Effectiveness of an Extension-Oriented Treatment Approach in a Subgroup of Subjects With Low Back Pain: A Randomized Clinical Trial

David A Browder, John D Childs, Joshua A Cleland, Julie M Fritz

Background and Purpose

The purpose of this multicenter randomized clinical trial was to examine the effectiveness of an extension-oriented treatment approach (EOTA) in a subgroup of subjects with low back pain (LBP) who were hypothesized to benefit from the treatment compared with similar subjects who received a lumbar spine strengthening exercise program.

Methods

Subjects with LBP and symptoms distal to the buttocks that centralized with extension movements were included. Forty-eight subjects were randomly assigned to groups that received an EOTA (n=26) or a strengthening exercise program (n=22). Subjects attended 8 physical therapy sessions and completed a home exercise program. Follow-up data were obtained at 1 week, 4 weeks, and 6 months after randomization. Primary outcome measures were disability (modified Oswestry Low Back Pain Disability Questionnaire) and pain (Numeric Pain Rating Scale).

Results

Subjects in the EOTA group experienced greater improvements in disability compared with subjects who received trunk strengthening exercises at 1 week (mean difference between groups from baseline=8.9, 95% confidence interval [CI]=2.0, 15.9), 4 weeks, (mean difference=14.4, 95% CI=4.8, 23.9), and 6 months (mean difference=14.6, 95% CI=4.6, 24.6). The EOTA group demonstrated greater change in pain at the 1-week follow-up only.

Discussion and Conclusion

An EOTA was more effective than trunk strengthening exercise in a subgroup of subjects hypothesized to benefit from this treatment approach. Additional research is needed to explore whether an EOTA may benefit other subgroups of patients.

DA Browder, MAJ, PT, DPT, OCS, is Director, Outpatient Physical Therapy, Physical Therapy Department, Wilford Hall Medical Center, San Antonio, Tex, and Assistant Professor, US Army–Baylor University Doctoral Program in Physical Therapy, San Antonio, Tex. Institutional address: 59 CSG/59 DTS/SGOYP, 2200 Bergquist Dr, Ste 1, Lackland AFB, TX 78154 (USA). Address all correspondence to Dr Browder at: david.browder@lackland.af.mil.

JD Childs, PT, PhD, MBA, OCS, FAAOMPT, is Assistant Professor and Director of Research, US Army–Baylor University Doctoral Program in Physical Therapy.

JA Cleland, PT, PhD, OCS, FAAOMPT, is Associate Professor, Franklin Pierce University, Concord, NH, and Physical Therapist, Rehabilitation Services, Concord Hospital, Concord, NH.

JM Fritz, PT, PhD, ATC, is Associate Professor, Division of Physical Therapy, University of Utah, and Clinical Outcomes Research Scientist, Intermountain Healthcare, Salt Lake City, Utah.

[Browder DA, Childs JD, Cleland JA, Fritz JM. Effectiveness of an extension-oriented treatment approach in a subgroup of subjects with low back pain: a randomized clinical trial. *Phys Ther*. 2007;87:1608–1618.]

Next to the common cold, low back pain (LBP) is the most common reason individuals visit a physician's office,[1] resulting in billions of dollars in medical expenditures and lost labor costs each year.[2] Attempts to identify effective nonsurgical treatment approaches such as exercise for the management of LBP have been largely unsuccessful,[3] resulting in a array of disparate treatment recommendations in LBP practice guidelines.[4]

The equivocal findings on the effectiveness of exercise for LBP may be attributable to the failure of researchers to adequately account for the importance of subgrouping, or classifying, subjects.[5] The use of broad inclusion criteria in previous research may result in the selection of heterogeneous samples that likely include many subjects for whom no benefit is expected from the particular treatment, thus potentially masking the intervention's true value. Consequently, the development of methods for identifying subgroups of subjects with LBP and matching them to the treatments most likely to benefit them has evolved as an important research priority.[5–7]

One subgroup of subjects with LBP consists of subjects proposed to benefit from an extension-oriented treatment approach (EOTA). This approach typically involves some combination of active or passive activities to promote extension in the lumbar spine.[8,9] Several studies have examined the effectiveness of an EOTA for subjects with LBP, with most finding no benefit compared with other treatments[10–17]; however, these studies have not sought to identify subjects *a priori* who might be likely to respond to an EOTA, leaving open the possibility that a subgroup of patients with LBP may exist for whom EOTA is a beneficial treatment.

Several recent studies[18–21] have provided preliminary evidence that the use of subgrouping classification methods for the physical therapist management of subjects with LBP may result in better outcomes than physical therapist management that is not classification based. The treatment-based classification system described by Delitto and colleagues[8] includes a subgroup of subjects thought to preferentially benefit from an EOTA. The key criterion for inclusion in the EOTA subgroup is the presence of the centralization phenomenon with extension movement testing during the physical examination.[18,22] Other authorities[9,23,24] also have proposed that centralization is important in identifying patients likely to benefit from an EOTA.

The centralization phenomenon occurs when a movement or position results in the migration of symptoms from an area more distal or lateral in the buttocks or lower extremity to a location more proximal or closer to the midline of the lumbar spine.[9] Although it is generally agreed that patients likely to benefit from an EOTA are those who experience centralization with lumbar extension movements, most previous studies have not incorporated this hypothesis into their design or inclusion criteria. The purpose of this study was to examine the effectiveness of an EOTA in a subgroup of subjects hypothesized to benefit from the treatment compared with a lumbar spine strengthening exercise program at both short-term and long-term follow-up.

Method

Consecutive patients who were receiving physical therapy intervention for a primary complaint of LBP were considered for participation. Ten physical therapists at 9 clinics in various settings in the United States (3 academic medical centers and 6 smaller outpatient practice settings) participated. The median age of the participating physical therapists was 37 years (range=30–40 years), with an average of 7 years of practice (range=1–16 years) in an outpatient orthopedic setting. Most participating sites were health care facilities within the Department of Defense that treated active-duty and retired personnel as well as dependent family members. Each site's institutional review board approved the study before recruitment began.

Inclusion criteria were age between 18 and 60 years, with LBP and symptoms of any duration extending distal to the buttocks on at least one lower extremity. The centralization phenomenon, determined by the examiner using active movement testing, had to be present. A single movement of lumbar extension was assessed first, followed by repeated extension movements consisting of 10 repetitions performed with the subject standing. Repeated extension movements also were performed with the subject positioned prone. Centralization was judged to be present when extension movement abolished symptoms or caused symptoms to move proximally toward the midline of the lumbar spine in at least one of these positions. The interrater reliability of determining the presence of centralization using this definition has been reported to be high.[22] A modified Oswestry Low Back Pain Disability Questionnaire (ODQ) score of at least 30% was required. Exclusion criteria were "red flags" possibly indicative of a pathological condition (eg, tumor, fracture, infection), current pregnancy, or surgery to the lumbar spine in the past 6 months. Once admitted, we used intention-to-treat principles, with no subject removed for nonadherence.

History and Physical Examination

At baseline, subjects completed several self-report measures and then received a standardized history and physical examination. Baseline assessments were performed by a physical therapist who was unaware of the subjects' treatment group. The re-examinations were not always conducted by an examiner who was unaware of the subjects' treatment group; however, the re-examination procedures consisted of self-report questionnaires that were completed by the subjects without any input or influence from the examiner.

Self-report measures included the ODQ, Numeric Pain Rating Scale (NPRS), and Fear-Avoidance Beliefs Questionnaire (FABQ). The ODQ is a region-specific disability scale for patients with LBP, with scores ranging from 0 to 100, that has been shown to exhibit high levels of reliability, validity, and responsiveness.[25] The NPRS is an 11-point pain rating scale ranging from 0 (no pain) to 10 (worst pain imaginable), which was used to assess current pain intensity and the best and worst level of pain during the last 24 hours.[26] The 3 scores were averaged. The FABQ was used to quantify the subjects' fear of pain and beliefs about avoiding activity.[27] Subjects also recorded the anatomic location of symptoms on a body diagram. The body diagram was used to determine the extent to which centralization occurred at follow-up visits. Symptom location was recorded using procedures shown to have excellent reliability.[24] The most distal symptoms were scored as: 0 if no symptoms were identified, 1 if the most distal symptoms were in the central low back, 2 in the lateral low back, 3 in the buttocks, 4 in the thigh, 5 in the calf, or 6 in the foot. Figure 1 shows the demarcations for each area for body chart scoring.

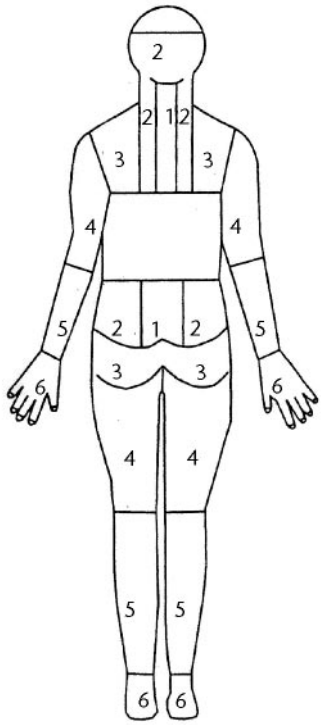

Figure 1.
Body chart for symptom location analysis.

The history consisted of demographic information, including age; sex; height; weight; past medical history; duration, location, and nature of symptoms; relieving and aggravating activities; prior episodes of LBP; occupation; and participation in leisure activities. Physical examination procedures included a neurological assessment of strength (muscle force-generating capacity), sensation, muscle-stretch reflexes, and straight leg raise test; measurements of active lumbar range of motion using a single inclinometer[28]; and posterior-to-anterior mobility of the lumbar spine performed with the subjects positioned prone.[29]

Therapist Training

Each participating physical therapist received a detailed manual of operating procedures defining all examination and treatment techniques used in the study. Each therapist also met with an investigator before data collection began to ensure proper performance of all examination and treatment procedures.

Treatment Groups

A random number generator was used to construct a randomization list prior to the study. Individual, sequentially numbered index cards with the randomization assignments were prepared. The index cards were folded and placed in sealed envelopes. After the baseline examination, the physical therapist who conducted the examination opened the envelope, indicating the treatment group assignment. Subjects were randomly assigned to 1 of 2 exercise groups: (1) the EOTA group or (2) the strengthening group. Subjects in both groups attended physical therapy sessions twice a week for the first 2 weeks, then once a week for the next 2 weeks, for a total of 6 sessions over 4 weeks.

Treatment was initiated immediately after completion of the baseline examination unless prohibited by time constraints, in which case the first treatment session took place within 48 hours of the baseline examination. All subjects were provided a copy of an exercise instruction booklet with detailed written descriptions and pictures of the proper performance, frequency, and progression of each exercise (Supplemental Appendixes 1 and 2 available online only at www.ptjournal.org). Subjects were instructed to record their adherence in an exercise log, which was reviewed by the treating therapist at each session to encourage adherence. Subjects were instructed to perform their assigned exercise program at home on the days that they did not attend physical therapy sessions. On the basis of the benefits associated with remaining active,[30] subjects in both groups also were

given advice to maintain their usual activity within the limits of pain.

EOTA group. Subjects in the EOTA group received exercise and mobilization to promote extension of the lumbar spine with the goal of producing centralization of symptoms. The first activity consisted of a series of extension-oriented exercises, including sustained and repeated lumbar extension in prone and standing positions. Extension exercises were progressed as tolerated starting with static prone positioning and progressing to repeated end-range prone and standing extension. A subject who tolerated the complete exercise program performed 3 sets of 10 repetitions of repeated end-range extension in prone position and then 3 sets of 10 repetitions of end-range extension in standing, holding each repetition at end range for 2 to 3 seconds (Supplemental Appendix 1).

The second activity to promote lumbar extension was posterior-to-anterior lumbar mobilization. The mobilization technique consisted of a series of 10 to 20 grade I to IV oscillations based on the procedures described by Maitland.[31] The therapist selected the grade and segmental level at which the mobilization was directed during each treatment session based on the consideration of several factors, including the goal of achieving maximum centralization, reducing segmental hypomobility, and decreasing symptoms.

In addition to the mobilization treatment and exercise program in the clinic, subjects were instructed to perform 1 set of 10 repetitions of the prone press-up exercise every 2 to 3 waking hours during the 4-week treatment period. Alternatively, they could perform 1 set of 10 repetitions of repeated extension in standing if they were unable to assume the prone position (eg, at work, out shopping). Therapists also provided education on how to maintain the natural lordosis of the lumbar spine while sitting, and subjects were instructed to avoid sitting for periods greater than 20 to 30 minutes. In addition, subjects were given general instructions to discontinue any activities and avoid positions that caused their symptoms to peripheralize or that led to an increase in the intensity of their symptoms. Alternatively, subjects were encouraged to perform activities and maintain positions that centralized or improved their symptoms.

Strengthening group. Systematic reviews recommend muscle strengthening exercises for patients with chronic LBP.[32] This study used a strengthening program designed by Hicks et al[33] to improve isolated contractions of the deep abdominal muscles (eg, transversus abdominus) and to strengthen primary stabilizers of the spine (eg, oblique abdominal, multifidus, quadratus lumborum, and erector spinae muscles).[34,35] The program is described in detail in Supplemental Appendix 2. Subjects performed the strengthening exercise program in the physical therapy clinic and were instructed to perform the program at home once daily on days they did not attend physical therapy sessions.

To balance possible attention effects between treatment groups, therapists closely supervised subjects performing strengthening exercises and provided frequent verbal encouragement and tactile cues while instructing the subjects in the exercises. Although this program was performed only once a day, compared with a home program performed several times a day by the subjects receiving an EOTA, the strengthening program required more time to complete, making the total amount of daily exercise time comparable between groups.

Follow-up Examinations

Follow-up examinations were performed 1 and 4 weeks after randomization. Follow-up examinations included re-assessment of the self-report measures. At approximately 6 months after discharge, the self-report questionnaires were mailed along with a questionnaire concerning additional interventions that the subjects may have received following completion of the study. If subjects did not respond to the initial follow-up mailing, multiple attempts were made to contact each subject to ensure that they received and had the opportunity to respond to the questionnaire.

Sample Size Calculation

Sample size calculations were based on detecting a 10-point difference on the ODQ, which has been identified as the minimum clinically important difference.[36] A sample size of 24 subjects per group provided 80% power to detect a clinically important difference of 10 points between groups, assuming a common standard deviation of 12.0 and a 2-sided hypothesis with an alpha level of .05.

Data Analysis

Baseline variables were compared between groups using independent *t* tests or Mann-Whitney *U* tests for continuous data or chi-square tests of independence for categorical data. Potential differences in the follow-up rate were examined using a Pearson chi-square test. The effects of treatment on pain and disability were examined with 2-way repeated-measures analysis of covariance (ANCOVA), with treatment group (EOTA versus strengthening) as the between-subjects variable and time (baseline and follow-up) as the within-subjects variable. The use of an ANCOVA was not preplanned, and the use of the planned analysis that did not adjust for previous surgery provides a different result. History of lumbar surgery was used as a

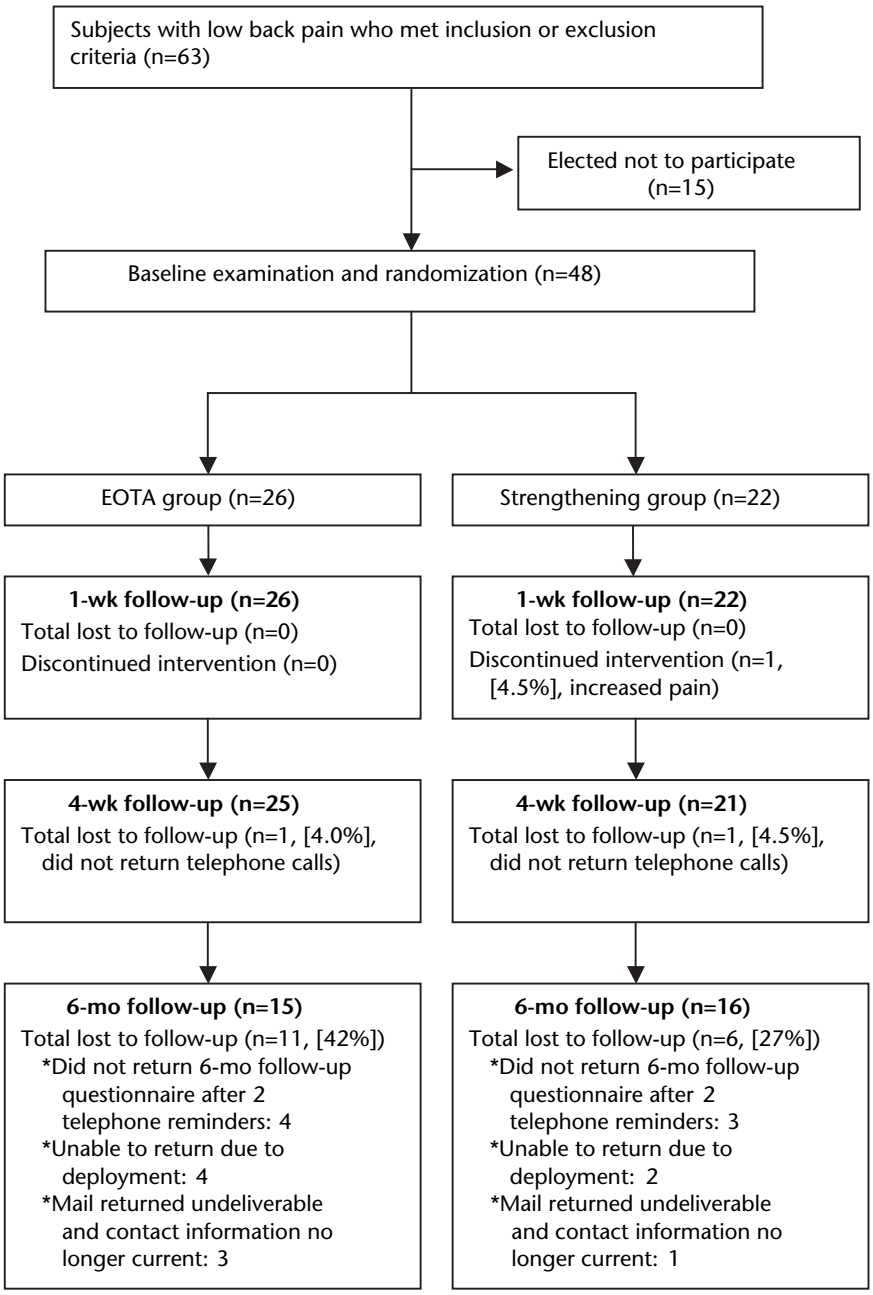

Figure 2.
Flow diagram for subject recruitment and randomization. EOTA=extension-oriented treatment approach.

covariate because previous lumbar surgery may adversely affect prognosis,[37,38] and it differed between groups. Separate ANCOVAs were performed with pain (NPRS) and disability (ODQ) as the dependent variable. For each ANCOVA, the hypothesis of interest was the 2-way interaction between time and group. We hypothesized that subjects in the EOTA group would experience greater improvement in pain and disability at each follow-up compared with subjects in the strengthening group. We also performed planned pair-wise comparisons to examine differences from baseline to each time point separately between the treatment groups.

The effect of treatment on location of symptoms was examined by comparing the proportion of patients in each group whose symptoms centralized at the 1- and 4-week follow-up assessments. At each follow-up, the subject's symptoms were categorized using a body chart (Fig. 1) as central (symptoms abolished or in only area 1 on the body chart) or non-central (symptoms present in area 2 or more distal on the body chart). We also categorized subjects as improved (symptoms moved more proximal than baseline location) or not improved (symptoms moved more distal or unmoved from baseline). We hypothesized that a greater proportion of subjects in the EOTA group would have central symptoms and experience improvement at 1 and 4 weeks. Intention-to-treat principles were used to account for subjects who dropped out by carrying the last available score forward.

Results

Approximately 300 patients were screened for eligibility during a 22-month period from March 2003 to December 2004; 63 patients satisfied the criteria for inclusion in the study. The high rate of ineligibility is attributable to our effort to identify a subgroup of subjects most likely to benefit from an EOTA, namely those subjects with LBP whose symptoms extend below the buttocks and who demonstrate centralization of symptoms with extension movements upon initial examination. Fifteen eligible subjects declined to participate: 5 for no particular reason and 10 due to time constraints. The remaining 48 subjects (mean age=39.0 years, SD=10.2; 31% female), were randomly assigned to the EOTA group (n=26) or to the strengthening group (n=22). Figure 2 illus-

Table 1.
Baseline Demographic and Self-Reported Variables for Both Treatment Groups[a]

	All Subjects (N=48)	Strengthening Group (n=22)	EOTA Group (n=26)
Age, y	39.0 (10.2)	37.9 (10.0)	40.0 (10.4)
Sex, % female	31.3	31.8	30.8
Body mass index, kg/m^2	27.0 (6.6)	25.9 (2.5)	28.0 (8.6)
Current smokers, %	14.6	9.1	19.2
History of low back pain, %	64.6	59.1	69.2
Median duration of current symptoms, d (range)	59.5 (2–1,550)	59.5 (8–1,095)	63.5 (2–1,550)
Taking medication for low back pain at baseline, %	87.5	81.8	92.3
Narcotic medication use for low back pain this episode, %	31.3	27.3	34.6
Received physical therapy prior to this episode, %	20.8	18.2	23.1
Prior lumbar spine surgery, %	10.4	0	19.2
Missed any work for this injury, %	43.8	45.5	42.3
Have not missed any work in the past 6 mo, %	70.8	68.2	73.1
Symptoms distal to the knee, %	56.3	50.0	61.5
FABQ physical activity subscale score	15.7 (5.4)	15.0 (5.2)	16.4 (5.6)
FABQ work subscale score	14.7 (10.7)	15.4 (10.9)	14.1 (10.7)
ODQ score	37.0 (12.9)	35.2 (10.5)	38.5 (14.7)
NPRS score	5.0 (1.7)	4.9 (1.9)	5.2 (1.6)

[a] Values presented as mean (SD) unless otherwise stated. EOTA=extension-oriented treatment approach, FABQ=Fear-Avoidance Beliefs Questionnaire, ODQ=modified Oswestry Low Back Pain Disability Questionnaire, NPRS=Numeric Pain Rating Scale.

trates the flow diagram for subject recruitment, randomization, and retention.

Baseline variables for each group are presented in Table 1. A notable difference between groups was the history of lumbar surgery (Tab. 1). Five subjects in the EOTA group reported a history of lumbar surgery compared with no subjects in the strengthening group. Patients with a recent history of surgery (within the past 6 months) were excluded from the study, but patients with a past history of surgery met the inclusion criteria.

Results of the repeated-measures ANCOVA showed a significant group × time interaction (P=.02) for the outcome of disability (ODQ), but not for pain (NPRS) (P=.07). Table 2 provides results at each time point with 95% confidence intervals (CIs) for differences in ODQ and NPRS scores between groups. Significantly greater improvement was observed in the EOTA group for the ODQ at each follow-up period (Fig. 3), but only at 1 week for the NPRS (Fig. 4).

Information on additional treatments or health care utilization was provided by 34 subjects (71%), 17 in each treatment group. No differences in additional treatments or health care utilization were found between groups at the 6-month follow-up. Of the subjects returning information, 2 in each treatment group had surgery over the 6-month period, 5 in each group had received additional physical therapy treatment, and 5 in each group were seeking additional treatment for LBP at the time of the 6-month follow-up.

After 1 week, 1 subject in the strengthening group (4.5%) and 7 subjects in the EOTA group (26.9%) had central symptoms (P=.04), whereas 6 subjects in the strengthening group and 17 subjects in the EOTA group showed improvement in pain location (P=.008). At the 4-week follow-up, 4 subjects in the strengthening group and 7 subjects in the EOTA group had central symptoms (P=.47), and 5 and 13 subjects in the strengthening and EOTA groups, respectively, showed improvement in pain location (P=.05) (Fig. 5).

Because of the disproportionate number of subjects with a history of lumbar surgery in the EOTA group (n=5), we compared the outcomes in the subjects receiving EOTA with a history of lumbar surgery with the subjects receiving EOTA without a

Table 2.
Change in Outcome Measures Over Time[a]

Measure[b]	Strengthening Group	EOTA Group	Mean Difference Between Groups From Baseline (95% CI)
1-wk change (95% CI)			
ODQ	4.2 (−0.70, 11.1)	13.1 (6.9, 19.4)	8.9 (2.0, 15.9)
NPRS	0.30 (−0.70, 1.3)	1.7 (0.80, 2.7)	1.4 (0.41, 2.5)
4-wk change (95% CI)			
ODQ	5.8 (−3.5, 15.2)	20.2 (11.6, 28.8)	14.4 (4.8, 23.9)
NPRS	1.0 (−0.30, 2.3)	2.3 (1.0, 3.6)	1.2 (−0.22, 2.7)
6-mo change (95% CI)			
ODQ	8.2 (−1.7, 18.0)	22.7 (13.7, 31.7)	14.6 (4.6, 24.6)
NPRS	1.4 (−0.10, 2.9)	2.5 (1.1, 3.9)	1.1 (−0.42, 2.6)

[a] EOTA=extension-oriented treatment approach, ODQ=modified Oswestry Low Back Pain Disability Questionnaire, NPRS=Numeric Pain Rating Scale.
[b] Change scores adjusted for covariate.

history of surgery, using ANCOVA procedures as previously described with the baseline score serving as the covariate. Significantly less improvement in disability (ODQ scores) was found in the subjects with a history of surgery after 1 week (mean difference=14.7 points, 95% CI=1.5, 27.8) and 4 weeks (mean difference=19.0 points, 95% CI=3.4, 34.6). The difference at 6 months approached significance (P=.07) even with a small number of patients (Fig. 6). Differences in changes in pain did not reach statistical significance.

Discussion

Recent studies[18–20] have reported that using specific inclusion criteria to identify more homogenous subgroups of subjects and attempting to match treatment to the subgroup has the potential to enhance treatment effects. Several previous studies examining the effectiveness of an EOTA treatment in a more heterogeneous group of subjects[10,11,13] have failed to find significant differences when compared with alternative treatment procedures. The present study examined a more homogenous sample (those with symptoms distal

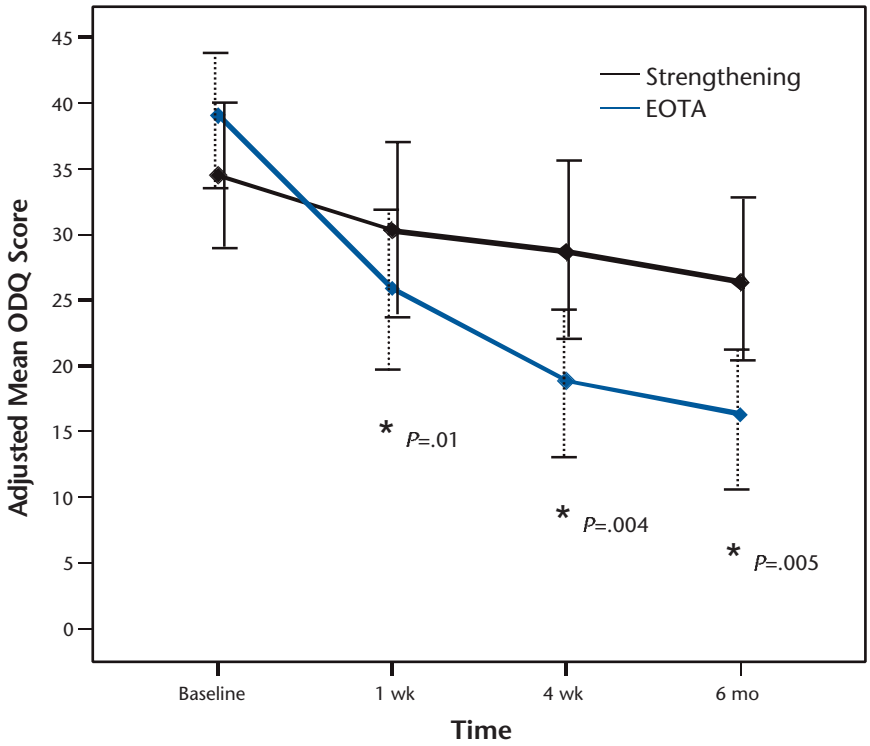

Figure 3.
Adjusted modified Oswestry Low Back Pain Disability Questionnaire (ODQ) scores at each assessment point. Asterisk (*) indicates significant difference between groups in change from the baseline score (P<.05). EOTA=extension-oriented treatment approach.

to the buttock demonstrating centralization with lumbar extension) and found significant differences in improvement in disability at each follow-up period. These findings support the hypothesis of improved outcomes when interventions are matched to more specific subgroups of patients. The small size and methodological shortcomings of the current study, however, indicate a persistent need for additional research investigating an EOTA approach using larger samples with longer and more complete follow-ups.

This study attempted to identify a subgroup of subjects *a priori* who were expected to respond more successfully to an EOTA than to other interventions. The inclusion criteria were based on previous reports suggesting that subjects centralizing with extension movements will improve if they are given exercises that encourage end-range movement in the direction of extension.[8,39] These previous reports were supported by the work of Long et al[21] who demonstrated greater improvement in disability over 2 weeks when subjects with a directional preference for extension were given an exercise matched to that preference. The current study extends this previous work by showing that subjects who centralized with extension who were given a treatment program matched to that direction had greater reductions in disability for up to 6 months than similar subjects who were given a strengthening exercise program that has demonstrated merit in other subgroups of patients with LBP.[32,40] In contrast to the study by Long et al,[21] no advanced training or certification was required of the therapists participating in this study, perhaps resulting in greater generalizability to physical therapists without specific training.

Further research is needed to clarify whether subjects who demonstrate a

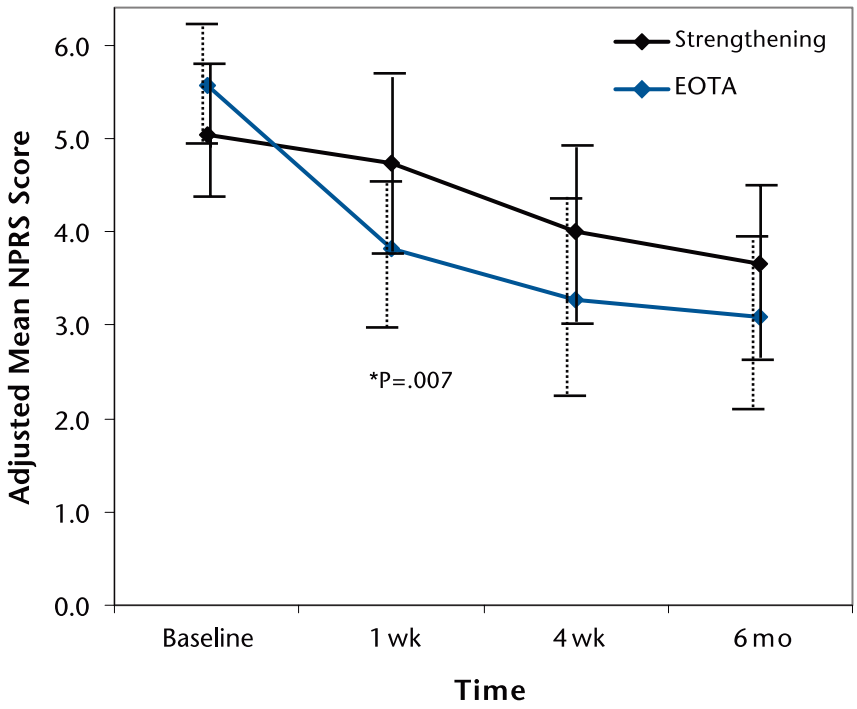

Figure 4.
Adjusted Numerical Pain Rating Scale (NPRS) scores at each assessment point. Asterisk (*) indicates significant difference between groups in change from the baseline score ($P<.05$). EOTA=extension-oriented treatment approach.

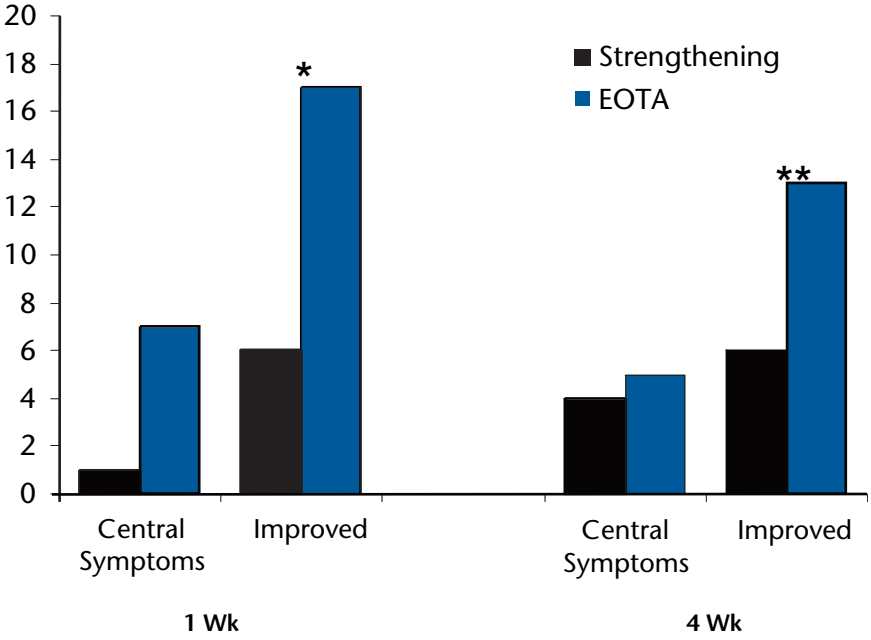

Figure 5.
Number of subjects with central symptoms or improved pain location at 1- and 4-week follow-ups. Asterisk (*) indicates $P<.05$ for the difference between groups, double asterisk (**) indicates $P=.05$ for difference between groups. EOTA=extension-oriented treatment approach.

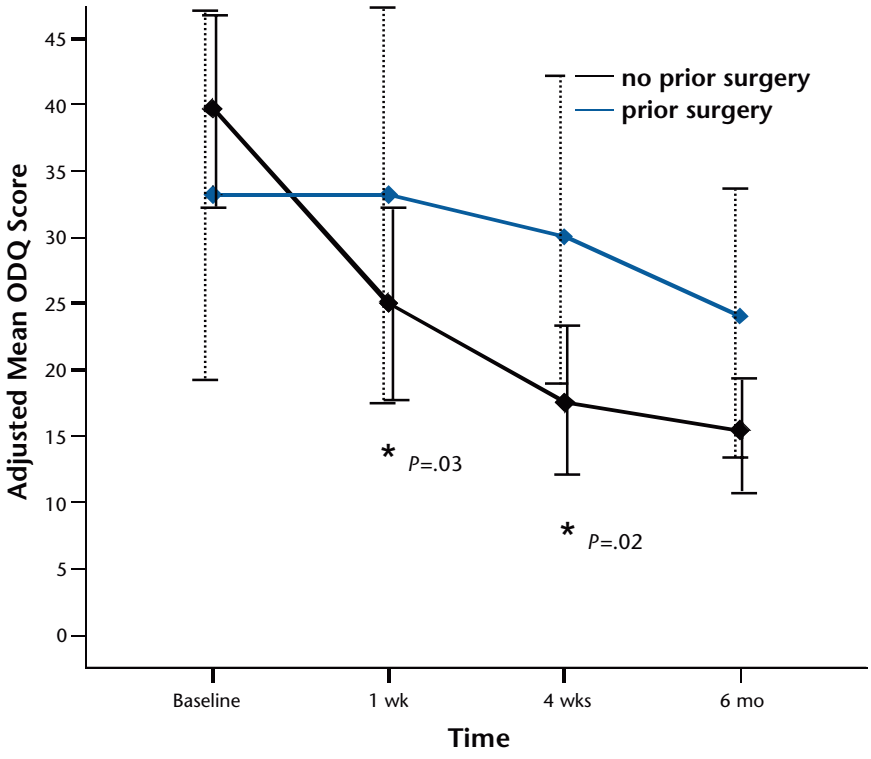

Figure 6.
Adjusted modified Oswestry Low Back Pain Disability Questionnaire (ODQ) scores for subjects in the extension-oriented treatment approach group with or without a history of lumbar surgery. Asterisk (*) indicates statistically significant difference between groups from the baseline score ($P<.05$).

preference for extension (ie, a directional preference or centralization) constitute a discrete subgroup of patients and, if so, what the optimal intervention strategy may be for this subgroup. The current study did not find significant differences in pain reduction between groups over the course of the study, and we were unable to document differences in resource utilization at the 6-month follow-up. These results indicate that additional research to more narrowly define the subgroup of patients that best responds to an EOTA would be beneficial. A clinical prediction rule to help accurately identify those patients who will most likely improve with an EOTA could allow for better delineation of this subgroup of patients by clinicians and improve the inclusion criteria for future clinical trials.

A potentially important factor identified in this study was the failure of subjects with a history of lumbar surgery to respond to an EOTA as successfully as other subjects. This finding suggests that patients with a history of surgery, even those who experience centralization with extension movement, may benefit more from a different treatment approach. However, the number of subjects in this study with a prior history of surgery was small (n=5), and none were randomly chosen to receive the strengthening exercise treatment, preventing a comparison of the outcome of an EOTA approach to an alternative in subjects who had a history of lumbar surgery.

Several shortcomings of the present study should be considered in assessing the results. Inherent in studies performed in military settings is the potential that results will not be generalizable to all populations. For this study, 30 subjects (63%) were recruited from military settings and 18 subjects (37%) were recruited from civilian settings. However, these subjects had a mean age of 39.0 years (SD=10.2) years and body mass index of 27.0 kg/m^2 (SD=6.6), indicating that, despite military affiliation, these subjects were not younger or leaner than the sample as a whole. Although caution is warranted, the results should be generalizable to other populations of patients with LBP.

A primary concern for this study was the 6-month follow-up rate. Six-month data were obtained from 73% of subjects in the strengthening group and 58% in the EOTA group. Based on the inclusion of active-duty military service members in the study, the low 6-month follow-up rate may be partially attributable to extended deployments with no ability to reach subjects via postal or electronic mail (Fig. 2). The rate of follow-up loss was apparently greater in the EOTA group, raising additional concerns. The loss to follow-up may have resulted in an exaggeration of the differences between the treatment groups, or may have attenuated these differences.[41] The 6-month results should be interpreted with caution.

Although the current study showed significant differences in improvement in disability favoring use of an EOTA approach in this relatively homogenous group of subjects, we did not find differences in improvement in pain beyond 1 week or in long-term resource utilization. There may be several explanations for these findings. First, although our inclusion criteria attempted to identify a relatively homogenous group of subjects likely to respond to an EOTA, we still may have included

some subjects who did not have good potential to respond to an EOTA, such as those with a history of surgery as mentioned previously. Conversely, we may have excluded some subjects who may have had a high likelihood of a positive response to an EOTA. We found approximately 20% of individuals with LBP fit our criteria of inclusion in the EOTA subgroup. Although this percentage is consistent with previous studies we have conducted,[20,42] it is possible that the subgroup is actually larger. For example, Long et al[21] used a directional preference instead of centralization as the criterion for inclusion, and reported that 61% of patients with LBP displayed a directional preference for extension movements. Perhaps a more encompassing criterion for inclusion would have resulted in a larger treatment effect in our study. Second, the EOTA protocol used, which included exercise and mobilization, may not have been sufficient to maximize the improvement. A higher dosage of exercise or mobilization may have resulted in a larger treatment effect.

Other studies that have assessed the effectiveness of extension-oriented exercise in a heterogeneous population with LBP[11,13] have shown minimal treatment effects. We looked at the effectiveness of an EOTA in a specific subgroup of patients with LBP by utilizing narrow inclusion criteria in order to select *a priori* a more homogeneous group of patients expected to respond to an EOTA. This study provides preliminary evidence that an EOTA is a more effective treatment than a strengthening approach for patients with symptoms extending to the buttocks or more peripherally who demonstrate centralization with extension movements. Because this study did not include patients who were not expected to respond to an EOTA, another possible interpretation of the results would be that the EOTA approach used in this study is superior to this strengthening approach in general, and not specifically to a particular subgroup of patients. Further validation of the existence of this subgroup of patients who preferentially respond to an EOTA could be achieved through randomized trials with broader inclusion criteria that examine the interaction among those fitting the criteria for the EOTA subgroup, treatment received, and outcomes.[19]

Conclusion

In a subgroup of subjects identified *a priori* as expecting to benefit from an EOTA, subjects who received an EOTA experienced significantly greater improvements in disability than subjects who received an alternative trunk strengthening program that also has evidence for its effectiveness in a different subgroup of patients. No differences were found between the groups for reductions in pain beyond 1 week. The results of this study support the belief that patients who centralize with extension movements during examination may preferentially benefit from a treatment approach focused on repeated extension movements.

Dr Childs and Dr Fritz provided concept/idea/research design and fund procurement. All authors provided writing. Dr Browder, Dr Childs, and Dr Cleland provided data collection. Dr Browder, Dr Childs, and Dr Fritz provided data analysis, Dr Browder provided project management and clerical/secretarial support. Dr Browder and Dr Cleland provided subjects and facilities/equipment. Dr Fritz provided institutional liaisons. Dr Childs, Dr Cleland, and Dr Fritz provided consultation (including review of manuscript before submission). The authors acknowledge the efforts of Sarah Eberhart, Kevin Johnson, Shane Koppenhaver, and Ismael Magtoto.

A platform presentation of the research was given at the Combined Sections Meeting of the American Physical Therapy Association; February 14–18, 2007; Boston, Mass.

Funding for the study was provided by a research grant from the Foundation for Physical Therapy to Dr Childs.

The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the US Air Force or Department of Defense.

This article was submitted September 28, 2006, and was accepted July 17, 2007.

DOI: 10.2522/ptj.20060297

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