#1061

Effects of Spinal Flexion and Extension Exercises on Low-Back Pain and Spinal Mobility in Chronic Mechanical Low-Back Pain Patients

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It has been estimated that one fourth to one half of all patients treated in physical therapy clinics suffer from low-back pain. The purpose of this study was to compare the effects of spinal flexion (Group I) and extension (Group II) exercises on low-back pain severity and thoracolumbar spinal mobility in chronic mechanical low-back pain patients. Both groups had significantly less low-back pain after treatment ($P < .10$). There was no significant difference, however, between the spinal flexion and extension exercises in reduction of low-back pain severity. The results indicated a significant difference between the groups in increasing the sagittal mobility ($P < .10$). The results did not indicate any significant difference between and within groups in increasing the coronal and transverse mobility of the thoracolumbar spine. Either the spinal flexion or extension exercises could be used to reduce chronic mechanical low-back pain severity, but the flexion exercises had an advantage in increasing the sagittal mobility within a short period of time. [Key words: low-back pain, physical therapy, flexion and extension exercises, sagittal mobility]

LOW-BACK PAIN (LBP) conditions are commonly seen in physical therapy clinics. It has been estimated that one fourth to one half of the patients treated in physical therapy clinics suffer from LBP.[1] Exercise is one of the many modalities used to treat this syndrome.[20] Perhaps no two methods of physical treatments for LBP are as contradictory in both theory and practice as spinal flexion and extension exercises.

There is little information concerning the effects of different exercise programs in the treatment of LBP. Tradition and belief appears to be the reason for selection of a particular exercise program.

Several studies in the literature have investigated the efficacy of exercise in the treatment of LBP. These studies used different exercise programs and reported conflicting results.[8,9,11,13,17,21,27] In most of the studies, exercises were given in combination with other physical treatment modalities that could have affected the outcome of the exercises. Some of the above-mentioned studies did not select a specific diagnostic criteria of LBP patients, which is an important factor in studying a multicausal syndrome.

In addition, the use of exercise to increase spinal mobility has not been studied well in LBP patients.[7] To our knowledge, only one earlier investigator studied spinal mobility in three dimensions when they investigated exercise therapy on LBP patients.[20]

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The study measured spinal mobility in three dimensions while comparing spinal flexion and extension exercises. However, this study was conducted on patients with LBP caused by verified prolapsed intervertebral disc rather than chronic mechanical LBP.

Supporting the flexion exercise theory, Williams[22–24] stated: "The sedentary life of most adults encourages the spinal flexors, mainly the abdominal muscles, to weaken from disuse while their antagonistic back muscles become stronger from overuse." A protrusion of the abdomen occurs, shifting the weight forward and displacing the center of gravity in the anterior direction. This displacement is compensated by an increase in the lumbosacral lordosis, thereby shifting the weight of the thorax in the posterior direction. During this process, an increasing force is exerted on the posterior lumbar and lumbosacral structures. If, at any time during this process of extension of the lumbosacral spine, a sudden increased extensive force is applied, back impairment may occur.[22–24]

The treatment, according to Williams,[22–24] should be directed toward reducing lumbosacral spine extension, thereby shifting the center of gravity forward and relieving the posterior load. To accomplish this, it is necessary to develop the flexors of the lumbosacral spine actively, and to stretch the contracted erector spinae apparatus passively, in order to obtain and maintain a balance between opposing postural muscles.[23–26]

Two clinical studies indicated that spinal flexion exercises yielded better clinical results than spinal extension exercises in the treatment of LBP patients.[8,11]

Supporting the extension exercise theory, McKenzie[14] reported that patients with LBP had reduced lumbar lordosis and usually expressed worse pain sitting and less pain walking. When lordosis was restored, the same patients were pain-free but tended to ache after prolonged bending or sitting. McKenzie[14] concluded that, if prolonged sitting with the lumbar spine flexed induces derangement, the prolonged or repeated extreme extension will reduce the derangement. This was the basis of his spinal extension program of treatment.

A clinical study indicated that spinal extension exercises yielded better clinical results than spinal flexion exercises in decreasing pain and increasing spinal mobility in LBP patients.[4]

The purposes of this study were as follows:

1. To investigate the effect of spinal flexion and extension exercises on LBP severity;
2. To evaluate the triaxial thoracolumbar spinal mobility in chronic mechanical LBP patients;
3. To compare the efficacy of two exercise regimens.

SUBJECTS

Fifty-six patients (28 male, 28 female) were diagnosed as having chronic mechanical LBP participated. Each patient was examined and

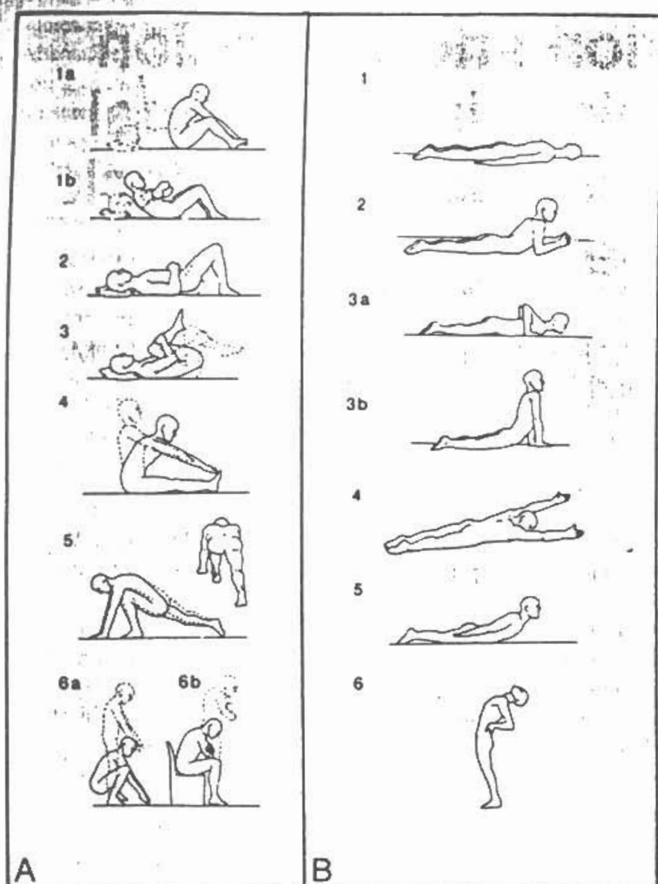

Fig 1. Flexion **(A)** and extension **(B)** exercises.

diagnosed by an orthopaedic surgeon. A radiographic examination consisting of anteroposterior and lateral views of the lumbosacral spine was conducted to rule out abnormalities.

All patients were ages 20–50 years and had experienced LBP for 3 months or more from the onset of illness. This criterion was based on the definition of chronic LBP by Dixon.[5]

After consent was obtained, the 56 patients were divided into two experimental groups: the spinal flexion exercises group or the spinal extension exercises group. The randomization was performed by drawing a card from a pile of randomly organized cards. There were 28 patients in each group. In the flexion group, there were 13 males and 15 females; the extension group comprised 15 males and 13 females.

TREATMENT PROCEDURES

The spinal flexion exercise group was treated with trunk flexion exercises for a period of 2 weeks. Every week, seven sessions were given for each patient: three were directed by a registered physical therapist; the other four were home treatments independently done by each patient. For the home sessions, each patient was provided with all the necessary instructions and illustrative figures (Figure 1) to perform the exercises.

The number of times each exercise was performed per session varied according to the physical ability of the patient, but in general, each exercise was done 10 times, as suggested by Williams.[26] Each exercise was done in two to three sets per session; each set had five repetitions with 1 minute's rest between the sets. Each repetition was held for five counts before the patient returned to the starting position of the exercise.

The other experimental group was treated by spinal extension exercises for a period of 2 weeks, following the same previously mentioned outline for a total number of treatments of 14 sessions in 2 weeks' time. The protocol of spinal extension exercises used was derived from McKenzie's technique of therapy for the lumbar spine[14] (Figure 1). In both groups, the patients performed their exercise at a free pace and were encouraged to curtail their motion pattern. The same procedure as in the flexion group was applied: two to three sets of exercises per session. The total time of the exercise program for both groups was 30 minutes per day.

Patient Evaluation. Two evaluations were done: pretreatment and post-treatment. The purpose of these evaluations was 1) to examine the effect of the treatment of spinal flexion exercises vs. spinal extension exercises on LBP severity and 2) to evaluate sagittal, coronal, and transverse mobility of the thoracolumbar spine.

Measurement of LBP Severity. LBP was assessed with the pain rating index of the modified McGill Pain Questionnaire,[18] which consists primarily of four major classes of word descriptors—sensory, affective, evaluative, and miscellaneous—that are used by patients to specify subjective pain experience. The McGill Pain Questionnaire provides quantitative information that can be treated statistically and is sufficiently sensitive to detect differences in pain perception in a patient group.[18] This study used the McGill Pain Questionnaire as modified by Ciner.[3] In the rating, the obtained score varied from 0 to 78 (78 = maximal rated pain).

Measurement of Thoracolumbar Spinal Mobility. Sagittal, coronal, and transverse mobility of the thoracolumbar spine was measured by the 3 Space Tracker System (Polhemus Navigation, Colchester, Vermont)

This system is a noninvasive technology capable of measuring motion with six degrees of freedom. It is accurate and has good reproducibility.[2] It uses a low-frequency magnetic field and multiple sensors to determine orientation of each sensor. Each sensor weighs less than 25 g. The 3 Space Tracker System was calibrated by the manufacturer, who found that the resolution of the sensor is one tenth of a degree. Buchalter et al[2] found that the sensors were accurate to at least five tenths of a degree.

The first sensor was fixed to the 7th cervical vertebra, the second sensor to the 12th thoracic vertebra, and the third sensor to the sacrum (Figure 2).

Measurement of the thoracolumbar spinal mobility consisted of a sequence of three main tests in the sagittal plane (flexion and hyperextension); coronal plane (right and left side-bending); and transverse plane (right and left axial rotation). The neutral position was calibrated for each plane while the patient was in the upright standing relaxed position with both arms resting at his or her sides.

Each patient was instructed to perform three trials in each direction with one minute rest between each trial. An outside examiner unaware of the assigned exercises performed the testing, and data were collected at the extremes of each motion. For the purpose of the data analysis, the mean (SD) of the three trials of each mobility was calculated and recorded for analysis.

STATISTICAL ANALYSIS

A two-tailed t-test was used to determine any difference between the two groups before treatment. An analysis of covariance was used to determine whether the changes in the severity of LBP, sagittal, coronal, and transverse mobility were significantly different between the two groups. The pretreatment values were kept as the covariates during the analysis. A Pearson correlation analysis was made between changes in pain rating and changes in mobility for all planes. The level of significance for this clinical study was chosen at $P < .10$.

RESULTS

The variables tested by the t-test were age, weight, height, duration of LBP, pretreatment of LBP severity, and pretreatment of spinal mobilities (Table 1). There were no differences between the groups with regard to these variables. In addition to the t-test and because of the relatively large standard deviations of the means for duration of pain in both groups, a chi-square test was run. This test showed no significant

Fig 2. The sensors fixed to the back.

difference between the groups as far as the duration of pain was concerned (Table 2). The analysis of covariance showed that there was no statistically significant difference between the changes in the severity of LBP between the two groups, although both groups had significantly less LBP after treatment ($F = 0.16$, $P = 0.68$). In the flexion group, the LBP severity rating decreased from 14.1 (9.8) pretreatment, to 8.9 (9.4) post-treatment. In the extension group, the LBP severity rating decreased from 15.9 (7.8) pretreatment, to 10.6 (8.6) post-treatment (Figure 3).

The analysis of covariance indicated a statistically significant difference between the flexion group and the extension group in terms of increase in sagittal mobility of the thoracolumbar spine ($F = 5.33$, $P = 0.02$). The mean sagittal mobility of the flexion group increased from 98.5° (23.4) before treatment to 109.5° (22.6) after treatment, a mean change of 11° (21.5). The mean sagittal mobility of the extension group increased from 93.9° (29.8) before treatment, to 95.2° (27.6) after treatment, a mean change of 1.3° (18.8) (Figure 4).

Table 2. Number of Patients Experiencing Pain, Classified According to Its Duration

Duration of Pain (mo)	*Flexion Group*	*Extension Group*	*Flexion and Extension Groups Combined*
≤24	10	6	16
>24 and <120	11	15	26
≥120	7	7	14
Total no. of patients	28	28	56

$\chi^2 = 1.62$; $P = 0.45$ (NS).

Based on the analysis of covariance, no statistically significant difference was found between the spinal flexion exercise group and the spinal extension exercises group in coronal and transverse mobility of the thoracolumbar spine ($P = 0.97$). The pretreatment means of the flexion group in terms of coronal mobility was 98.0° (19.4); the pretreatment mean of the extension group was 97.0° (18.3) (Figure 5). The mean transverse mobility of the flexion group was 88.6° (18.4) before treatment; the mean of the extension group was 88.0° (18.2) (Figure 6).

The correlational analysis of the total population of 56 patients (both groups combined) and for the flexion and extension groups separately showed a weak negative correlation between the change in LBP severity and the change in the spinal mobility of the thoracolumbar spine (Table 3).

DISCUSSION

This study demonstrated that spinal flexion and extension exercises reduced LBP severity and increased the thoracolumbar spinal mobility in chronic mechanical LBP patients aged 20–50 years.

Both the flexion and extension exercise groups had less pain after treatment; the percentage of pain reduction was 37% in the flexion group 33% in the extension group ($P < 0.01$).

In this study, neither of the exercise programs exhibited superiority over the other in terms of reduction of LBP severity. This finding is different from those of other authors,[4,20,21] all of whom reported that spinal extension exercises were more effective for relieving LBP than

Table 1. Demographic and Clinical Data of the Spinal Flexion and Extension Groups Before Treatment

Variable	*Group*	*N*	*Mean*	*SD*	*t*	*P*
Age (yr)	Flexion	28	37.5	7.2	1.60	0.12 (NS)
	Extension	28	40.5	7.2		
Weight (kg)	Flexion	28	73.6	15.7	0.63	0.53 (NS)
	Extension	28	76.2	15.1		
Height (cm)	Flexion	28	169.5	10.8	1.00	0.32 (NS)
	Extension	28	172.3	9.8		
Duration of pain (mo)	Flexion	28	72.2	61.2	0.87	0.39 (NS)
	Extension	28	88.8	80.0		
Back pain severity (0-78)	Flexion	28	14.1	9.8	0.76	0.45 (NS)
	Extension	28	15.9	7.8		
Sagittal mobility (°)	Flexion	28	98.5	23.4	0.64	0.53 (NS)
	Extension	28	93.9	29.8		
Coronal mobility (°)	Flexion	28	98.0	19.4	0.21	0.83 (NS)
	Extension	28	97.0	18.3		
Transverse mobility (°)	Flexion	28	88.6	18.4	0.55	0.59 (NS)
	Extension	28	86.0	18.2		

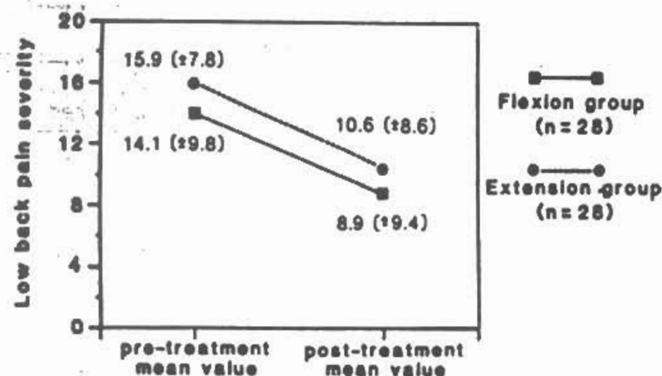

Fig 3. Effect of spinal flexion and extension exercises on reduction of low-back pain severity.

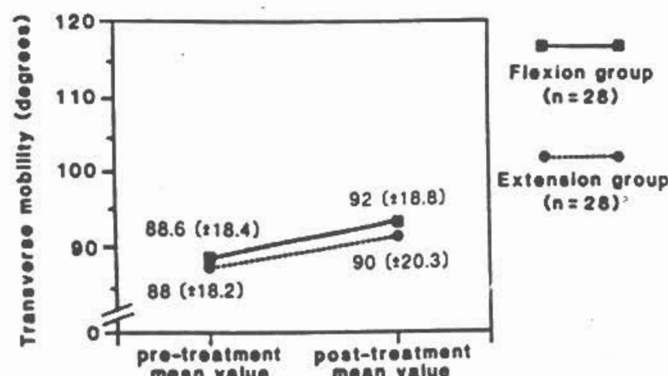

Fig 6. Effect of spinal flexion and extension exercises on the transverse mobility of the thoracolumbar spine.

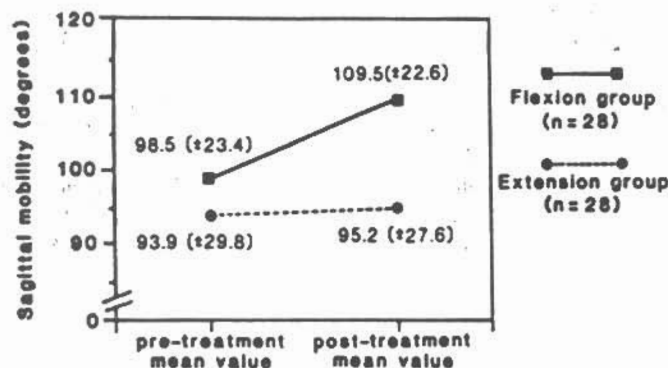

Fig 4. Effect of spinal flexion and extension exercises on the sagittal mobility of the thoracolumbar spine.

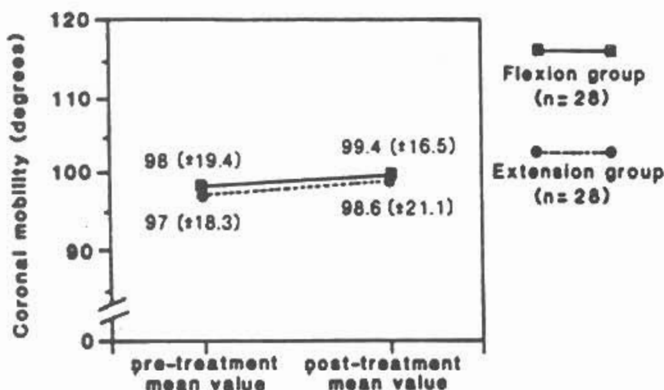

Fig 5. Effect of spinal flexion and extension exercises on the coronal mobility of the thoracolumbar spine.

spinal flexion exercises. Likewise, studies supporting the spinal flexion exercises rather than the spinal extension exercises for relief of back pain[8,11] were not supported by this study.

In comparing earlier studies,[8,11,20,21] the possible confounding factors may be the diagnostic criteria of LBP patients, patient age, stage of illness, duration of pain, and methodology. Sagittal mobility increased significantly ($P < .02$) in the flexion exercise group but remained unchanged in the extension group. This is in agreement with Kendall and Jenkins[8] but in disagreement with other studies.[4,20,21] The reasons for more gain of range of motion may be explained by the type of exercise in the flexion program and because the spine is more flexible in flexion.

There was no difference between the spinal flexion exercise group and the spinal extension exercise group in regard to coronal mobility of the thoracolumbar spine. The results did not even show an intergroup difference. Both groups increased their coronal mobility by less than 2°.

This finding is not surprising for two reasons. First, the pretreatment means of the coronal mobility were 98° and 97° for the flexion and extension groups, respectively. These figures are similar to the mean of coronal mobility of normal subjects.[2] Second, neither the flexion exercises group nor the extension exercises group included any side-bending exercises.

Furthermore, there was no significant difference between the spinal flexion exercise group and the spinal extension exercise group in increasing the transverse mobility of the thoracolumbar spine. This is in disagreement with the findings of Nwuga and Nwuga,[20] who were the only authors in the literature to measure transverse spinal mobility in LBP patients treated with spinal flexion and extension exercises. They found that spinal extension exercises produced a greater increase of the transverse mobility than did spinal flexion exercises and that this

Table 3. Relationship Between Change in Low-Back Pain Severity and Change in Three-Dimensional Thoracolumbar Spinal Mobility

	Flexion and Extension Groups			*Flexion Group*			*Extension Group*		
	CLBPS & CSAG	*CLBPS & CCOR*	*CLBPS & CTRA*	*CLBPS & CSAG*	*CLBPS & CCOR*	*CLBPS & CTRA*	*CLBPS & CSAG*	*CLBPS & CCOR*	*CLBPS & CTRA*
Pearson correlation coefficient (r)	−0.24	−0.35	−0.35	−0.17	−0.40	−0.31	−0.41	−0.34	−0.43
Coefficient of determination (r^2)	0.06	0.12	0.12	0.03	0.16	0.10	0.17	0.12	0.18
Level of significance (P)	0.07	0.008	0.008	0.40*	0.04	0.10	0.03	0.08	0.02

CLBPS = change in low-back pain severity; CSAG = change in the sagittal mobility of the thoracolumbar spinal mobility; CCOR = change in the coronal mobility of the thoracolumbar spinal mobility; CTRA = change in the transverse mobility of the thoracolumbar spinal mobility.
*Not significant.

difference was statistically significant. However, because their study analyzed patients with verified disc herniations, the results are not directly comparable.

This study showed weak negative correlation between the changes in LBP severity and changes in thoracolumbar mobility for the total population. The study does not support entirely the concept that increased mobility will yield less pain severity (Table 3). This may be explained by the low mean of changes in all three planes and the high interindividual variation. One possible explanation of the high variation is the pain duration of subjects (ie, the longer the pain, the stiffer the spine), but this needs further research.

The results of the relationship between the change in LBP severity and change in the thoracolumbar spinal mobility are in agreement with several earlier studies. Kendall and Jenkins,[8] Davies et al[4] and Mellin et al[16,17] reported that a decrease in LBP was associated with an increase in the spinal flexion range of motion.

Lidstrom and Zachrisson,[11] in their comparative study between isotonic and isometric exercises for LBP patients, found that patients treated with isometric strengthening exercises had less pain after treatment, which was accompanied by a significant decrease in spinal flexion and side-bending. This type of exercise was not used in our study, and this might explain why their patients had loss of mobility accompanied with less severity of LBP. In the same study,[11] patients who received isotonic mobilization and strengthening dynamic spinal exercises increased their spinal mobility while having less back pain, which supports the results of our study.

According to other investigators, however, the sagittal and coronal mobility of patients with chronic mechanical LBP decreased their mobility while they had less pain.[9,10] Their findings are not in agreement with the results of our study. The findings of Lankhorst et al[9,10] favor the concept that increasing spinal stiffness produces a more stable and less painful spine.

Three main reasons could be behind this difference in findings:

1. In this study, we used the 3 Space Tracker to measure spinal mobility, whereas Lankhorst et al[9,10] used tape measurements for the assessment of spinal mobility.

2. In this study, we compared spinal flexion vs. extension exercises, whereas Lankhorst et al[9,10] compared Swedish Back School vs. placebo treatment. These differences in methodology probably accounted for the difference between the results of these studies.

3. Probably the most important difference was the age factor. The mean age of patients in the Lankhorst[10] study was 50.4 (7.9) years for the back school group and 51.4 (10.7) years for the control group. The mean age in our study was 37.5 (7.2) years for the flexion group and 40.5 (7.2) years for the extension group. Age-related loss of mobility in normals and LBP patients[6,15,19] might explain the difference between the results.

Martin et al[12] studied the effects of mobilizing and isometric exercises in the treatment of subacute and chronic LBP patients. They studied spinal mobility in three dimensions: sagittal, coronal, and transverse. They found that changes in spinal mobility did not correlate with change in pain. In their study, the diagnostic category of the patient, stage of illness, and methodology used were different from our study. Martin[12] et al studied subacute and chronic LBP patients of different diagnostic categories and allocated them to three treatment conditions: mobilizing exercises, isometric exercises, or a placebo control group. In our study, all the patients had chronic mechanical LBP and were treated with exercises.

CONCLUSIONS

1. Both the spinal flexion and the spinal extension exercises provided significant reduction in LBP severity in chronic mechanical LBP patients. There was no statistically significant difference between the treatment groups.

2. There was no statistically significant difference between the pretreatment sagittal mobility of both groups. Spinal flexion exercises led to greater sagittal plane mobility. Therefore, it was concluded that the nature of the spinal flexion exercises increased the sagittal mobility more effectively than did the spinal extension exercises. The clinical practicality may be of less importance, however, because the mean value for increase was only 11°.

3. The transverse and coronal mobility of the thoracolumbar spine was unaffected by the exercise treatments.

4. This study indicates that a negative moderate correlation exists between changes of range of motion and perceived pain in patients with mechanical LBP.

5. The clinical conclusion is that the use of spinal flexion or extension exercises is a safe, effective method to treat chronic mechanical LBP patients between the ages of 20 and 50 years. Either type of exercise can possibly be used to reduce pain and increase spinal mobility.

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