δ score = changed score between before and after 8 weeks of exercise). All statistical analyses were conducted using the PC version of the Statistical Package for the Social Sciences (SPSS version 21.0; IBM Corporation, Armonk, NY, USA), and statistical significance was set at p < 0.05.

RESULTS

According to angle, the changes in low back extensor strength showed significant interaction effects of measurement time and group at 12° (p = 0.034), 24° (p = 0.029), and 36° (p = 0.011). However, at 48°, 60°, and 72°, both the control group and experimental group showed no interaction effect despite showing an increasing trend in low back extensor strength after the experiment compared with before

| Group          | Age (years) | Height (cm) | Weight (kg) | BMI (kg/m²) |
|----------------|-------------|-------------|-------------|-------------|
| Control (N = 10) | 27.7 ± 4.2  | 170.2 ± 9.4 | 65.5 ± 15.2 | 22.3 ± 3.4  |
| Exercise (N = 10) | 29.1 ± 4.8  | 172.5 ± 3.7 | 69.1 ± 12.1 | 23.1 ± 3.5  |

Data are means±SD
the experiment.

The VAS and Oswestry Low Back Pain Disability Questionnaire scores showed a decreasing trend after the experiment compared with before the experiment, both in the control group and the experimental group. However, there was no interaction effect of the additional treadmill exercise in the experimental group compared to the control group (Table 3).

DISCUSSION

Low back pain is one of the most widespread diseases in modern society. Rapid economic development and a sedentary lifestyle have brought about a reduction in physical activity and changes in physical function and posture, leading to the incidence of low back pain. In most low back pain patients, muscular weakness and imbalance around the lumbar spine caused by lack of exercise are the major factors that cause activity impairment. This is because muscular weakness and imbalance lead to low back pain, and this pain limits the range of motion and prevents the proper exertion of muscular strength. Generally, low back pain patients reduce their physical activity to avoid the pain caused during the performance of their daily routine activities\(^1\)\(^9\), leading to a vicious circle of relapse and chronicization of low back pain, which in turn reduces aerobic exercise capacity (cardiorespiratory fitness)\(^1\)\(^9\). The reduction of activities of daily living (ADL) after the occurrence of low back pain causes sarcopenia and reduces muscular strength, muscular endurance, and cardiopulmonary function, leading to an increase in the likelihood of development of metabolic risk factors\(^2\)\(^9\). Therefore, performing aerobic exercise to improve low back extensor strength is important. In this study, additional treadmill exercise was conducted by patients performing a low back pain rehabilitation program for 8 weeks to determine if the addition of this exercise was effective.

In this study, changes in low back extensor strength showed a significant interaction effect by angle at 12\(^\circ\), 24\(^\circ\), and 36\(^\circ\), which was considered to be the effect of the treadmill exercise conducted under the supervision of experts who ensured that the patients performed the exercise with their backs straight and made initial contact with their heel. In other words, low back extensors are activated and muscular strength increases by walking properly and improving lordosis; these findings are attributed to the effect of training the supporting muscles involved in the angle changes of extensors often used in the lumbar region when performing walking exercises.

Kankaanpää et al.\(^2\)\(^1\) found that the low back extensors of chronic low back pain patients were weak and got easily

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**Table 2. Comparison of the average change in low back extensor strength between both groups**

| Degree | Group   | Pre-test     | Post-test   | Δscore     |
|--------|---------|--------------|-------------|------------|
| 0\(^\circ\) | Control | 97.3 ± 59.2  | 130.6 ± 73.4| 33.3 ± 28.2|
|        | Exercise| 99.1 ± 59.6  | 141.5 ± 60.2| 42.4 ± 30.1**|
| 12\(^\circ\) | Control | 130.3 ± 77.6 | 157.6 ± 80.7| 27.3 ± 24.2|
|        | Exercise| 125.1 ± 57.4 | 179.6 ± 60.9†| 54.5 ± 28.6***|
| 24\(^\circ\) | Control | 148.3 ± 81.7 | 181.2 ± 80.9| 32.9 ± 28.4|
|        | Exercise| 146.8 ± 64.6 | 214.2 ± 52.1†| 67.4 ± 36.0***|
| 36\(^\circ\) | Control | 166.7 ± 83.4 | 198.6 ± 86.6| 31.9 ± 19.6|
|        | Exercise| 157.9 ± 63.7 | 220.8 ± 51.4†| 62.9 ± 28.1***|
| 48\(^\circ\) | Control | 183.1 ± 87.7 | 218.0 ± 96.6| 34.9 ± 25.8|
|        | Exercise| 174.9 ± 62.6 | 233.6 ± 57.6| 58.7 ± 30.8***|
| 60\(^\circ\) | Control | 203.4 ± 97.4 | 240.9 ± 107.8| 37.5 ± 31.4|
|        | Exercise| 189.1 ± 66.1 | 247.9 ± 61.9| 58.8 ± 25.5***|
| 72\(^\circ\) | Control | 214.5 ± 10.9 | 257.2 ± 113.6| 42.7 ± 27.2|
|        | Exercise| 208.2 ± 73.9 | 258.6 ± 67.3| 50.4 ± 37.5***|

Data are means±SD. Δscore = change in score. Paired t-test: \(*p<0.05; \**p<0.01; \***p<0.001\). Two-way ANOVA test (group×time): \(*p<0.05; \††p<0.01; \†††p<0.001\)

**Table 3. Changes in the visual analog scale and Oswestry Low Back Pain Disability Scores**

| Variable          | Group   | Pre-test     | Post-test   | Δscore     |
|-------------------|---------|--------------|-------------|------------|
| VAS               | Control | 36.3 ± 17.4  | 20.5 ± 13.1 | −15.8 ± 13.5|
|                   | Exercise| 31.3 ± 17.9  | 16.9 ± 9.3  | −14.4 ± 12.3**|
| Oswestry questionnaire | Control | 16.5 ± 3.5  | 14.4 ± 5.0  | −2.1 ± 3.0  |
|                   | Exercise| 14.9 ± 3.0  | 11.7 ± 1.7  | −3.2 ± 2.0***|

Data are means±SD. Δscore = change in score. Paired t-test: \(*p<0.05; \**p<0.01; \***p<0.001\). Two-way ANOVA test (group×time): \(*p<0.05; \††p<0.01; \†††p<0.001\). VAS: visual analog scale, Oswestry questionnaire: Oswestry Low Back Pain Disability Questionnaire
tired as compared with those of normal people. Lamoth et al. concluded that walking training should be considered in rehabilitation programs for chronic low back pain patients, since the stability between their lumbar sections was low and the coordination between the low back extensors was poor. From a rehabilitative perspective, it can be said that walking programs are helpful for simultaneously stabilizing the trunk and controlling the motion of the limbs by strengthening the waist muscles and abdominal muscles supporting the spine.

In this study, the VAS and Oswestry Low Back Pain Disability Questionnaire scores of the experimental group showed no interaction effect of the additional treadmill exercise as compared with those of the control group. Tritilanunt et al. found that chronic low back pain patients that performed an aerobic exercise program for 3 months showed a significantly reduced pain index compared with those who performed only lumbar flexion exercise. Also, Chatzitheodorou et al. found that chronic low back pain patients that performed high-intensity aerobic exercise for 12 weeks showed significantly reduced pain, dysfunction, and psychological burdens compared with those who received only conservative physical therapy. However, Chan et al. found that aerobic exercise combined with an 8-week physical therapy had no additional effect on the alleviation of pain and dysfunction, similar to the findings of this study. The lack of an additional effect of treadmill exercise in this study is attributed to the fact that both groups underwent back mobilization, performed abdominal stabilization exercise, and received back care advice based on ergonomic principles in addition to traditional physical therapy. However, as many studies have reported an additional effect of aerobic exercise, further systematic long-term studies with many subjects are required to confirm the findings of the present study.

Considering all the outcomes of this study, the changes in low back extensor strength by angle showed an additional effect of treadmill exercise at 12°, 24°, and 36°, and pain level and dysfunction index showed a decreasing trend after the experiment in both groups, with no significant difference between groups. It is thought that treadmill exercise combined with traditional physical therapy has a partial effect on improvement of low back extensor strength.

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