Isokinetic Measurement of Trunk Muscle Strength in Women with Chronic Low-Back Pain

ABSTRACT
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Objectives: To investigate the relationships among chronic low-back pain and obesity, total spinal range of motion, and trunk muscle strength. The short-term impact of trunk muscle strengthening exercises on this condition was also examined.

Design: A controlled, prospective study of trunk muscle strengths of patients with chronic low-back pain and the short-term impact of exercise on strength. The study group consisted of 25 female patients who had been experiencing low-back pain for at least 3 mo, and the control group included 20 age-matched women without known low-back trouble. The Davenport Index was used to calculate the body mass indexes of all subjects. The Oswestry Disability Questionnaire was used to assess pain in the study group. Full flexion and extension ranges of motion were measured, then isokinetic measurements of trunk muscles were performed at 60-, 120-, and 180-degrees/sec velocities. Isometric measurements were also recorded for both flexors and extensors at a 60-degree angle.

Results: Increased body mass index and decreased trunk muscle strength were found to be directly associated with chronic low-back pain ($P < 0.05$). After a 15-day standard trunk strengthening exercise program in the patient group, trunk muscle strength was found to be increased ($P < 0.05$).

Conclusions: Obesity and decrease in trunk muscle strength are important factors in chronic low-back pain, and a trunk muscle strengthening program will be helpful in reducing the pain.

Key Words: Low-Back Pain, Obesity, Trunk Muscle Strength, Isokinetic Dynamometry
Chronic low-back pain (CLBP) constitutes a major healthcare problem in industrialized countries. Not only is this condition very common, its treatment is difficult and time-consuming. It is very unusual for a CLBP patient to be pain-free after the first visit to a physician with its accompanying treatment. Also, economic costs rise as numerous treatment protocols are attempted.

Chronic low-back pain has been found to be associated with certain anthropometric, postural, muscular, and mobility characteristics. Numerous etiologic factors have been linked to the condition: obesity, increased lumbar lordosis, poor abdominal muscle strength, imbalance between flexor and extensor trunk muscle strength, reduced spinal mobility, tight hamstrings, and leg-length inequality. Trunk muscle strength has been extensively studied in relation to CLBP. One investigation found the strength of spinal and abdominal muscles to be of questionable importance in the prevention of low-back syndrome. Another noted that trunk muscle strength ratios of patients seeking hospitalization for chronic low-back disorders did not differ significantly from those of healthy subjects, whereas the majority of researchers have found trunk muscle strength to be an important factor in CLBP. It has been demonstrated that extensor strength is affected more than flexor strength. Obesity was considered to be both a direct and indirect factor in CLBP. However, specific evidence that identifies these factors as important has yet to be presented.

The purposes of this study are to compare body weight, mobility, and strength of lumbar spine of women with CLBP with normal female subjects, to find if those factors are related to the occurrence of CLBP, and to investigate the effects of an exercise program on those factors. The reason why only female subjects were selected is that age-matched males were either actively working or engaged in a sports activity, so it could be erroneous to compare the muscle strengths and mobilities of these subjects with the women living a sedentary life.

METHODS

The study group (group 1) included 25 female patients who had been experiencing low-back pain for at least 3 mo. The control group (group 2) was made up of 20 age-matched women that had no known history of low-back pain in the past 2 yr. Both group 1 and group 2 subjects were housewives or they were retired (i.e., they had been living a sedentary life and had no regular or irregular sports habits). A complete neurologic and musculoskeletal examination was performed on both groups. Subjects with acute radicular signs or symptoms and those who had radiographic evidence of inflammatory disease affecting the spine, tumor, fracture, spondylolysis, spondylolisthesis, or scoliosis were excluded from the study.

After recording the subject’s age, height, weight, BMI, and chest and with the dynamometric axis positioned at the third lumbar vertebral body. Each subject was first asked to perform as much flexion and extension as possible, and the total angle was calculated as total spinal ROM. Next, subjects performed five repetitions of flexion and extension for isokinetic assessment at each velocity and one flexion and one extension for 30 sec at a 60-degree angle for isometric assessment. Maximum peak torque was chosen as a measure of muscle strength in pounds. For each subject, these measurements were done twice on 2 consecutive days to assess for any learning effect. Finally, group 1 was assigned an exercise program of sit-ups, double straight leg-lowers, and prone trunk extensions twice daily for 15 days under the supervision of a trained physiotherapist. The number of sit-ups, double straight leg-lowers, and prone trunk extensions was 5 for the first 3 days, and then the number was increased to 10 until the end of the 15-day program. After this period, these patients’ trunk muscle strengths were reassessed by isokinetic dynamometry.

Statistical Analysis

Statistical testing was carried out using the SPSS for Windows software package. We used the Student’s t test for paired and unpaired samples and Spearman’s correlation coefficient to assess for correlations among variables.

RESULTS

The age, height, weight, BMI, and total spinal ROM measurements of the patients and controls are listed in Table 1. The isokinetic and isometric measurements are shown in Tables 2 and 3. As mentioned above, isokinetic assessment was performed twice on each subject to test for any learning effect with regard to peak torque. The results of the second measurement were significantly
higher (P < 0.05); for this reason, we used the data of the second measurement for statistical analyses.

Pain Intensity Issue. In the study group, no correlation was found between the score obtained by the Oswestry Disability Questionnaire and trunk muscle strength or total spinal ROM. The mean initial score obtained in the questionnaire was 38.64, and the score obtained at the end of the program was 38.01. This difference was not statistically significant.

Correlation Between Strength and ROM. There was a positive correlation between total spinal ROM and isometric concentric flexor strength at 60 degrees/sec (r = 0.66, P = 0.0001), 120 degrees/sec (r = 0.69, P = 0.0001), and 180 degrees/sec (r = 0.69, P = 0.0001); between ROM and extensor strength at 60 degrees/sec (r = 0.73, P = 0.0001), 120 degrees/sec (r = 0.70, P = 0.0001), and 180 degrees/sec (r = 0.53, P = 0.0001); and between ROM and isometric concentric extensor peak torque at 60 degrees (r = 0.58, P = 0.002). There was also a positive correlation between total spinal ROM and isokinetic concentric flexor/extensor peak torque ratio at 180 degrees/sec (r = 0.57, P = 0.003).

Comparison Between Patients and Normal Subjects. The CLBP patients had significantly higher BMIs than the control group. In the control group, height was not correlated with trunk strength at any mode and velocity. However, there was a positive correlation between weight and isometric flexor peak torque at 60 degrees (r = 0.53, P = 0.016). Whereas there was a positive correlation be-

| TABLE 1 |
| --- |
| Age, height, weight, body mass index (BMI), and total spinal range of motion (ROM) for groups 1 and 2 |
| Group 1 | Group 2 | P |
| Age (yr) | (n = 25) | (n = 20) |  |
| Height (cm) | 59.52 ± 7.17 | 54.45 ± 10.92 | >0.05 |
| Weight (kg) | 159 ± 6.7 | 158 ± 6.6 | >0.05 |
| BMI | 73.82 ± 9.67 | 65.45 ± 11.24 | <0.05 |
| Total spinal ROM (degrees) | 90.06 ± 15.65 | 101.85 ± 8.98 | <0.05 |

| TABLE 2 |
| --- |
| Isokinetic concentric flexor and extensor peak torques (in ft.lb) and flexor/extensor ratios of groups 1 and 2 on the first and second days |
| Velocity | Day 1 | Day 2 | Day 1 | Day 2 | P |
| 60 degrees/sec flexor | 29.16 ± 28.91 | 35.44 ± 29.32 | 52.75 ± 29.48 | 61.95 ± 25.56 | <0.05 |
| 60 degrees/sec extensor | 15.24 ± 14.43 | 17.44 ± 15.49 | 35.65 ± 22.67 | 41.25 ± 22.21 | <0.05 |
| 60 degrees/sec flexor/extensor | 2.55 ± 2.21 | 2.52 ± 1.48 | 1.53 ± 0.72 | 1.80 ± 0.70 | <0.05 |
| 120 degrees/sec flexor | 10.84 ± 17.14 | 11.64 ± 14.16 | 21.50 ± 18.08 | 26.95 ± 21.80 | <0.05 |
| 120 degrees/sec extensor | 3.64 ± 4.92 | 3.80 ± 4.13 | 10.60 ± 12.19 | 14.45 ± 5.15 | <0.05 |
| 120 degrees/sec flexor/extensor | 2.52 ± 1.29 | 2.76 ± 1.24 | 2.81 ± 1.59 | 3.14 ± 2.16 | <0.05 |
| 180 degrees/sec flexor | 5.16 ± 4.34 | 5.52 ± 5.02 | 8.90 ± 5.69 | 10.40 ± 7.53 | <0.05 |
| 180 degrees/sec extensor | 2.72 ± 1.69 | 2.76 ± 1.71 | 4.95 ± 3.64 | 5.15 ± 3.54 | <0.05 |
| 180 degrees/sec flexor/extensor | 1.98 ± 1.04 | 1.93 ± 0.68 | 1.99 ± 0.97 | 2.13 ± 0.84 | >0.05 |

| TABLE 3 |
| --- |
| Isometric concentric peak torques (in ft.lb) and flexor/extensor ratios of groups 1 and 2 on the first and second days |
| Isometric | Day 1 | Day 2 | Day 1 | Day 2 | P |
| Flexor | 67 ± 24.35 | 74.40 ± 26.20 | 75.30 ± 25.59 | 91.55 ± 28.39 | <0.05 |
| Extensor | 25.60 ± 17.07 | 29.72 ± 16.10 | 57.40 ± 36.04 | 65.60 ± 30.63 | <0.05 |
| Flexor/extensor ratio | 1.82 ± 1.24 | 5.13 ± 10.75 | 1.82 ± 1.02 | 1.90 ± 1.94 | >0.05 |
Effects of Exercise. To observe the short-term effect of a 15-day exercise program, the isokinetic test was repeated on the study group after training. Isokinetic extensor strength at all velocities, isokinetic flexor strength at 120 and 180 degrees/sec, isokinetic flexor/extensor ratio at 60 degrees/sec, and isometric flexor strength at 60 degrees/sec were found to be increased. These results are shown in Table 6.

DISCUSSION

Chronic low-back pain is a common disorder in the general population, and mechanical factors are known to play an important role in its etiology. Chronic pain is a disease state in which many factors interact with one another (one reinforcing the other) and often being initiated by a physical insult, yet being or becoming independent of any continuing physical insult or damage to the body. Chronic pain is described as a syndrome of five components, the “Five D Syndrome”: (1) drug: abuse or misuse; (2) dysfunction: a decrease in function, performance, or even the quality of life; (3) disease: loss of flexibility, strength, endurance, and alternate degeneration; (4) depression: with significant loss, real or fantasized, reactive depression may result; and (5) disability: inability to perform activities of daily living or pursue gainful employment. The dysfunction and disability components of this syndrome especially seem to be related to the purpose of this study. The major purpose of this project was to identify any significant difference in trunk muscle strength between women who have CLBP and those who are unaffected.

In our study, isokinetic flexor and extensor trunk muscle strengths were higher in the control group at all velocities tested. In CLBP individuals, the extensor group was affected more than the flexors with regard to isokinetic strength, but both muscle groups were equally affected with regard to isometric strength. As the velocity of movement increased from 60 to 180 degrees/sec, the peak torques of both flexors and extensors fell in both groups. Extensors are postural muscles that have fewer fast-twitch fibers than abdominal muscles, thus their strength drops off as velocity increases. This occurs in healthy individuals as well as in CLBP patients. The same is usually not true for flexors in normal subjects but does hold for those with CLBP. One previous study noted that the extensor/flexor ratio remains constant between 18 and 44 yr of age (>1:1) and found trunk extensors to be the strongest muscles, their peak torques dropping as velocity increased.

Isometric endurance measurements of trunk muscle strength have yielded conflicting results. One report stated that isometric strength was lower in individuals with CLBP, whereas another showed this was not the case. Results from another investigation indicated that the strength of spinal and abdominal muscles is of questionable impor-

## Table 4

|                  | Flexion  | Extension | P  |
|------------------|----------|-----------|----|
| 60 degrees/sec   | 34.87 ± 29.81 | 17.08 ± 15.72 | <0.05 |
| 120 degrees/sec  | 11.91 ± 14.39  | 3.83 ± 4.21   | <0.05 |
| 180 degrees/sec  | 6.00 ± 5.11    | 2.79 ± 1.74   | <0.05 |
| Isometric        | 75.29 ± 26.37  | 29.04 ± 16.07 | <0.05 |

Comparison of strength (in ft.lbf) between flexors and extensors of group 1

## Table 5

|                  | Flexion  | Extension | P  |
|------------------|----------|-----------|----|
| 60 degrees/sec   | 61.95 ± 25.56  | 41.25 ± 22.21 | <0.05 |
| 120 degrees/sec  | 26.95 ± 21.80  | 14.45 ± 14.42 | <0.05 |
| 180 degrees/sec  | 10.40 ± 7.53   | 5.15 ± 3.54   | <0.05 |
| Isometric        | 91.55 ± 28.39  | 65.60 ± 30.63 | <0.05 |

Comparison of strength between flexors and extensors of group 2

between weight and flexor/extensor peak torque ratio at 120 degrees/sec, this result was not statistically significant. BMI and isokinetic flexor/extensor peak torque ratio at 120 degrees/sec were positively correlated (r = 0.51, P = 0.021); although there was a negative correlation between BMI and isokinetic concentric extensor peak torque at 120 degrees/sec, this was not statistically significant (P = 0.053). Controls showed positive correlations only between total spinal ROM and isokinetic concentric flexor strength at 60 degrees/sec (r = 0.46, P = 0.04) and 120 degrees/sec (r = 0.47, P = 0.034) in contrast to group 1, in which there was a significant relationship between ROM and strength at all isometric and isokinetic measurements.
tance in the prevention of low-back syndrome but noted that patients who had been inactive for more than 1 mo had decreased isometric strength results. These conflicting findings could be because of variations in range of different elements: equipment used, muscle lengths, direction of the axis of movement, patient position during testing, and test protocols. Whatever the exact numbers may be, it is agreed that extensors are generally the muscles most affected. Clearly, extensor strengthening exercises should be emphasized for patients with CLBP.

Comparison of back strength between healthy subjects and those with CLBP is fraught with difficulty. The origin of pain can vary widely, and the discomfort alone can affect strength. Because maximum strength might be altered by pain, one could, in fact, be measuring pain level and tolerance as opposed to strength. However, this usually only holds true for patients with acute pain. The pain issue that might be a confounding factor in our study is reflex inhibition of surrounding muscles. The voluntary strengths measured in at least some of the tests are likely determined by grip strength, arm strength, postural stability, and other such factors. In an attempt to exclude these elements, we stabilized the patient using knee stabilizers and back and chest pads. The axis for dynamic measurement was positioned at the third lumbar vertebral body, as previously described.

Newton et al. suggested that learning had a significant effect on peak torque values and stated that this was observed in CLBP patients. In contrast, we observed this effect in the control group, not in the patient group. The reason for this may be that the women not suffering from low-back pain can get used to the testing more easily than the ones affected because the latter may have even a small amount of fear of pain while performing the test.

After patients had followed an exercise protocol of sit-ups, double straight leg-lowers, and prone back extensions twice daily for 15 days, we found an increase in isokinetic extensor strength at all velocities, flexor strength at 120 and 180 degrees/sec, and isometric flexor strength. The effect was attributable, in part, to the exercise itself, but also to patient cooperation during testing and exercise. Patient cooperation is an important factor, especially in isokinetic dynamometry because minor deviations while performing flexions and extensions may give erroneous results. We believe that CLBP patients should be encouraged to engage in an exercise program and informed that the problem is a treatable one, although its course is long. It has been suggested that a functional restoration program consisting of pain desensitization, antidepressive medication, other psychologic support, and exercise would help CLBP patients. Other authors have also suggested that increased preprogram training and education facilitate a more rapid elimination of inhibitory factors that often impede physical training.

Research has proven obesity to be directly and indirectly associated with CLBP, but most studies have not pinpointed excessive weight as the sole cause of low-back pain. Whereas reports state that obese males have CLBP, apparently this is not the case for females. Mellin revealed a negative correlation between obesity and mobility measurements, and because spinal mobility is associated with CLBP, he suggested an indirect relationship between obesity and this type of pain. Our CLBP patients had significantly higher BMIs than the control group, which led us to conclude that obesity was one etiologic factor in CLBP. But an argument on this comment may be that inactivity caused by CLBP will result in secondary obesity; so, it will be better to talk about a cause-and-effect relationship between obesity and CLBP.

We found that total spinal ROM, calculated as the sum of the full flexion and extension dynamometry val-

| TABLE 6 | Pre- and postexercise trunk strengths of group 1 (ft-lb) |
|---------|----------------------------------------------------------|
|         | Pre-exercise         | Postexercise         | P  |
| Extensor 60 degrees/sec | 17.08 ± 15.72 | 22.00 ± 15.95 | <0.05 |
| Extensor 120 degrees/sec | 3.83 ± 4.21 | 7.12 ± 8.88 | <0.05 |
| Extensor 180 degrees/sec | 2.79 ± 1.74 | 3.37 ± 2.14 | <0.05 |
| Flexor 60 degrees/sec | 34.87 ± 29.81 | 39.83 ± 29.93 | <0.05 |
| Flexor 120 degrees/sec | 11.91 ± 14.39 | 15.45 ± 19.70 | <0.05 |
| Flexor 180 degrees/sec | 6.00 ± 5.11 | 8.16 ± 7.86 | <0.05 |
| Flexor/extensor ratio 60 degrees/sec | 2.55 ± 1.50 | 1.73 ± 1.06 | <0.05 |
| Flexor/extensor ratio 120 degrees/sec | 2.81 ± 1.24 | 2.39 ± 1.97 | >0.05 |
| Flexor/extensor ratio 180 degrees/sec | 1.93 ± 0.69 | 2.02 ± 1.08 | >0.05 |
| Isometric flexor at 60 degrees | 75.29 ± 26.37 | 85.37 ± 26.01 | <0.05 |
| Isometric extensor at 60 degrees | 29.04 ± 16.07 | 35.00 ± 20.13 | >0.057 |
| Isometric flexor/extensor ratio at 60 degrees | 5.30 ± 10.95 | 2.57 ± 1.64 | >0.05 |
values, was significantly greater in the control group than in patients with back pain. Spinal ROM is also an important factor to be considered when prescribing exercises for CLBP patients. Spinal mobility and disability are usually strongly correlated with acute low-back pain, but this correlation is questionable in CLBP. None of the patients in our study were suffering from an acute pain attack; thus, we believe that the measured ROM represented a true limit, not one resulting from pain.

We found that CLBP patients had higher BMIs, weaker trunk muscles, and more limited spinal ROM than normal individuals. Patients’ trunk muscle strength increased significantly after exercise. In conclusion, we believe that weight reduction, together with an exercise program aimed at increasing trunk muscle strength and spinal ROM, can significantly help CLBP patients. However, a prospective study is required to prove that weight reduction is effective as a mode of treatment for CLBP.

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Isokinetic Measurement of Muscle Strength 655