The Relationship of Lumbar Flexion to Disability in Patients With Low Back Pain

Background and Purpose. Physical therapists routinely assess spinal active range of motion (AROM) in patients with low back pain (LBP). The purpose of this study was to use 2 approaches to examine the relationship between impairment of lumbar spine flexion AROM and disability. One approach relied on the use of normative data to determine when an impairment in flexion AROM was present. The other approach required therapists to make judgments of whether the flexion AROM impairment was relevant to the patient’s disability.

Subjects. Fifteen physical therapists and 81 patients with LBP completed in the study. Methods. Patients completed the Roland-Morris Back Pain Questionnaire (RMQ), and the therapists assessed lumbar spine flexion AROM using a dual-inclinometer technique at the initial visit and again at discharge. Results. Correlations between the lumbar flexion AROM measure and disability were low and did not vary appreciably for the 2 approaches tested. Conclusion and Discussion. Measures of lumbar flexion AROM should not be used as surrogate measures of disability. Lumbar spine flexion AROM and disability are weakly correlated, suggesting that flexion AROM measures should not be used as treatment goals. [Sullivan MS, Shoaf LD, Riddle DL. The relationship of lumbar flexion to disability in patients with low back pain. Phys Ther. 2000;80:240–250.]

Key Words: Impairment, Low back pain, Range of motion, Roland-Morris Back Pain Questionnaire.

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In a recent article discussing the need for physical therapy research in the area of impairment and disability relationships, Jette stated, “Physical therapy clinical research needs to explicitly state and then investigate the nature of the hypothesized relationship between different impairments and specific disabilities. Included in such research is an examination of the impact of changes in impairments on change in disability and the investigation of important covariates that alter these relationships. There is a paucity of examples of such research in all the health professions’ literature, not only in physical therapy.”

Physical therapists routinely assess for impairments of spinal range of motion (ROM) in people with low back pain (LBP). Battie and colleagues, for example, found that, when a large group of physical therapists in the state of Washington were surveyed, 81% to 93% stated that they would assess spinal ROM, given 3 hypothetical patient cases. Presumably, spinal ROM is examined, in part, to identify impairments of ROM that influence the patient’s disability. Identification of impairments is also an integral component of treatment planning in physical therapy. Jette et al reported that increased spinal ROM was a treatment goal in 57% of care episodes for LBP; this goal was the second most frequently cited following the goal of reducing pain.

The data of Battie et al and Jette et al suggest that physical therapists believe that spinal ROM and disability are closely linked. Research has indicated, however, that the correlation between spinal ROM and disability is weak. In perhaps the most extensive study of the impairment-disability relationship in patients with LBP, Waddell and colleagues measured different types of impairments (eg, abdominal muscle performance, spinal ROM) in 120 patients with chronic LBP. Patients also completed a Roland-Morris Back Pain Questionnaire (RMQ). Among the impairments studied were those affecting lumbar flexion and trunk flexion active range of motion.
Lumbar flexion was measured by the use of an inclinometer positioned on the skin overlying the S2 and then the L1 spinous processes while the patient was upright and again when the spine was fully flexed. A measure of lumbar flexion was then derived by subtracting the values obtained in the starting position from the values obtained in the fully flexed position. The correlation (Pearson $r$) between lumbar flexion AROM and disability was .44. Total flexion, a measure obtained by positioning an inclinometer on the skin overlying L1 immediately before and after the patient maximally flexes the spine from a standing position, was also weakly correlated to disability ($r = .47$), as measured with the RMQ. The remaining impairments that were assessed (eg, those involving spinal extension, lumbar lordosis, pelvic flexion, spinal lateral flexion) had weaker impairment-disability relationships (Pearson $r = .03–.35$) compared with the flexion measures.

Other authors tend to agree with the work of Waddell et al.$^5$ Deyo and Diehl$^6$ found a Pearson $r$ of .48 for the correlation between spinal flexion AROM (using a fingertip-to-floor method) and disability (as measured by the Sickness Impact Profile). In an earlier study, Waddell and colleagues$^8$ found that lumbar flexion AROM measurements—obtained using the tape measure method described by Moll and Wright$^9$—were weakly correlated (Pearson $r = .35$) with the Waddell and Main Disability Index. Other studies$^{10–12}$ examining the ROM impairment-to-disability relationship for patients with LBP are summarized in Table 1. All studies summarized in Table 1 used linear models to describe the impairment-disability relationship. No studies were found that used nonlinear models. The data in Table 1 suggest that impairment-disability relationships are generally weak for patients with LBP and that impaired spinal flexion tends to be the spinal impairment most strongly related to disability. In the studies summarized in Table 1, the researchers only reported point estimates for the correlations. Confidence intervals (CIs) were not reported, and it may be that, if interval estimates were reported, they may actually overlap for many of the studies.

We found only one study in which the relationship between impairment and disability change scores following treatment was examined. Deyo and Centor$^{13}$ examined 114 patients with LBP, 80% of whom had symptoms for less than 1 month. The patients’ trunk flexion was assessed using the fingertip-to-floor method, and they completed an RMQ. Scores were obtained at an initial visit and a 3-week follow-up visit. A Pearson $r$ of .29 was

### Table 1.

<table>
<thead>
<tr>
<th>Author</th>
<th>Sample Size and Type</th>
<th>Disability Measure</th>
<th>Range-of-Motion Measure</th>
<th>Correlation ($r$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waddell et al$^5$</td>
<td>120 patients with LBP &gt; 3 mo</td>
<td>Roland-Morris Scale</td>
<td>Single inclinometer total flexion</td>
<td>-.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dual inclinometer lumbar flexion</td>
<td>-.44</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Single inclinometer total extension</td>
<td>-.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Single inclinometer average of right and left lateral flexion</td>
<td>-.35</td>
</tr>
<tr>
<td>Rainville et al$^{11}$</td>
<td>89 patients with LBP &gt; 3 mo</td>
<td>Million Visual Analog Scale</td>
<td>Dual inclinometer lumbar flexion</td>
<td>.37</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Single inclinometer total flexion</td>
<td>.33</td>
</tr>
<tr>
<td>Deyo and Diehl$^6$</td>
<td>80 patients, majority with acute LBP</td>
<td>Sickness Impact Profile</td>
<td>Fingertip-to-floor</td>
<td>.48$^{a}$</td>
</tr>
<tr>
<td>Waddell and Main$^8$</td>
<td>160 patients with LBP &gt; 3 mo</td>
<td>Waddell and Main Disability Index</td>
<td>Tape measure method of Moll and Wright$^9$</td>
<td>.35</td>
</tr>
<tr>
<td>Gronblad et al$^{12}$</td>
<td>55 patients with LBP &gt; 3 mo</td>
<td>Oswestry Disability Questionnaire</td>
<td>Dual inclinometer lumbar flexion</td>
<td>.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Dual inclinometer lumbar extension</td>
<td>-.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tape measure mean of right and left trunk side bending</td>
<td>-.24</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Single inclinometer mean of right and left rotation</td>
<td>.34</td>
</tr>
<tr>
<td>Deyo$^{10}$</td>
<td>129 patients, majority with acute LBP</td>
<td>Sickness Impact Profile</td>
<td>Fingertip-to-floor</td>
<td>.30$^{a}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Roland-Morris Scale</td>
<td></td>
<td>.42$^{a}$</td>
</tr>
</tbody>
</table>

$^a$ Spearman rho ($\rho$).
found for the correlation between the change in spinal flexion and the change in RMQ scores.

Some of the variation in the estimates of the relationship of impairment to disability summarized in Table 1 may be due to the different methods used to measure AROM impairment. There are a variety of methods used to assess lumbar spine flexion AROM. One instrument used to measure lumbar spine flexion AROM is the inclinometer. At least 2 methods of measurement of spinal flexion AROM using an inclinometer have been described. One method, recommended in the American Medical Association’s Guides to the Evaluation of Permanent Impairment, has been criticized because of the lack of substantive normative data that may be used to determine when an impairment of lumbar spine flexion AROM is present. An alternative method for determining lumbar spine flexion AROM has been proposed by Troup and colleagues and was used in our study. A reliability study conducted on a sample of 335 subjects, most of whom were asymptomatic, suggested that measurements obtained with this procedure are reliable (Pearson \( r = .91 \)). One advantage of the method proposed by Troup and colleagues is that a normative database has been developed. The data have been stratified by age and sex, and they can be used to determine whether impairment in lumbar flexion AROM is present in patients with LBP. No evidence was found that indicated the inclinometer method used in our study was valid for inferring the actual amount of flexion in the lumbar spine. Evidence does exist to indicate a dual inclinometer method similar to that used in our study is valid based on comparisons with radiographic measurements. Saur et al found that the Pearson \( r \) correlation between a dual inclinometer technique and a radiographic measure of lumbar flexion was .98 for 54 patients with LBP.

Although a weak linear relationship between lumbar spine flexion AROM and disability has repeatedly been found in heterogeneous groups of patients, physical therapists may still hypothesize that a strong linear relationship between impaired lumbar spine flexion AROM and disability exists for a given patient. We found no studies in the literature that attempted to identify patient characteristics that may influence the impairment-disability relationship.

One approach to identifying subgroups of patients with stronger impairment-disability relationships is to determine whether the therapist concludes that the impairment is clinically relevant. Clinical relevance, in this context, deals with whether the therapist believes the impairment is associated with the disability. We believe many therapists not only look for the presence of impairments, they also make judgments of the clinical relevance of the impairments. For example, if a patient reportedly had difficulty with activities that required sitting and bending forward and the therapist found that the patient’s lumbar flexion was limited and painful during AROM testing, the therapist may conclude that the limited lumbar flexion is strongly associated with the patient’s disability. In this case, the lumbar flexion AROM impairment might be viewed as a clinically relevant impairment. However, if a patient was judged to have limited lumbar flexion AROM, but the patient only had difficulty with walking-related activities, the therapist may conclude that the limited lumbar flexion was not associated with the patient’s disability. In this case, the lumbar flexion AROM impairment would not be considered clinically relevant. We suspected that the linear relationship between lumbar flexion AROM impairment and disability would be stronger for patients judged to have a clinically relevant impairment of lumbar flexion AROM compared with patients whose lumbar flexion AROM measure was judged to be not relevant to their disability.

We also used a normative data approach to assess the lumbar flexion AROM impairment-disability relationship. Because the method used to collect data in this study was identical to the method used by Troup et al and Sullivan et al, we could compare our data with the normative data. Theoretically, patients with more severe limitations in lumbar flexion AROM should demonstrate a stronger impairment-disability relationship than patients whose AROM is judged to be “normal” based on the normative data. We suspected that patients whose lumbar flexion AROM was greater than 1 standard deviation below that of an age- and sex-matched normative sample would have a stronger impairment-disability relationship than patients who were within 1 standard deviation of the mean for the normative data.

The purpose of our study was to assess the relationship between lumbar flexion AROM impairment and disability from 3 perspectives. First, we determined the relationship between lumbar flexion AROM impairment and disability for the entire sample. Second, we compared the impairment-disability relationship for patients judged to have a clinically relevant impairment with that of patients judged not to have a clinically relevant impairment. Third, we compared the impairment-disability relationship for patients judged to have limited lumbar flexion AROM based on normative data with that of patients judged not to have limited flexion AROM. The relationships were examined for measurements of lumbar flexion AROM and disability obtained when patients were admitted to the study and for the change scores derived from measurements obtained at admission and at discharge. We tested several hypotheses:
1. We hypothesized that patients who were judged by the participating therapists to have a clinically relevant loss of lumbar flexion AROM would have a stronger lumbar flexion AROM impairment-disability relationship than patients who were not judged to have a clinically relevant impairment of lumbar flexion AROM. The first hypothesis was tested using the lumbar flexion AROM impairment and disability scores obtained during the patients’ first visit for physical therapy.

2. We hypothesized that the changes in the impairment and disability scores of patients judged to have clinically relevant lumbar flexion AROM impairments would be more strongly correlated than the change in the scores of patients judged not to have a clinically relevant lumbar flexion AROM impairment. We tested this hypothesis by using the change scores derived from admission and discharge measures.

3. We hypothesized that patients with limited lumbar flexion AROM, based on a normative data comparison, would have a stronger impairment-disability relationship than patients who did not have limited lumbar flexion AROM. The third hypothesis was tested using the lumbar flexion AROM impairment and disability scores obtained during the patients’ first visit for physical therapy.

4. We hypothesized that changes in the impairment and disability scores of patients judged to have limited lumbar flexion AROM at admission, based on normative data, would be more strongly correlated than the change in the scores of patients judged not to have limited lumbar flexion AROM impairment. First, we used the flexion AROM measurements obtained at admission to identify 2 groups of patients: those whose AROM was limited and those who did not have limited AROM based on a normative data comparison. Second, the hypothesis was tested by using the change in the admission and disability scores for the 2 groups.

Sample

Subjects. A sample of convenience was chosen by recruiting consecutive patients who met the inclusion criteria at 5 outpatient physical therapy offices (3 facilities were located in Virginia and 2 facilities were located in New York). Inclusion criteria were: patients must be between the ages of 18 and 75 years, patients must be able to read English, and patients must be referred to one of the participating facilities for treatment of LBP with or without sciatica. Low back pain was defined as any pain posterior to the midaxillary line between T12 and the gluteal folds. Sciatica was defined as any lower-extremity pain that was believed to be associated with LBP, as determined by either the referring physician or the physical therapist. Patients with any of the following conditions, as determined by the referring physician, were excluded: spondylolysis, spondylolisthesis, infectious arthritis, spinal tumor, ankylosing spondylitis, or idiopathic scoliosis. Patients who had spinal surgery or who had neurological findings were admitted to the study.

Between June 1994 and March 1995, a total of 116 patients were admitted to this study (Tab. 2). Thirty-five patients, at some point in their rehabilitation, did not return for completion of physical therapy treatment and for follow-up measures. Eighty-one patients were followed from the day of their initial physical therapy evaluation until they were discharged from physical therapy.

Physical therapists. A total of 15 physical therapists (X = 10.2 years of experience, SD = 3 years, range = 2–20 years) participated in this study. Three clinics each employed 2 therapists, 4 therapists worked at 1 clinic, and 5 therapists worked at the fifth clinic. One of the 15 therapists was an orthopedic certified specialist, and all therapists routinely treated patients with orthopedic problems. At the time of the study, all physical therapists worked full time in the participating outpatient orthopedic settings.

Method

Design

This was a pretreatment-posttreatment observational study. Data were collected at 2 points in time: on the day of the initial evaluation and on the day the patient was discharged from physical therapy. We used the discharge data because we believed these data would maximize the variance in change scores. Some patients were likely to change slightly or not at all, whereas others were expected to show large changes in AROM and disability. The mean time between admission and discharge was 51 days (SD = 41 days, range = 2–210 days).
After each patient completed the RMQ, the therapist took the patient history and assessed the patient’s lumbar spine AROM using whatever methods the therapist was accustomed to using. In addition, all therapists completed their examinations using whatever procedures the therapists were accustomed to using. On a form, the therapist identified the procedure(s) used to assess lumbar spine flexion. The therapist was also asked a 2-part yes-no question on the form. The first part of the question was “From your initial examination of this patient, is it your judgment that the patient’s lumbar spine AROM is less than normal?” The second part of the question was “If you answered ‘yes,’ is it your judgment that the patient’s lumbar spine flexion AROM impairment is relevant to the patient’s current LBP and the associated disability?” A response of “yes” to both parts of the question indicated the presence of a clinically relevant impairment of lumbar spine flexion AROM. A response of “no” to either part of the question indicated that a clinically relevant impairment of lumbar spine flexion AROM was not present. The methods used by the therapists to determine whether a clinically relevant impairment of lumbar spine flexion AROM was present are summarized in Table 3.

A total of 36 of the 116 patients were assessed a second time by another physical therapist to determine the intertester reliability of judgments of the clinical relevance of lumbar spine flexion AROM. The second therapist was permitted to collect historical information and any other examination data necessary to make a judgment of clinical relevance. The second therapist was unaware of the rating made by the first therapist. A generalized kappa statistic (κ) was calculated to describe the reliability of judgments of the clinical relevance of impairments of lumbar flexion AROM. The generalized kappa statistic is a coefficient of agreement for nominal measurements that corrects for chance agreement.22 The generalized kappa value for repeated assessments of the relevance of lumbar flexion impairments was .84 (standard error=.11). The 36 patients assessed for intertester reliability were the first 12 patients seen in 3 of the 5 participating clinics.

### Table 2.
Characteristics of the Patients Who Completed the Study and Those Who Did Not Complete the Study

<table>
<thead>
<tr>
<th></th>
<th>Patients Who Completed the Study (n=81)</th>
<th>Patients Who Did Not Complete the Study (n=35)</th>
<th>Value of Statistic (t)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>39.6 ± 12.6</td>
<td>18–70</td>
<td>37.54 ± 10</td>
<td>19–57</td>
</tr>
<tr>
<td>Sex (frequency)</td>
<td>Male: 33</td>
<td>Female: 48</td>
<td>Male: 21</td>
<td>Female: 14</td>
</tr>
<tr>
<td>Pain duration (d)</td>
<td>244.6 ± 579.9</td>
<td>3–3,870</td>
<td>302.5 ± 579.6</td>
<td>2–2,959</td>
</tr>
<tr>
<td>Formal education (y)</td>
<td>13.6 ± 3.5</td>
<td>2–20</td>
<td>13.5 ± 2.7</td>
<td>10–21</td>
</tr>
<tr>
<td>Workers’ compensation (frequency)</td>
<td>Yes: 21</td>
<td>No: 59</td>
<td>Yes: 9</td>
<td>No: 24</td>
</tr>
<tr>
<td>10-cm visual analog pain scale</td>
<td>4.3 ± 2.5</td>
<td>0–9.8</td>
<td>5.1 ± 2.3</td>
<td>1–10</td>
</tr>
<tr>
<td>Flexion AROM measure</td>
<td>15.9 ± 8.9</td>
<td>−3–37</td>
<td>13.2 ± 10.2</td>
<td>−8–43</td>
</tr>
<tr>
<td>RMQ score</td>
<td>10.1 ± 4.6</td>
<td>1–22</td>
<td>12.5 ± 5.5</td>
<td>0–21</td>
</tr>
<tr>
<td>Pain below knee (%)</td>
<td>29.6</td>
<td>28.6</td>
<td>.38</td>
<td>.54</td>
</tr>
</tbody>
</table>

*χ² statistic.

AROM=active range of motion.

RMQ=Roland-Morris Back Pain Questionnaire.

### Table 3.
Examination Methods Used by Physical Therapists to Determine the Presence of Clinically Relevant Impairments of Lumbar Spine Flexion Active Range of Motion

<table>
<thead>
<tr>
<th>Examination Method Used</th>
<th>% of Physical Therapists Indicating Use of Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross movement observation</td>
<td>100</td>
</tr>
<tr>
<td>Movement pattern observation</td>
<td>93</td>
</tr>
<tr>
<td>Correlation of observation with patient history</td>
<td>89.6</td>
</tr>
<tr>
<td>Movement hesitation observation</td>
<td>84.3</td>
</tr>
<tr>
<td>Patient verbalization of pain</td>
<td>79.1</td>
</tr>
<tr>
<td>Segmental movement observation</td>
<td>68.7</td>
</tr>
<tr>
<td>Movement velocity observation</td>
<td>66.1</td>
</tr>
<tr>
<td>Palpation during movement</td>
<td>45.2</td>
</tr>
<tr>
<td>Patient nonverbal expression of pain</td>
<td>44.3</td>
</tr>
<tr>
<td>Application of overpressure</td>
<td>33</td>
</tr>
<tr>
<td>Other</td>
<td>19.1</td>
</tr>
</tbody>
</table>
Following the judgment of clinical relevance, the therapist used a digital inclinometer* that measures angles in 1-degree increments to measure lumbar spine flexion AROM. The inclinometer measurement of lumbar spine flexion AROM was taken according to the procedure described by Sullivan et al.\textsuperscript{17} The patient wore a hospital gown over his or her undergarments. The patient was seated on the edge of a chair with the feet firmly on the floor and the knees spread comfortably apart. The patient was then asked by the therapist to bend at the waist as far forward as was tolerable given the patient’s symptoms. While the patient sat in this position, the examiner found S1 in the following manner: (1) The iliac crests of the patient were palpated, (2) the therapist then found the spinal segment that was intersected by the imaginary line connecting the iliac crests, which was assumed to be the L4–5 motion segment, (3) the examining therapist then counted down 2 spinous processes, placed the upper edge of the inclinometer on S1, positioned the inclinometer so it also rested on S2, and “zeroed” the inclinometer, and (4) the therapist then counted spinous processes up to T12, placed the upper edge of the inclinometer on T12, positioned the inclinometer so it also rested on L1, and recorded the value of flexion.\textsuperscript{17} The participating therapists were given written instructions for taking measurements with the inclinometer and, prior to the start of the study, were allowed to practice this measurement until they were comfortable with the procedure. Therapists were unaware of the RMQ scores when taking either the clinical relevance measurements or the inclinometer measurements. Intratester reliability for the inclinometer of clinical relevance measurements was not assessed because we were unable to control the bias present when testers are aware of scores obtained previously on a patient.

A total of 36 of the 116 patients were reassessed by another physical therapist immediately after the first therapist completed measurements. These were the same 36 patients assessed for the intertester reliability of clinical relevance assessments. The second therapist was unaware of the measurements obtained by the first therapist. The intraclass correlation coefficient (ICC [2,1]) was calculated to describe reliability.\textsuperscript{28} The ICC (2,1) was .75 (95% CI = .56 to .86).

Patients then underwent physical therapy for their LBP. We did not study physical therapy treatments received by these patients. At the time of discharge from physical therapy, patients were asked to complete the RMQ again. At this time, another measurement of lumbar spine flexion AROM was taken with the inclinometer. In most cases, the same therapist took both admission and discharge inclinometer measurements on a patient.

**Data Analysis**

A Pearson $r$ correlation was calculated to describe the association between lumbar flexion AROM and disability scores obtained at admission for the sample with complete data ($n=81$). A Pearson $r$ was also calculated to describe the association between changes in the scores for AROM and disability derived from admission and discharge measures.

For each hypothesis, Pearson $r$ correlations were calculated for the subgroups of patients identified in each hypothesis. A Fisher’s $Z$ transformation statistic\textsuperscript{24} was used to determine whether the relationship between disability and impairment was stronger for the subgroup of patients identified in each hypothesis. Using the Bonferroni procedure, the 1-tailed alpha level was set at .01 so that the Fisher’s $Z$ test could correct for multiple comparisons.\textsuperscript{25}

**Results**

The correlation ($r$) between the inclinometer measurements of lumbar spine flexion AROM and RMQ disability scores was $-.25$ (95% CI = $-.44$ to $-.03$). The correlation was negative because, as AROM increased, the RMQ scores tended to decrease. The correlation ($r$) between lumbar spine flexion and RMQ change scores was $.35$ (95% CI = $+.14$ to $+.33$). Change scores were derived by subtracting AROM scores at admission (usually the smaller number) from AROM scores at discharge. Disability change scores were derived by subtracting the discharge score (usually the smaller number) from the admission score.

For hypothesis 1, the correlation ($r$) between lumbar spine flexion AROM impairment and disability for patients judged to have a clinically relevant impairment ($n=63$) was $-.11$ (95% CI = $-.15$ to $+.1$). The correlation ($r$) between lumbar spine flexion AROM and disability for patients judged not to have a clinically relevant impairment ($n=18$) was $-.39$ (95% CI = $-.68$ to $+.01$).

For hypothesis 2, the correlation ($r$) between lumbar spine flexion AROM change scores and disability change scores for patients judged to have a clinically relevant impairment ($n=63$) was $+.36$ (95% CI = $+.16$ to $+.53$). The correlation ($r$) between lumbar spine flexion AROM change scores and disability change scores for patients judged not to have a clinically relevant impairment ($n=18$) was $+.19$ (95% CI = $-.23$ to $+.55$).

For hypothesis 3, the correlation ($r$) between lumbar spine flexion AROM measures and RMQ disability measures for patients who had limited AROM based on

\* The Saunders Group, 4250 Norex Dr, Chaska, MN 55318.
normative data (n=38) was .05 (95% CI= -.22 to .33). The correlation (r) between lumbar spine flexion AROM measures and disability measures for patients whose AROM was not limited based on normative data (n=43) was -.26 (95% CI= -.48 to 0).

For hypothesis 4, the correlation (r) between lumbar spine flexion AROM change scores and disability change scores for patients who had limited AROM at admission, based on normative data (n=38), was .14 (95% CI= -.14 to .40). The correlation (r) between lumbar spine flexion AROM change scores and disability change scores for patients who did not have limited AROM at admission, based on normative data (n=43), was .19 (95% CI= -.06 to .42). All comparisons tested for the 4 hypotheses were not statistically significant (P>.01).

**Discussion**

We were surprised to find that none of our hypotheses were supported. The size of the linear relationship between flexion AROM impairment and disability in patients with LBP was not influenced by therapists’ belief that the limited flexion is an important contributor to the patient’s disability or that the motion is truly limited based on a normative data comparison. These data provide further support for the notion that therapists should measure both AROM and disability in patients with LBP. One measure is clearly not a surrogate for the other. Therapists interested in documenting changes in a patient’s disability with treatment should probably not restrict their observations to changes in the patient’s AROM impairments.

We did not conduct a power analysis prior to the study. We had no evidence to estimate the effects of the clinical relevance or true motion limitation judgments on the impairment-disability relationship. In an a posteriori analysis, we calculated the power for the data collected for hypothesis 2 (comparison of coefficients for change scores of patients who either had or did not have a clinically relevant impairment of lumbar flexion). We calculated power for this hypothesis because the magnitude of the coefficients was consistent with our hypothesis. That is, the Pearson correlation coefficient for the patients with a clinically relevant impairment was larger than for the patients who did not have a clinically relevant lumbar flexion impairment. For hypotheses 1 and 3, the group we speculated would have the larger Pearson correlation coefficient (patients with clinically relevant impairments for hypothesis 1 and patients with limited AROM based on a normative data comparison for hypothesis 3) actually had a smaller Pearson correlation coefficient than did the comparison group. The power for hypothesis 2 was 20%, and approximately 360 patients per group would have been needed to detect a difference among the 2 groups. We did not have an adequate sample size to detect statistically significant differences in impairment-disability correlations among the groups examined. However, given the CIs for most correlations in the study, we do not believe another study with a larger sample size is warranted. In most cases, the CIs for the correlation coefficients suggest that, at best, lumbar flexion measures explain only about 20% of the variance in disability. Given our results, it does not appear that a larger sample would have an appreciable impact on the clinical importance of the results.

Data obtained by Jette et al4 indicate that therapists frequently establish treatment goals of increasing a patient’s spinal ROM. Presumably, therapists believe that changes in AROM represent clinically meaningful changes. Our study suggests that changes in lumbar flexion AROM are only weakly associated (or in some cases, not associated at all) with changes in disability. Therefore, therapists should not assume that impairment and disability are strongly linked either at admission or during treatment. To further examine the impairment-disability relationship, we conducted an a posteriori analysis of the relationship between lumbar flexion AROM and RMQ disability measurements obtained at discharge. The measurements were not normally distributed, so we used a Spearman rho correlation (ρ) and found that flexion AROM and disability are also not correlated at discharge (estimated ρ=.08).

The relationship between lumbar flexion AROM impairment and disability found in this study was generally slightly weaker than the relationships reported in the literature and summarized in Table 1. The most likely explanation for this weaker relationship is the somewhat lower reliability found for our method of measuring lumbar flexion. Other authors5-26 have reported intertester reliability coefficients (ICC [1,1]) on the order of .9 or higher for flexion measurements used in the studies summarized in Table 1. Our intertester reliability was .75, suggesting that a somewhat larger amount of error was present in our measurements compared with those of other studies. This extra error may have contributed to the somewhat low correlations between lumbar flexion AROM impairment and disability as compared with correlations for other measures reported in the literature.

A strength of our method of measuring lumbar spine flexion AROM was that it allowed us to compare our data with a database of over 1,000 asymptomatic subjects grouped by age and sex. This is the first study that we are aware of that has used normative data to examine impairment-disability relationships in patients with LBP. The results were disappointing. Patients with limited lumbar flexion AROM, based on a normative data compar-
ison, did not have a stronger impairment-disability relationship than patients whose AROM was not limited. We found there was essentially no relationship between impairment and disability (Pearson $r = .05$) in patients with limited lumbar spine flexion ($n = 38$). This low correlation may have been due, in part, to a truncated range in the measurements for patients who had greater than a one-standard deviation limitation in motion compared with the database. A truncated range in the measurements would lead to a smaller variance and deflated coefficients. The AROM of patients whose motion was judged to be limited based on the normative data ranged from $-3$ degrees to $17$ degrees (range $= 20^\circ$). The AROM of patients whose motion was judged to be normal based on normative data ranged from $15$ to $37$ degrees (range $= 22^\circ$). The RMQ scores were also fairly evenly distributed across the possible range of scores. Truncated AROM or RMQ scores are not likely to be an explanation for the very low correlation between AROM impairment and disability in patients with limited motion.

Another factor that could explain the low correlations between impairment and disability was that the relationship may be better explained with a nonlinear model. We did not find any literature that examined whether a nonlinear model could better explain the impairment-disability relationship in patients with LBP as compared with a linear model. Literature exists to support the contention that nonlinear models may better explain impairment and disability relationships for some conditions. In an a posteriori analysis, we used SPSS 7.5 to calculate curve estimations for several nonlinear models. We tested quadratic, cubic, compound, growth, exponential, and logistic nonlinear models. We calculated $r^2$ and conducted F tests on the models for the entire sample and for the groups of patients judged to either have or not have a clinically relevant lumbar spine flexion impairment. We also assessed nonlinear relationships for the groups of patients with either limited or normal AROM based on the normative data comparison. In all cases, the F test value was essentially the same or greater for the linear model compared with the other models tested. In some cases, the $r^2$ value increased slightly for some nonlinear models but not without a reduction in the F test value. We found no evidence to indicate that nonlinear models explain more variance, but we were limited by a relatively small sample.

There are notable limitations to this study. Our determinant for a clinically relevant impairment of lumbar spine flexion AROM was not examined for validity. We do not know, for example, whether those patients judged to have a clinically relevant impairment of flexion were substantively different from patients judged not to have a clinically relevant impairment. We were able to determine whether the flexion AROM measurements obtained from the 2 groups were different. We conducted an a posteriori analysis to determine whether the lumbar flexion AROM of the patients judged to have a clinically relevant impairment was significantly different from that of patients judged not to have a clinically relevant impairment. The mean AROM for patients judged to have clinically relevant AROM limitations was $14.7$ degrees, whereas the AROM for patients who did not have a clinically relevant impairment was $20.4$ degrees. A t test comparing the 2 means was statistically significant ($t_{78} = 2.4, P = .02$). The t test results suggest that the 2 groups are different in the amount of lumbar spine motion present; however, we have no other data to support the usefulness of the clinical relevance measure. We believe, however, that therapists frequently make similar judgments in clinical practice and use the data for decision making.

Another limitation was the small sample size. The subgroup of patients judged not to have a clinically relevant flexion impairment, for example, consisted of only 18 patients. The correlation coefficients were likely influenced by the small sample size. Future research should examine larger samples of patients. The study is also limited by the use of the dual inclinometer procedure proposed by Troup and colleagues. We believe that this procedure is probably not commonly used in clinical situations, and the results may not apply to flexion AROM measurements obtained using other methods.

We did not look at the influence that patient demographic variables (eg, height, weight, sex) may have on the impairment-disability relationship. The literature reviewed in Table 1 did not assess the influence of other variables on the impairment-disability relationship, and we believed that, to make valid comparisons to the work of others, it was important to look at the impairment-disability relationship in isolation. In an a posteriori analysis, we conducted 2 multiple regression analyses to determine whether the impairment-disability relationship changed when we controlled for the effects of age, sex, height, and weight in the models. We conducted an analysis using admission scores and one using change scores for the entire sample ($n = 81$). For scores obtained at admission, flexion AROM impairment measurements explained only $1\%$ of the variance in disability when age, height, weight, and sex were controlled. When demographic variables were not controlled, flexion AROM explained $6\%$ of the variance ($r = .25$) in disability. For change scores, flexion AROM impairment measurements explained $9\%$ of the variance in disability when age, height, weight, and sex were controlled. When these demographic variables were not controlled, the change
in flexion AROM impairment explained 12% of the variance (r=.35) in disability change scores. Lumbar flexion AROM impairment explains a very small percentage of the variance in disability, and this small amount of explained variance becomes even smaller when controlling for patient height, weight, age, and sex.

We examined the relationship between a single impairment—lumbar flexion AROM—and disability. We chose this impairment measure because we believe it is the most commonly assessed AROM for patients with LBP and it is the AROM impairment that is generally most closely related to disability (Tab. 1). Waddell et al.5 examined the relationship between multiple impairment measures and disability in a sample of 120 patients with chronic LBP. They found that, when a combination of impairment measures (lumbar flexion, trunk flexion, extension, lateral flexion, straight leg raise, tenderness to palpation, and a sit-up procedure) were examined in a multiple regression analysis, only trunk flexion and a palpation assessment were included in the model. The authors found that they were able to explain 30% of the variance in disability with trunk flexion and palpation measures. The authors did not control for other factors that may influence disability such as age and sex nor did they report use of nonlinear models.

Future research in the area of impairment and disability relationships should focus on identifying other determinants of disability in people with LBP. Our results and the results of other studies5,6,9,10 indicate that physical impairments alone explain only a small percentage of the variance in disability associated with LBP. A model of LBP that includes biological, psychological, and social factors has been proposed.30 Physical therapists may benefit by investigating these factors together as potential determinants of and changes in disability.

Comparison of Patients Completing the Study With Those Lost to Follow-up

The demographic variables and impairment and disability measurements among study participants (n=81) and those lost to follow-up (n=35) were compared to determine whether there is evidence of sample bias. Continuous variables were compared using an independent t test with Bonferroni correction for multiple comparisons.25 Frequency counts of dichotomous variables were compared by the use of a chi-square analysis. A 2-tailed test of significance was used for the chi-square analyses with α=.01.

Table 2 describes the patients who were lost to follow-up and compares demographic and other selected data obtained from these patients with data obtained from the patients who completed the study. There were no significant differences between the study participants and those lost to follow-up for the 9 measures examined. We found no evidence of sample bias or clinically important differences among the 2 groups of subjects in the study. We did not examine the statistical power of these comparisons. There was a higher proportion of male subjects who did not complete the study, but the meaningfulness of this finding is not clear.

Conclusion

The relationship between flexion AROM impairment and disability in patients with LBP is weak. A weak impairment-disability relationship exists for scores obtained at admission, for change scores derived from admission and discharge measures, and for discharge measures. We were unable to identify subgroups of patients that, theoretically, should have had a stronger impairment-disability relationship. These data suggest that therapists should measure both impairment and disability when examining and treating patients with LBP. Impairment and disability measures should not serve as surrogate measures for each other. These data also call into question the use of lumbar flexion AROM measures as treatment goals when the goal of treatment is to resolve functional limitation and disability.

References

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