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Lumbar Strengthening in Chronic Low Back Pain Patients

Physiologic and Psychological Benefits

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The effects of exercise for isolated lumbar extensor muscles were examined in 54 chronic low-back pain patients. Subjects were randomly assigned to a 10-week exercise program ($N = 31$) or a wait-list control group ($N = 23$). Results indicated a significant increase in isometric lumbar extension strength for the treatment group and a significant reduction in reported pain compared with the control group (P 0.05). Treated subjects reported less physical and psychosocial dysfunction whereas the control group increased in pain, and physical and psychosocial dysfunction. There were no concomitant changes in reported daily activity levels. These results show that lumbar extension exercise is beneficial for strengthening the lumbar extensors and results in decreased pain and improved perceptions of physical and psychosocial functioning in chronic back pain patients. However, these improvements were not related to changes in activities or psychological distress. [Key words: chronic low-back pain, lumbar extension strength, psychological distress]

Chronic low-back pain afflicts millions of persons each year and is associated with significant impairment in physical and psychosocial functioning. The chronic pain experience is recognized to be a multidimensional syndrome with many different causes, which is influenced by varying socio-environmental factors, predispositions, and personalities.[1,15,38] Hence, multimodal treatment programs have been developed in an attempt to address the physical, psychological, and environmental components involved. These multidisciplinary programs have been shown to be beneficial in the treatment of chronic pain,[3–4] but the effectiveness of the specific components is unclear. One common component of pain treatment programs is a focus on increased physical activities and exercise reconditioning. This aspect is deemed important given the existing evidence that deconditioning as a result of pain and avoidance of activity in chronic low-back pain patients can result in muscular atrophy.[5–9,11,35] However, the impact of physical rehabilitation on psychosocial impairment has not been clearly demonstrated.[11,19,28–30,36]

Physical reconditioning is thought to be an important treatment modality for patients with chronic low-back pain, particularly reconditioning of specific atrophied muscles. Chronic low-back pain patients are subject to atrophied muscles secondary to avoiding physical activity in an attempt to decrease their pain. This, in turn, results in more muscle atrophy, increased pain, and psychological distress.[6–9,11,18,28–31,36]

Typically, studies assessing the benefits of lumbar extensor exercise in chronic low-back pain patients either look only at physical strength changes or they combine multiple treatment interventions aimed at ameliorating the physical and psychological deficits. Studies have not addressed the independent contribution of a specific exercise for the isolated lumbar extensor muscles on subsequent psychological and psychosocial functioning.[16–17,22,27–31,34]

This study's purpose was to determine whether effective lumbar extension exercise with a diverse chronic low-back pain population would increase strength and concomitantly decrease pain. The role of exercise for reducing pain was explored in that verbal complaints of pain can result in seeking of continued treatment and overuse of the health care system.[25] Another purpose was to determine if lumbar extensor exercise relieves symptoms of low-back pain, and if so, would that lead to a concomitant decrease in psychological distress (specifically anxiety and depression). This hypothesis was based on research suggesting that aerobic and anaerobic exercise can decrease anxiety and depression.[10,12–13,20,23] Also, would adherence to the exercise training and strength changes in low-back pain patients be predicted by their inter-

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nal attributions for treatment success. Given the hypothesis that patients avoid exercise based on their negative past experiences, mastery and internal attributions were believed to contribute to the person's motivation to continue in a rigorous exercise program.

Materials and Methods

Subjects. Fifty-four patients (34 men and 20 women) with chronic low-back pain were referred for rehabilitation by an orthopaedic surgeon specializing in spinal disorders. Average patient age was 45 years (range, 22–70 years). The sample was predominantly white (91%) and married (76%). Subjects experienced low-back pain for an average of 8 years (range, 1–26 years), had two surgeries or less, were ambulatory, and were not dependent (daily use) on narcotic analgesics. Fifty-four percent of the subjects were receiving worker's compensation or disability payments as their primary source of income. The average time off work because of pain was 37 months (range, 0–168 months). Thirty-five percent of the subjects were employed full-time and 46% were unemployed because of back pain. The onset of pain was described as sudden and was related to an automobile or work accident for 83% of the sample.

Subjects were most frequently diagnosed with combinations of low-back pain with sciatica (56%), low-back pain without sciatica (43%) myofacial syndrome (50%), spinal stenosis (28%), lumbar spondylosis (46%) and lumbar instability (43%) (Table 1).

Before participation in the study, subjects completed a demographic and medical history, an Exercise Objectives Locus of Control Scale,[32] an activity questionnaire, the West-Haven Yale Multidimensional Pain Inventory (WHYMPI),[24] the Mental Health Inventory (MHI),[37] and the Sickness Impact Profile (SIP).[2,14] The experimental protocol was approved by the Institutional Review Board of the University of Florida. All subjects gave written informed consent.

Lumbar Extensor Strength Testing and Training. Isometric strength of the lumbar extensor muscles was measured at seven joint angles within each subject's range of motion up to a maximum range of 72° with a MedX™ (Ocala, FL) lumbar extension machine. Subjects were seated with their knees positioned so that their femurs were parallel to the seat. Subjects were secured in place by specially designed femur and thigh restraints used to stabilize the pelvis.17 To begin each test, patients were locked into position at their most flexed position (between 48° and 72° degrees of flexion) and instructed to extend backwards slowly against the upper back pad. Once maximal tension had been achieved, the subjects were instructed to maintain a maximal contraction for one to two seconds before relaxing. A 10-second rest interval was provided between each isometric contraction while the next angle of measurement was set. During the contractions, the subjects were provided with concurrent visual feedback of their generated torque and were verbally encouraged to give a maximum effort. Complete details of restraint system, counterbalancing procedure, and testing protocol have been previously published.[17,22]

Maximum isometric torque was measured at each of the seven angles and a computerized force curve was obtained. The subjects then completed a dynamic exercise through their range of motion with a weight load equal to one half of their peak isometric strength. The subjects were instructed to complete as many repetitions as possible until they experienced fatigue. At this point, a second isometric

Table 1. Patient Charactersitcs of the Wait-List Control and Treatment Groups Studied for Effects of Exercise of the Lumbar Extensor Muscles

	Treatment Group (N=31)	Control Group (N=23)
Sex		
Male	18	16
Female	13	7
Unemployed due to back pain (%)	42	52
Financial support (%)		
Employment	42	26
Workers compensation	39	31
Social Security	7	34
Other	7	9
Diagnosis		
Low back pain with sciatica	18	12
Low back pain without sciatica	12	11
Myotacial syndrome	13	14
Spinal stenosis	7	8
Lumbar spondylosis	15	10
Lumbar instability	13	10
Average age (yr) (range)	44 (22–70)	47 (25–70)
Marital status (%)		
Married	71	91
Divorced/separated	26	4
Single	3	4
Average duration of pain (mo) (range)	84 (12–312)	89 (12–288)
Time since last worked (mo) (range)	22 (0–132)	56 (1–168)*
Daily hours in pain (range)	13 (2–24)	15 (2–24)

* $P < 0.05$.

test was given. The torque values generated from the two isometric tests were compared for similarity and the difference between them was used as a measure of muscular fatigue. Hence, the first seven-angle test provided a baseline isometric strength curve.

For the next two clinic visits, patients were instructed in the proper training techniques by registered physical therapists. Instruction and training consisted of dynamic variable resistance exercise at a work load of one half the subject's peak isometric strength (torque measured in in Nm). When the subject exceeded 12 repetitions, the torque was increased 5 ft-lb. When subjects returned for their fourth clinic visit, they were again administered the seven-angle isometric strength test. This second strength curve was considered the criterion measure of pretraining lumbar extensor strength. Previous research has shown that one practice test is required to obtain the most reliable results.[17]

Patients were then randomly assigned to a 10-week treatment group (Tx, $N = 31$) or a wait-list control group (Co, $N = 23$). Group assignment was accomplished by random drawing of predetermined cards indicating group assignment based on a 2:3 ratio for the treatment group. Before they signed informed consent all subjects were told that they may have to wait 10 weeks to start treatment. The treatment group participated in variable resistance dynamic exercises 2 times a week for 4 weeks followed by 1 time a week for 6 weeks. The control group was placed on a waiting list for 10 weeks and were instructed to make no changes in their current lifestyle in terms of exercise training or other physical activities. At the end of 10 weeks, all patients were given the psychological questionnaires again and were tested for isometric strength in a similar fashion as described for the pretest. The wait-list control group began treatment after the 10-week waiting period and second testing session.

Statistical Analysis. The design of this study enabled the investigators to measure changes of physical strength, psychological status, and functional abilities as a function of the exercise treatment. Pretreatment and posttreatment differences on demographic variables and medical treatment histories were addressed with multivariate analysis of variance and chi-square statistics. Multivariate analysis of covariance using change scores was performed on the physiological and psychological data followed by exploration of univariate repeated measures for analysis of within group interactions. Physiologic changes were based on comparisons between pretreatment and posttreatment isometric strength curves. Given that patients varied in their ability to complete a 72° range of motion, the torque generated at seven different angles within the subjects' range of motion was used as the dependent variable in a regression analysis. Regressed standardized angles were generated for each patient and the resultant slopes and intercepts were obtained and utilized for between group analysis. Additionally, exercise locus of control (internal and external), activities, positive social support, and pain ratings were entered into a stepwise multiple regression analysis for prediction of outcome as assessed by their relationship with the posttreatment strength measures. Statistical significance was accepted at $P \leq 0.05$.

■ Results

There were no significant pretreatment differences between the treatment and control groups on demographic variables or pain histories. There were also no differences between groups in their medical examination (i.e., grimacing, ambulation, or cooperativeness).

There were no significant pretreatment differences between groups in age, duration of their pain problem, medication usage, or previous treatment histories. There was a significant difference found between groups in the time since last worked. The control group reported more time since they last worked compared to the treatment group ($F\ (1, 42) = 4.10$, $P < 0.05$). Consistent with above, there was also a difference between groups noted in the incidence of individuals receiving social security retirement benefits, but there were no differences between groups for worker's compensation payments or other private sources of income ($X^2\ (1, 3) = 7.7$, $P < 0.05$). Hence, pretreatment differences were statistically controlled for in the analysis of posttreatment differences. There were no differences noted between groups in relation to financial support, marital status, or perceived partner support (as measured by the West-Haven Yale Multidimensional Pain Inventory) in treatment outcome.

Posttreatment analysis of self-reported medical interventions and activities indicated no differences between the control and treatment groups in active participation with treatment interventions during the course of the study (Table 1).

Physiologic Results

There were no pretreatment differences between groups in mean intercept scores as measures of isometric strength. At posttreatment, there were no differences in change scores between groups for the slope of the isometric strength curves, but there were significant differences between the change scores for the intercepts, ($F\ (2, 52) = 6.50$, $P < 0.01$). Results indicated that the mean intercept significantly increased in the treatment group while it remained the same for the control group. When addressing change scores at each standard angle, the results indicated that the treatment group significantly increased their strength at all angles within the patient's range of motion (Table 2).

Psychological Results

Results of the pretreatment analysis indicated that the control group reported significantly more physical and psychosocial dysfunction when compared to the treatment group. When controlling for pretreatment differences, there were significant differences between the groups in change scores on the physical dysfunction scale. A group × time interaction was noted in

Table 2. Physiological Measures of Peak Isometric Torque of the Lumbar Extensors

	Treatment Group		Control Group		F Statistic
	Before Treatment	After Treatment	Before Treatment	After Treatment	P Value
Mean intercept	73.2 (45.1)	104.1 (63.5)	73.4 (54.6)	73.6 (58.8)	$F(2, 52) = 6.50$ $P < 0.01$
Mean slope	1.4 (0.8)	1.4 (0.7)	1.9 (1.1)	1.7 (0.9)	NS
Mean torque at 7 standard angles in ° of lumbar flexion					
Angle 0	70.9 (43.9) ($N = 31$)	100.7 (63.4) ($N = 31$)	74.0 (54.5) ($N = 23$)	72.2 (58.7) ($N = 23$)	$F(2,51) = 6.89$ $P < 0.01$
Angle 12	91.2 (47.3) ($N = 31$)	123.5 (64.5) ($N = 31$)	96.5 (60.6) ($N = 23$)	94.1 (56.5) ($N = 23$)	$F(2,51) = 9.46$ $P < 0.003$
Angle 24	108.9 (51.4) ($N = 31$)	140.9 (67.2) ($N = 31$)	121.7 (68.8) ($N = 23$)	116.6 (57.9) ($N = 23$)	$F(2,51) = 10.93$ $P < 0.002$
Angle 36	129.1 (55.0) ($N = 30$)	158.4 (69.9) ($N = 31$)	149.1 (77.2) ($N = 22$)	139.6 (61.5) ($N = 22$)	$F(2,48) = 10.17$ $P < 0.002$
Angle 48	143.2 (63.1) ($N = 28$)	177.0 (74.6) ($N = 29$)	160.2 (86.1) ($N = 17$)	162.3 (66.7) ($N = 19$)	$F(2,31) = 13.77$ $P < 0.02$
Angle 60	157.9 (73.9) ($N = 23$)	193.3 (82.5) ($N = 27$)	195.5 (100.3) ($N = 12$)	173.6 (67.0) ($N = 12$)	$F(2,41) = 5.38$ $P < 0.0008$
Angle 72	170.3 (67.8) ($N = 9$)	211.5 (68.6) ($N = 12$)	148.5 (59.4) ($N = 4$)	156.4 (62.2) ($N = 5$)	$F(2,10) = 7.53$ $P < 0.02$

Values in parentheses are SD.
*Data represent torque in Nm.

that the treatment group reduced their scores in reported physical dysfunction after exercise and the control group increased in their reported physical limitations ($F(2, 52) = 4.77$, $P < 0.03$). A similar effect was found on the psychosocial subscale. Again controlling for pretreatment differences, there were significant differences between the groups in change scores on the psychosocial dysfunction scale. The treatment group decreased their scores and the control group increased in their reported psychosocial dysfunction ($F(2, 52) = 5.05$, $P < 0.03$). See Table 3.

Two different subscales of the Mental Health Inventory that measure anxiety and depression combine to form a subscale entitled Psychological Distress. Employing this scale as a measure of anxiety and depression, pretreatment scores indicated that both groups experienced high levels of psychological distress and the control group expressed a significantly higher level than the treatment group. Controlling for pretreatment differences, there were no differences following treatment between groups for psychological distress, or psychological well-being. Despite all subjects reporting high levels of stress and distress pretreatment, there were no pretreatment difference between groups on the level of self-reported pain. In contrast, there was a significant posttreatment group × time interaction which indicated that the treatment group reported a significant reduction in pain and the control group reported an increase in pain ($F(2, 51) = 6.83$, $P < 0.002$). See Table 3.

In assessing the individual's perceived ability to master the exercise program, there were no pretreatment differences between groups on internal or external locus of control, but there were significant posttreatment differences found. Analysis of change scores indicated that the treatment group maintained their internal locus of control whereas the control group decreased internal control ($F(2, 50) = 6.07$, $P < 0.02$). The control group reported higher levels of external locus of control at the end of the study whereas the treatment group's scores remained the same ($F(2, 50) = 4.59$, $P < 0.04$) (Table 3).

To assess pretreatment predictors of therapeutic gain (increased isometric lumbar extensor strength), the positive support, pain, past-week activity levels, and internal or external locus of control variables were entered into a stepwise regression model. The analysis indicated that 28% of the variance was attributable to pretreatment measures of the past week's activity level, pain, and external locus of control (F(3,

Table 3. Physiological Dysfunction and Pain

	Treatment Group		Control Group		F Statistic
	Before Treatment	After Treatment	Before Treatment	After Treatment	P Value
Sickness Impact Profile					
Physical dysfunction	9.1 ± 9.3	7.7 ± 9.4	15.2 ± 10.4	19.3 ± 15.6	P < 0.03
Psychosocial dysfunction	12.5 ± 14.3	10.3 ± 12.8	20.8 ± 18.0	24.8 ± 23.7	P < 0.03
Mental Health Inventory					
Psychologic stress	58.8 ± 18.8	59.0 ± 20.9	71.7 ± 28.9	70.3 ± 32.5	NS
Psychologic well-being	51.3 ± 13.9	52.2 ± 14.5	45.1 ± 18.1	46.8 ± 19.0	NS
West Haven-Yale Multidimensional Pain Inventory					
Pain subscale	3.4 ± 1.6	2.9 ± 1.7	3.7 ± 1.6	4.1 ± 1.5	P < 0.002
Positive support subscale	3.6 ± 1.3	3.4 ± 1.5	2.6 ± 1.7	3.0 ± 1.5	NS
Negative support subscale	1.2 ± 1.0	1.2 ± 1.1	2.1 ± 1.5	1.7 ± 1.4	NS
Exercise Locus of Control					
Internal control	23.3 ± 5.2	23.9 ± 4.4	21.8 ± 5.2	19.9 ± 6.7	P < 0.02

Values are mean ± SD.

52) = 6.22, $P < 0.001$). The relationship between pretreatment pain and posttreatment strength gains accounted for 19% of the total variance in the model and was the only significant variable influencing strength outcome ($F(4, 48) = 4.81$, $P < 0.002$) (Table 4).

■ Discussion

The findings of this study indicate that specific exercise for isolated lumbar extensor muscles substantially increased low-back strength in chronic low-back pain patients. Additionally, increased strength was associated with perceived improvements in physical and psychosocial functioning.

Psychological factors found to be associated with treatment outcome consistently improved in the treatment group and declined in the control group. The treatment group reported less dysfunction whereas the control group increased their percept of physical and psychosocial impairment. Interestingly, despite reporting improved physical and psychosocial functioning, there were no differences or changes in self-reported daily activities.

Lumbar extension exercise was also related to significant changes in self-reported pain. Again, the treatment group decreased their pain reports while the control group reported even higher levels of pain at the end of the study. These findings lend support to the hypothesis that patients with low-back pain may avoid activities that previously created pain, which results in muscular disuse and atrophy. A result of atrophied muscles and consequent instability or further weakness of the low back may potentially lead to increased pain independent of the original pain stimuli.[11,35] Hence, specific exercise and subsequent increased strength of low-back muscles reduced reported pain and has the potential for a reduction in the overuse of the health care system associated with this population.

Changes in pain and physical dysfunction were hypothesized to result in decreases in psychological distress (depression and anxiety), but the findings of this study did not support this hypothesis. Patients in this study reported significantly high levels of psychological distress prior to entering the protocol and at the end of treatment both groups continued to report significantly high levels of psychological distress. Because the control group demonstrated a pretreatment difference in psychological distress and time unemployed because of pain compared with the treatment group, the control group may have experienced higher levels of psychological distress in response to their less stable economic and social situation as a function of longer durations of unemployment. This suggestion seems plausible given that physical findings, activities, pain behaviors, and pain report were not significantly different between the groups pretreatment. The fact that psychological distress did not significantly decrease is consistent with studies which have found that exercise leads to decreases in mild to

Table 4. Multiple Regression of the Relationship of Pretreatment Psychologic Variables to Posttreatment Intercept Values

Step	Variable	Model R^2	Partial R^2	F Statistic	P Value	Beta Weight
1	Pain	0.19	0.19	12.12	0.001	-12.3
2	Activity	0.24	0.05	3.05	0.08	12.7
3	External LOC	0.28	0.04	2.52	0.12	3.5
4	Internal LOC	0.28	0.01	0.69	0.41	1.3

LOC, locus of control.

moderate, but not severe, levels of depression and anxiety.[21] Given the high level of psychological distress in this study's population, more intensive interventions or longer treatment protocols may be needed to lessen depression and anxiety in these patients.

The implications from these findings are that patients exhibiting a chronic low-back pain syndrome improve in lumbar extensor muscle strength, and they experience a reduction in pain following specific lumbar extensor muscle exercise. Although this exercise improved low-back strength, it did not result in significant decreases in psychological distress in this patient population. This suggests that perceived or actual limitations for returning to gainful function in society remained impaired and potentially exacerbated psychological distress. Hence, the failure to find improvement in psychological distress in this study suggests that chronic pain patients with severe levels of dysfunction may require longer treatment interventions or alternative treatment programs that emphasize physical reconditioning with concomitant interventions addressing vocational, psychological and socio-environmental factors.

In this study, internal locus of control for mastering the exercise regimen was the only psychological measure positively correlated with changes in strength. Pretreatment scores of internal locus of control were not found to be predictive of therapeutic gain as originally hypothesized. However, increased strength was highly associated with maintenance of an internal attribution for success. The higher external locus of control scores in the control group at posttreatment suggests that as pain persists and passive treatment modalities (i.e., hot/cold packs and massage) fail to ameliorate the symptoms, the subject's personal expectations may decline and in turn, they may seek external resources for meeting their needs. Conversely, subjects who experienced success with exercise and subsequent reductions in pain were more apt to internalize their treatment goals.[6–9] These findings suggest that patients who are encouraged to take an active role in their rehabilitation adapt an internal attribution for treatment success, which is associated with actual therapeutic gains. In contrast, patients who wait for helpful treatment interventions may become more dependent on others for help, which potentially increases their psychological distress and pain. Increased pain in turn may further limit activity which causes more muscle weakness (atrophy) which may be related to increased pain. This creates a cyclic effect. Lumbar extensor muscle exercise training may help break the atrophy-pain cycle and enhance the individual's internal locus of control.

Previous studies addressing strength gains in healthy individuals following lumbar extensor muscle exercise report strength gains of 25% to 100% from full flexion to extension.[16,27,34] The patients participating in training in this study increased lumbar strength from 20% to 42% whereas the control group remained the same. Given the chronicity of disability experienced by this sample and the conservative treatment protocol for pain patients as compared to healthy subjects, this finding is remarkable.

Changes in strength were associated positively with decreased pain reports and increased physical and psychosocial functioning. There was no relationship between changes in strength and psychological distress. The findings of this study have potential implications for the severely disabled low-back pain population as well as the less disabled back pain patient as is typically found in out-patient treatment programs. Of particular interest is the fact that those who have significantly high levels of psychological distress and physical disabilities exhibit positive changes with lumbar extension exercise. Research has shown that less chronic and dysfunctional patients benefit from physical exercise modalities.[33] The results of this study suggest that a less severely disabled group might demonstrate even greater therapeutic gains with low-back extensor muscle exercise because of lower levels of pretreatment pain and psychological distress.

■ Summary

The current study showed that specific exercise of the low-back in chronic low-back pain patients is important for increasing strength and reducing pain and psychosocial dysfunction. This treatment did not ameliorate psychological distress or socio-environmental influences. This implies that physical rehabilitation is an important component of rehabilitation for chronic low-back pain patients and should be included with psychological rehabilitation for maximizing return to work and improved daily functioning.

In conclusion, this study demonstrated that lumbar extension exercise strengthened the low-back extensor muscles in a population of chronic low-back pain patients. Associated improvements were also found in the experience of pain and perceived physical and psychosocial dysfunction as measured by the Sickness Impact Profile. More research is needed to address the long-term benefits of lumbar extensor muscle exercise in a chronic low-back pain population. Continued research is also needed to further investigate the long-term effects of lumbar extensor muscle exercise on psychological distress, return to work, and changes in daily activities.

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