Endurance Training of the Trunk Extensor Muscles in People With Subacute Low Back Pain

Background and Purpose. Clinicians treating patients with low back pain often use exercise to reduce pain and improve function. The aim of this study was to evaluate the effectiveness of trunk extensor endurance training in reducing pain and decreasing disability in subjects with subacute low back pain (i.e., onset of back pain within 7 days to 7 weeks).

Subjects and Methods. Patients were randomly assigned to either an experimental group or a control group. A visual analog scale and the Pain Rating Index (PRI) of the McGill Pain Questionnaire (MPQ) were used to obtain baseline measurements of pain. The Roland-Morris Disability Questionnaire (RMDQ) was used to measure disability, and the Sorensen Test was used to measure trunk extensor endurance. Subjects in the experimental group attended exercise sessions 3 times per week for 6 weeks. Subjects in the control group did not do exercises. Both groups were given back care advice and hot packs for 15 minutes, 3 to 5 times per week. Reassessments were carried out at 3 and 6 weeks.

Results. There were differences between the 2 groups at 3 weeks with regard to pain intensity during the evaluation session, pain experienced over the preceding 24 hours, the total MPQ PRI, the sensory component of the MPQ PRI, and the RMDQ. At 6 weeks, no differences were found for pain measurements, disability scores, and holding time on the Sorensen Test.

Conclusion and Discussion. Trunk extensor endurance training reduced pain and improved function at 3 weeks but resulted in no improvement at 6 weeks when compared with the control group. Endurance exercise is considered to expedite the recovery process for patients with an acute episode of low back pain. [Chok B, Lee R, Latimer J, Tan SB. Endurance training of the trunk extensor muscles in people with subacute low back pain. Phys Ther. 1999;79:1032–1042.]

Key Words: Controlled randomized trial, Exercise, Subacute low back pain, Trunk endurance.

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Some authorities suggest that muscle is a potential source of low back pain. They argue that failure of muscles to protect passive structures from excessive loading may result in damage to these pain-sensitive structures and produce pain. Enhancing muscle endurance, therefore, may help to reduce low back pain.

Poor endurance of the trunk muscles may induce strain on the passive structures of the lumbar spine, leading eventually to low back pain. Evidence suggests that muscle endurance is lower for people with low back pain than for individuals without low back pain. Using the Sorensen Test as a measure of spinal extensor endurance, some researchers have found a difference in holding time between subjects with chronic low back pain (CLBP) and individuals without low back pain. These findings seem to suggest that poor trunk extensor endurance is associated with prolonged or recurrent back pain.

The endurance of the trunk muscles may be related to low back pain. Fatigue can affect the ability of people with low back pain to respond to the demands of an unexpected load. Fatigue after repetitive loading also leads to a loss of control and precision, which may predispose an individual to developing low back pain. Therefore, trunk muscle endurance training has been recommended to elevate fatigue threshold and improve performance, thus reducing disability.

There is evidence to suggest that endurance training of the low back extensors can be effective in relieving low back pain. In one study, 42 subjects with acute low back pain and 26 subjects with CLBP were examined. The duration of the acute back pain was usually 1 to 2 weeks, and 50% of these patients had complaints of discomfort for more than 5 years prior to this acute episode. More than 80% of the subjects with CLBP had symptoms of more than 5 years' duration. Following endurance training, 41 of the 42 subjects with acute low back pain became symptom free. Fifteen subjects with CLBP became symptom free, 7 subjects reported some improvement, and 4 subjects reported no improvement. The guidelines for the exercise progression, however,
were not clearly defined. Although assistance was given if subjects were unable to perform the task, the criteria used to determine the amount of assistance provided remained unspecified. Unfortunately, the intervention was not standardized, and pain was the only outcome measure. There was no measure of disability. There was also no control group (ie, a group with a clinical presentation similar to that of the experimental group and given no intervention) to account for the high spontaneous recovery rate usually found in subjects with acute low back pain.15,16

More recently, however, the results of a controlled clinical trial suggest that endurance exercise is effective for people with CLBP.13 The results of that trial suggest that intensive extension exercises are superior to using an exercise program with isometric back extension and abdominal exercises. Outcome measures used in that study included the Sorensen Test, a pain scale, and a disability questionnaire. The disability questionnaire was designed by the authors and consisted of 15 questions pertaining to everyday activities. Its reliability and validity were not investigated. Unfortunately, the Sorensen Test scores were not documented separately from the other impairment scores. Thus, it was not possible to evaluate the effectiveness of the exercise program on back extensor endurance alone.

In one study,17 workers with back pain who participated in an exercise program that included endurance exercise returned to work earlier than the subjects in a control group. The subjects with subacute low back pain were given a variety of exercises to improve the endurance of the back extensors and abdominal muscles and their cardiovascular fitness. The control group received traditional medical care only, such as analgesics and rest. The results demonstrated that subjects participating in the exercise program returned to work earlier than those receiving the control treatment. Unfortunately, the exercises that had been particularly effective could not be determined from this study. Thus, even though generalized endurance exercises have been shown to be efficacious for subjects with subacute low back pain, there have been no randomized controlled studies to demonstrate the effectiveness of endurance training of only the trunk extensors.

Gains in endurance of the back extensors following training have been shown to occur in subjects without low back pain.18,19 Muscle endurance was measured by the Sorensen Test19 and the time taken for the peak torque to decrease to 50% of its original value as measured by a dynamometer.18 Moffroid et al14 found 22% improvement in muscle endurance performance of the trunk extensors using the Sorensen Test after a 6-week exercise program for women without low back pain. The exercise program consisted of 5 exercises directed at improving trunk extensor endurance.

The effects of muscle endurance training have been investigated in subjects with CLBP13 and in individuals without low back pain.14 The efficacy of such training in patients with subacute low back pain has not been studied. Therefore, our study was designed to evaluate the effectiveness of trunk muscle endurance training in reducing pain and improving muscle endurance and function in patients with subacute low back pain. Function was defined as the individual’s ability to perform the necessary everyday activities. Subacute low back pain was defined as an episode of low back pain occurring during the previous 7 days to 7 weeks.20 Our hypotheses were: (1) trunk extensor endurance training reduces pain and disability and improves trunk extensor endurance, and (2) there is a relationship between trunk extensor endurance (as measured using the Sorensen Test), pain, and disability.

**Method**

**Subjects**

Sixty-six subjects were recruited from the patients regularly referred to Outpatient Physiotherapy Services, Physiotherapy Department, Singapore General Hospital. In addition, orthopedic consultants at the outpatient specialist clinic and the medical officer at the accident and emergency department were given a description of the study, including its title, purpose, and subject inclusion and exclusion criteria. They were requested to refer suitable patients to the physical therapy department on the same day. The registration clerk in the physical therapy department directed the referred patients to the researcher (BC) immediately. The subjects were randomly assigned to either an experimental or a control group using a randomized number sheet. The inclusion criteria were: (1) Subjects were between 20 and 55 years of age; (2) subjects had low back pain as a primary complaint, with or without associated leg pain; (3) the onset of pain was between 7 days and 7 weeks before the study began; (4) subjects had no history of back pain for a period of 6 months prior to the current episode; and (5) subjects were able to understand the English language. Subjects were excluded if they: (1) were receiving concurrent treatments from another practitioner for their low back pain such as traditional Chinese medicine, which is often used in Singapore; (2) were diagnosed as having a tumor, infection, or inflammatory disease affecting the spine; (3) had spinal or lower-limb surgery; (4) had spinal fractures or structural deformities such as spondylolisthesis and spondylosis; (5) had any contraindications to exercise therapy (eg, uncontrolled hypertension, previous myocardial infarction, cerebrovascular disease, peripheral vascular disease,
respiratory disorders); (6) were involved in workers’ compensation claims; (7) had signs of nerve root compromise, defined as decreased tendon reflexes, sensory loss, and motor deficits; and (8) were receiving medications other than analgesics and nonsteroidal anti-inflammatory drugs. All subjects were informed of the protection of their rights and gave written informed consent.

Twelve subjects (8 subjects from the experimental group and 4 subjects from the control group) were eliminated from the study within the first 3 weeks due to absenteeism or personal reasons. As a result, data obtained from 54 subjects (41 men and 13 women) were included in the data analysis. The characteristics of these subjects are shown in the Table. There were no differences in age or pain duration between the experimental and control groups. There were also no differences between the experimental and control groups in regard to their physical activity levels during activities of daily living with $P<.05$ (sedentary: $\chi^2=0.29$, $df=1$, $P>.5$; recreational: $\chi^2=3.2$, $df=1$, $P>.07$).

**Outcome Measures**

Pain was measured using a visual analog scale (VAS) and the Pain Rating Index (PRI) of the McGill Pain Questionnaire (MPQ).21,22 The MPQ PRI has 3 components: sensory PRI, affective PRI, and evaluative PRI.22 The VAS correlates well with the numerical scale of pain intensity but appears to have poor construct validity when pain is defined in terms of both intensity and affect.23–27 The MPQ, however, is capable of capturing both the affective and sensory components of pain.22 The results of our unpublished pilot study28 demonstrated acceptable test-retest reliability for patients with low back pain.

Disability was measured using the Roland-Morris Disability Questionnaire (RMDQ).29 The test-retest reliability for the RMDQ in a Singaporean sample population was also shown to be sufficiently reliable in our unpublished pilot study.28

Endurance of the trunk extensors was measured using the Sorensen Test (Fig. 1). The Sorensen Test measures the trunk extensors’ capability of sustaining an antigravity position over time. During this test, subjects lie prone with the pelvis at the edge of a plinth. We instructed our subjects to maintain their body in the horizontal position for as long as they could tolerate that position (Fig. 1).30 If the torso deviated more than 6 degrees from the stable position for longer than 6 seconds, the test was terminated and the time the subject took to maintain the horizontal position was entered. The torso deviation was monitored using the B-Tracker, a multiaxial electrogoniometer specifically designed to measure angular displacement of the spine. Test-retest reliability for the Sorensen Test was demonstrated by an intraclass correlation coefficient (3,1) of .84 for subjects who were pain-free, using 6 degrees over 6 seconds as the termi-

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**Table.**

Subject Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Experimental Group (n=30)</th>
<th>Control Group (n=24)</th>
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<tr>
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<td>Previous LBP (&gt;1 y)</td>
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<tr>
<td>Exercise adherence (%)</td>
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</table>

* LBP = low back pain; NA = not applicable; sedentary lifestyle = perform aerobic exercise at least once a week; active lifestyle = perform aerobic exercise at least 3 times a week. Exercise attendance is defined as the percentage of attendances out of a total of 18 exercise sessions (3 times per week for 6 weeks) (exercise attendance = [X attendance/18 sessions] ×100%).

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**Figure 1.**

Subject performing the Sorensen Test.
nation criteria. We believe this value is sufficiently reliable.

Subjects were given a rest of at least 10 to 15 minutes before performing the retest. Electromyographic frequency spectrum signals usually return to normal after subjects have rested for 5 minutes. The 10- to 15-minute rest period, therefore, should have provided adequate rest before the retest. In summary, the pilot studies showed that the outcome measures used to evaluate pain, disability, and endurance of the trunk extensors were, in our opinion, sufficiently reliable to use in the main study.

**Procedure**

All subjects completed a questionnaire designed to elicit demographic data, the VAS for measuring present pain and pain in the preceding 24 hours, the MPQ PRI, and the pain component of the RMDQ. All subjects also performed the Sorensen Test, which was conducted by a physical therapist who was unaware of the subjects’ group assignment.

Subjects in the experimental group were asked to exercise 3 times a week for 6 weeks at the physical therapy department. The endurance exercise protocol was adopted from the study by Moffroid et al. The exercise consisted of 4 levels (Fig. 2). The first level consisted of bilateral shoulder lifts in a prone position. The second level consisted of contralateral arm and leg lifts in a prone position. The third level required the subject to place both hands behind the head and perform bilateral shoulder lifts. The fourth level consisted of bilateral shoulder lifts with arms fully elevated. The first exercise session commenced immediately following the initial assessment. The warm-up protocol included cycling on an ergometer at 40 to 90 W for 7 to 10 minutes. Ten repetitions of back extensor stretches were performed before and after the endurance exercise program.

The ease of coping with the exercise was assessed using a categorical scale. The scale’s 5 grades were: 1 = “no sweat, could have done 1 more round,” 2 = “just nice,” 3 = “slightly strenuous, but coping okay,” 4 = “can’t continue anymore,” and 5 = “just can’t do it.” Subjects were progressed to the next exercise in addition to the existing exercise if their responses were scale grades 1, 2, or 3. They were asked to stop if their response was scale grade 4 or 5. A record was kept by the physical therapist. The ease of exercise was assessed during and at the end of each exercise session.

If pain was aggravated during the exercise, the subjects were asked to stop. If the pain diminished within 5 minutes after the exercise, they were asked to continue the exercise but to hold the exercise position for only 5 seconds. They were progressed to 10 seconds if there was no adverse response. Each exercise was repeated 9 times. After 10 repetitions, the subjects were instructed to rest for 30 seconds to 1 minute. For subjects who performed well and had indicated the level of ease as grade 1 or 2, the rest interval was 1 minute for every 50 repetitions until 300 repetitions were completed. The dosage of 5 series of 10 repetitions for 6 cycles was adopted from a previous protocol for subjects with acute low back pain. Holding time in the unsupported position was gradually increased to 20 seconds to provide a greater training stimulus. The exercise period ranged

**Figure 2.** Endurance training of the trunk extensors: (A) bilateral shoulder lifts, (B) contralateral arm and leg lifts, (C) bilateral shoulder lifts with hands behind the head, (D) bilateral shoulder lifts with arms in full elevation.
from 30 to 45 minutes. Subjects who encountered difficulty with a particular level of exercise (eg, level 2) were asked to stop the exercise and try to perform the exercise at a higher level (eg, level 3). If they were able to perform the higher-level exercise (level 3), they would continue at that level and discontinue the seemingly lower-level exercise (level 2). If subjects were unable to cope with the level 3 exercise, however, they would continue the level 1 exercise and slowly progress to the level 2 exercise. The aim was to encourage the subjects to exert moderately within pain tolerance, particularly on entry into the program.

At the end of the treatment session, a hot pack was applied to relieve soreness and discomfort in the lower back. Subjects were instructed to read the back care booklet provided by the physical therapy department. Postural education and back care advice were also given during the initial session.34

Subjects in the experimental group continued the trunk extensor endurance training program following the guidelines described for 6 weeks (ie, until the end of the study). Subjects in the control group were given a hot pack after the Sorensen Test. They were advised to use the hot pack at home, and they were not given further treatment at the physical therapy department. They were given postural and back care advice and the back care booklet, as described for the experimental group. Subjects were reminded not to seek treatment from other health care professionals or physicians practicing traditional Chinese medicine. They were advised to telephone the researcher (BC) if there were any problems during this period.

For both the experimental and control groups, 2 more measurements were made for all subjects following the initial assessment. The reassessments were scheduled at 3 and 6 weeks after entry into the study. During these reassessment sessions, subjects completed the VAS, the MPQ, and the RMDQ and they performed the Sorensen Test.

Data Analysis

Pain and disability scores did not assume normality using the Lilliefors modification of the Kolmogorov-Smirnov test (N=54). If the number of subjects is sufficiently large, despite the argument that these scores are ordinal or interval scale data, the sample may assume a normal
distribution. Then, what is left to decide would be whether the MPQ and RMDQ scores should be regarded as ordinal or interval scale data to satisfy the assumption of parametric tests. Therefore, differences in pain and disability measures between the experimental and control groups were compared by a nonparametric method (ie, Mann-Whitney U test, with an alpha level of .05) at the 3- and 6-week reassessment sessions. Lilliefors modification of the Kolmogorov-Smirnov test demonstrated that data obtained from the Sorensen Test assumed normality. Thus, differences between the 2 groups were analyzed using a parametric 2-way analysis of variance (ANOVA) at 3 and 6 weeks with the alpha set at .05. Finally, the Spearman correlation coefficient was used to determine the relationships between the various pain measures, the RMDQ, and the Sorensen Test with the alpha level set at .05.

**Results**

The experimental and control groups were not different from each other at the beginning of the study with regard to VAS and PRI scores ($P > .05$) (Figs. 3–6). At the 3-week reassessment, the VAS scores for present pain and pain during the preceding 24 hours, total PRI score, and sensory PRI score were lower for the experimental group than for the control group ($P < .05$). There was no difference in affective PRI and evaluative PRI between the groups. At the 6-week reassessment, there were no differences in all of the pain scores between the groups ($P > .05$) (Figs. 3–6).

During the initial assessment, there was no difference in back disability between the 2 groups as measured by use of the RMDQ. The disability score was lower in the experimental group than in the control group at 3 weeks ($P < .05$), but not at 6 weeks ($P > .05$) (Fig. 7).

There was no interaction in the main effects using 2-way ANOVA for the Sorensen Test, as shown in Figure 8. A post hoc test demonstrated no differences between groups, and the improvement made in both groups was not statistically significant.

At the beginning of the study and during the 3- and 6-week reassessment sessions, pain scores were generally not highly correlated with muscle endurance as measured by the Sorensen Test ($r = .43$, $P < .05$). There was some correlation, however, between various pain measurements and the RMDQ scores for both groups ($r = .49–.81$, $P < .05$). In

![Figure 5](image-url).

**Figure 5.** Differences in the total Pain Rating Index (PRI) scores between the experimental and control groups. Error bar represents range (sig = significant at $P < .05$, ns = not significant at $P < .05$; Mann-Whitney U test).

![Figure 6](image-url).

**Figure 6.** Differences in sensory Pain Rating Index (PRI) scores between the experimental and control groups. Error bar represents range (sig = significant at $P < .05$, ns = not significant at $P < .05$; Mann-Whitney U test).
particular, the quantity aspect of pain, that is, the VAS and sensory PRI scores, appeared to correlate with the RMDQ scores over time in the control group ($r = .71-.81, P < .05$).

There was a weak correlation at 6 weeks between the Sorensen Test scores and the RMDQ scores for the experimental group ($r = -0.41$) and for the control group ($r = -0.50$). In the control group, the strength of the correlation between the Sorensen Test and VAS scores obtained immediately before and after the test increased over time (initially: $r = .43, P < .05$; at 6 weeks: $r = .60, P < .01$). Such correlation was not significant in the experimental group ($P > .05$).

**Discussion**

Our study indicated that endurance training of the trunk extensors reduced pain in the short term (ie, up to 3 weeks) in subjects with subacute low back pain. The amount of pain experienced was reduced faster in the experimental group than in the control group. At the 6-week reassessment, however, both groups reported similar pain. For subjects with subacute low back pain, it is possible that healing may have been completed 6 weeks after entry into the study. Thus, the pain may have been resolved due to factors other than the endurance exercise protocol.\(^{20,35,36}\) The pain may have been caused by tissue damage in the acute and subacute phases.\(^{37}\) Regardless of intervention, however, both groups experienced minimal pain after 6 weeks. This observation concurs with previous reports that that patients with nonspecific low back pain recovered within 2 months.\(^{15,16,38}\)

The results of our study differ from those of studies in which no improvements were found following exercise intervention.\(^{16,39-41}\) The exercise program in these studies consisted of flexion and extension mobility exercises. This exercise program was different from the program of extensor endurance exercises used in our study. Lindström et al\(^{17}\) and Indahl et al\(^{42}\) found some positive effects of their exercise programs on pain and function. In these studies, exercises or activities that trained the trunk muscles were encouraged. Thus, muscle rehabilitation may have been more important than simple mobilization exercises in improving function at the subacute stage of low back pain.

Our data support the hypothesis that endurance training of the trunk extensors reduces disability, but only after 3 weeks of exercise and not after 6 weeks of exercise.
Exercise had a beneficial effect on the emotional and cognitive aspects of the pain experience as measured by the affective and evaluative PRIs of the MPQ. The subjects’ pain perception may have influenced their perception of disability as a result of their back pain. This argument is supported by the strong correlation between pain and disability as measured by the RMDQ (Spearman rho = 53–83). As the pain scores decreased, the RMDQ scores also decreased. The reduction of pain may have enabled the subjects to carry on with their activities of daily living, and thus they reported reduced disability.

Our results do not support the hypothesis that muscle endurance training improves extensor endurance as measured by the Sorensen Test at 3 and 6 weeks. The experimental group and the control group made comparable progress on test performance regardless of exercise. The exercise program required subjects to exercise 3 times a week for 6 weeks. This finding differs from those in previous studies. Our results could be due to differences in exercise dosage and patient profile. In the study by Moffroid et al., subjects without low back pain exercised for 2 sessions a day. Kahanovitz et al. studied a group of women without low back pain who exercised 5 times per week. In these studies, a higher-intensity exercise was generally used as compared with our study; therefore, there may have been an increased likelihood of improved function. Furthermore, we studied subjects with subacute low back pain. Pain may have inhibited an optimum exercise training stimulus. If the exercise stimulus is relatively low, such as that demonstrated in the submaximal exercise program of our study, increased oxidative capacity may or may not have resulted. Thus, the submaximal exertion demanded by the exercise program in our study on subjects with subacute low back pain was not able to demonstrate an effect on the muscle endurance as measured by the Sorensen Test.

Disability was better correlated with pain measures than endurance performance in our subjects with subacute low back pain. This finding is in agreement with the findings of Roland and Morris and Hides et al. In both studies, the correlation between pain and back disability as measured by the RMDQ was examined for subjects with acute low back pain. Our findings, however, differed from those of Jensen et al. and Co et al. who examined the correlation between pain and back disability as measured by the Oswestry Disability Questionnaire in subjects with CLBP.

The correlation between the VAS and RMDQ improved over time in our control group but not in our experimental group. In the control group (no exercise program), the subjects’ pain level appeared to be highly related to the level of their back disability, with the strength of this relationship steadily increasing from the initial assessment to the 6-week assessment. Similarly, trunk muscle endurance also became increasingly correlated with pain perception from the beginning of the study to the 6-week assessment, although this increase was not as large as for back disability as measured by the RMDQ. In the experimental group, none of this relationship existed. It may be suggested that exercises may have an effect in modifying this relationship between pain and back disability.

Physical therapy for acute and subacute low back pain commonly involves active range of movement exercise and passive movements, including mobilization and manipulation, combined with some muscle conditioning. In contrast to early active muscle contraction for peripheral joint injuries, intensive muscle exercise for the back has not been advocated because of the risk of exacerbating the symptoms. Findings from our study appear to suggest that muscle endurance exercise not only does not aggravate pain generally, it helps to relieve pain and bring about earlier restoration of back function, at least in the short term (ie, up to 3 weeks). Over a decade ago, a study by Deyo et al. demonstrated that patients benefited from minimal bed rest, with 78% of their sample population being subjects with subacute low back pain. Our findings further support those of Deyo et al.

Similar to other treatments for nonspecific low back pain such as manipulation combined with range of motion exercises, muscle endurance exercise demonstrated an effect in the short term. This short-term effect must not be underestimated, however, as patients with an episode of subacute low back pain are very keen to have their pain relieved earlier. The faster improvement with exercise may imply an earlier return to normal duty in the workforce, which helps to increase productivity and minimizes additional health care costs.

A limitation of our study is that it did not examine the placebo effect of endurance exercise training. Although subjects in the experimental group attended the exercise program under the supervision of the researcher 3 times a week, subjects in the control group were not given the same amount of contact time. The subjects in the control group were assessed once every 3 weeks. It is possible, therefore, that the attention given by the researcher to the subjects in the experimental group may have contributed to the improvements seen in this group. A sham exercise group could have been included in the design of this study, although we believe it would have been difficult to design a sham exercise program.
Conclusion
We demonstrated a positive effect of muscle reconditioning on decreasing pain and improving function in the short term, that is, at 3 weeks after exercise intervention. Because the effectiveness of endurance training of the trunk extensors was demonstrated, we suggest that future studies should evaluate the effectiveness of a program incorporating early muscle reconditioning for 3 weeks, followed by task-specific training and workplace integration.

References


