Effects of a Single Session of Posterior-to-Anterior Spinal Mobilization and Press-up Exercise on Pain Response and Lumbar Spine Extension in People With Nonspecific Low Back Pain

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Background and Purpose

Posterior-to-anterior (PA) mobilization and press-up exercises are common physical therapy interventions used to treat low back pain. The purpose of this study was to examine the immediate effects of PA mobilization and a press-up exercise on pain with standing extension and lumbar extension in people with nonspecific low back pain.

Subjects

The study participants were 30 adults (19 women and 11 men) who were 18 to 45 years of age and had a diagnosis of nonspecific low back pain.

Methods

Lumbar segmental extension during a press-up maneuver was measured by dynamic magnetic resonance imaging prior to and immediately following a single session of either PA spinal mobilization or a press-up exercise. Pain scores before and after intervention were recorded with a visual analog scale. Differences between the treatment groups in pain and total lumbar extension were compared over time by use of a 2-way analysis of variance.

Results

Following both interventions, there was a significant reduction in the average pain scores for both groups (significant main effect for time, no interaction). Similarly, total lumbar extension significantly increased in both the PA mobilization group and the press-up group (significant main effect for time, no interaction). No significant differences between the 2 interventions in pain or lumbar extension were found.

Discussion and Conclusion

The findings of this study support the use of PA mobilization and a press-up exercise for improving lumbar extension in people with nonspecific low back pain. Although statistically significant within-group changes in pain were detected, the clinical meaningfulness of these changes is questionable.

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Approximately 12% to 33% of the adult workforce is affected by low back pain each year, and it has been suggested that 70% to 95% of adults will have low back pain at some time during their lives.[1–6] The California Board of Worker Compensation ranks low back pain (and other, related ICD-9 diagnoses) as the primary reason for missed workdays and restricted-activity days.[7] Unlike the expenses associated with the management of other orthopedic disorders, the expenses associated with the management of back pain have increased over the last 20 to 30 years.[2,3,8]

People who report low back pain often have reduced spinal motion.[9–11] When motion is limited, spinal extension is frequently more restricted than flexion.[10,12] Reduced spinal extension can be the result of pain or stiffness and can be classified as being either general (ie, total spine) or segmental (ie, one vertebral level).[9–11,13,14] Spinal mobilization techniques and range-of-motion exercises often are prescribed by physical therapists in an attempt to improve lumbar extension and ultimately reduce low back pain.[15–17]

Two commonly used methods for improving spinal extension are passive segmental mobilization and press-up exercises. Maitland et al[18] advocated the use of a segment-specific approach (ie, posterior-to-anterior [PA] mobilization), in which the intervention is focused on the specific vertebral levels that demonstrate restricted motion. In contrast, McKenzie and May[19] advocated a more general approach, in which a press-up exercise is used as a means of decreasing pain and increasing spinal motion.

A review of the literature revealed only 2 studies that have reported on the effects of PA mobilization on pain intensity and lumbar extension in people with nonspecific low back pain.[20,21] Although both of these investigations reported a reduction in pain following the mobilization procedure, neither study found that PA mobilization had an influence on lumbar extension. Similarly, the use of a press-up exercise has been shown to decrease symptoms in people with nonspecific low back pain in a number of studies.[22–25] Of these studies, only 2 quantified lumbar extension range of motion[22,24]; however, these authors did not report an increase in motion following the press-up exercise.

One possible explanation for the lack of significant findings with respect to changes in lumbar extension following PA mobilization or press-up exercises may be related to the fact that the methods used to quantify spinal motion (ie, double inclinometers and an electromagnetic tracking system) were not sensitive enough to detect subtle, but perhaps clinically meaningful, changes in motion. Recently, we reported on the use of dynamic magnetic resonance imaging (MRI) to quantify segmental motion of the lumbar spine during a PA force application.[26–28] This modality appears to have an advantage over more conventional means of measuring spinal mobility because segmental motion can be assessed more precisely without the errors typically associated with skin movement and soft tissue bulk.

The purpose of this study was to assess the immediate effects of a single session of PA spinal mobilization and a press-up exercise on pain with standing extension and lumbar segmental extension (as quantified by dynamic imaging techniques) in people with low back pain. We sought to examine the immediate effects of each intervention because both Maitland et al[18] and McKenzie and May[19] advocated postintervention assessments to detect changes in pain and spinal motion. In addition, immediate changes in pain and motion have been shown to predict intervention outcomes.[29] We hypothesized that both interventions would be effective in reducing pain and increasing lumbar extension in people with nonspecific low back pain.

Method

Subjects

Thirty people (19 women and 11 men) who were 18 to 45 years of age and had a diagnosis of nonspecific low back pain participated in this study. People over the age of 45 years were excluded to control for the possible confounding effects of spine osteoarthritis. The number of subjects recruited was based on an *a priori* sample size calculation (see below).

Subjects were recruited from the Department of Physical Medicine and Rehabilitation and the Outpatient Physical Therapy Clinic at Stanford University Medical Center. Only people who reported a recent onset of low back pain (duration of <3 months) and the following signs and symptoms were admitted: localized low back pain at or above the waist level, decreased lumbar extension (assessed qualitatively while standing), and increased localized pain with lumbar extension during standing. The primary exclusion criteria were: spinal malignancy, cardiovascular disease, evidence of cord compression, aortic aneurysm, hiatal hernia, uncontrolled hypertension, spinal infection, severe respiratory disease, pregnancy, abdominal hernia, prior low back surgery, gross spinal deformity, spondylolisthesis, known rheumatic joint disease, and implanted devices that could interact with the magnetic field (eg, pacemakers, cochlear implants, or ferromagnetic cerebral aneurysm clips). In addition to these exclusion criteria, subjects were screened for any clinical evidence of lumbar disk pa-

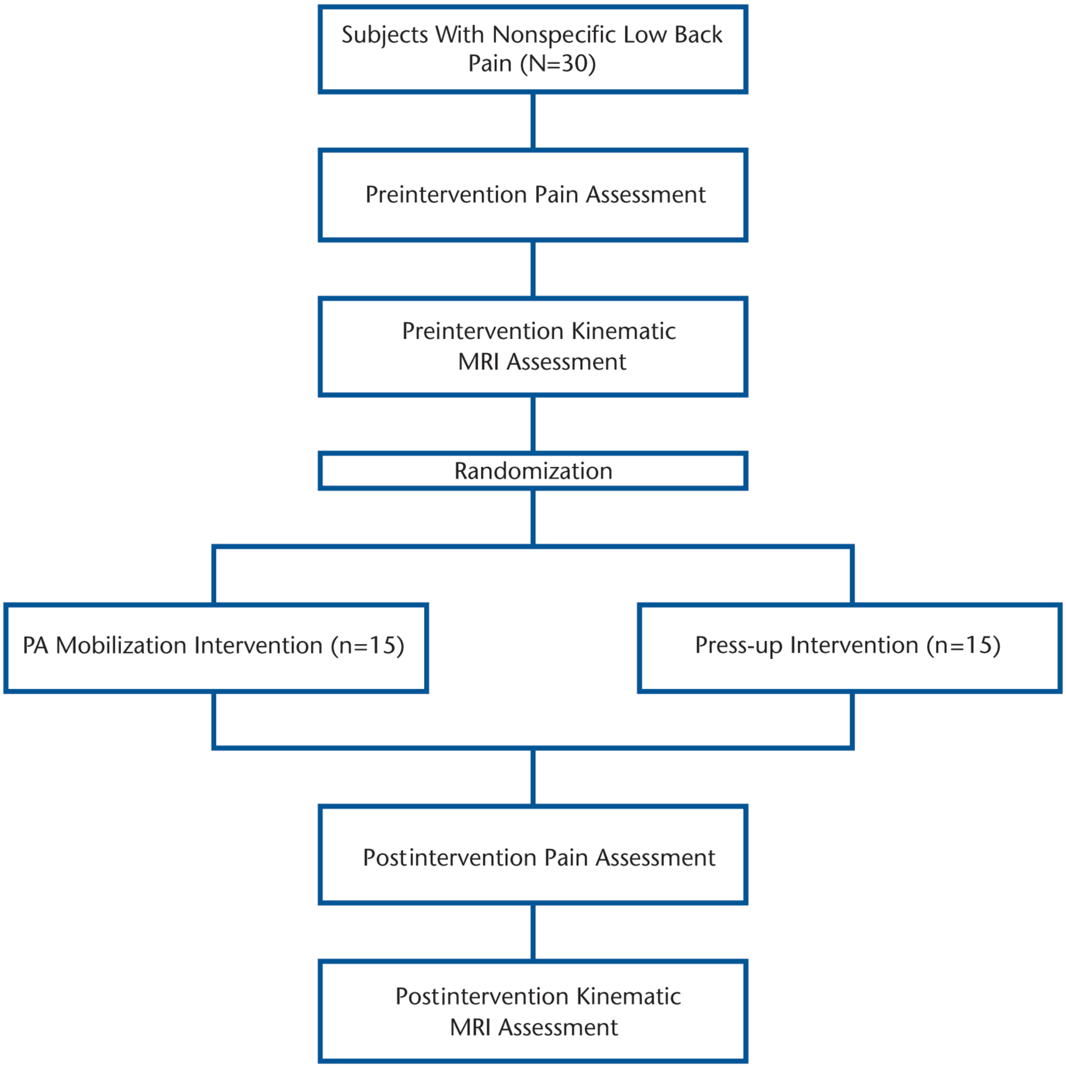

Figure 1.
Flow diagram summarizing study design. MRI=magnetic resonance imaging, PA=posterior to anterior.

thology. Therefore, subjects who demonstrated any of the following were excluded: radiating pain below the level of the buttocks; sensation changes in the lower extremities; diminished reflexes; lower-extremity weakness, neurological signs, or both; urinary or fecal incontinence; and increased peripheral pain with repeated lumbar extension.

All subjects were referred for the study by the same physician. As part of the routine examination process, subjects were screened through history, physical examination, and standard anterior-posterior, lateral, and oblique radiographs. Although disk pathology cannot be definitively diagnosed through physical examination or radiographs, subjects with disk herniation observed during MRI were dropped from the study and referred back to the physician for additional follow-up.

Instrumentation

As described in previous publications,[26–28] dynamic imaging of the lumbar spine was performed with a vertically opened (double-donut design) MRI system (0.5 T; Signa SP*). This system was equipped with a pulse sequence programming environment and real-time interactive MRI capability. Sagittal-plane imaging of the spine was performed with a receive-only surface coil and an ultrafast spoiled GRASS (gradient-recalled acquisition in the steady state) pulse sequence. Images were obtained at a rate of one per second with the following parameters: repetition time, 200 milliseconds; echo

* General Electric Medical Systems, 2421 N Fairview Rd, Milwaukee, WI 53226.

time, 18 milliseconds; number of excitations, 1.0; matrix, 256×256; field of view, 28×21 cm; and a 7-mm section thickness with an interslice spacing of 1 mm. The surface coil was flexible so as not to limit spinal motion during the press-up maneuver.

Procedure

A flow diagram of the study design is shown in Figure 1. Subjects participated in pretreatment pain and MRI assessments, an intervention session, and then posttreatment pain and MRI assessments. Prior to participation, all procedures were explained to each subject, and informed consent was obtained. Subjects signed a human subject consent form approved by the institutional review boards of Stanford University and the University of Southern California.

Pretreatment pain and MRI assessments. Prior to the pretreatment MRI assessment, each subject's initial pain level was assessed. Subjects were asked to stand, bend backward with their hands on their hips, and rate their low back pain with a visual analog scale.

In the pretreatment MRI assessment, sagittal-plane images of the lumbar spine were obtained with subjects at rest and performing a press-up maneuver. Subjects were placed on a sliding table in the prone position with a pillow under the abdomen. The sliding table was situated such that the spine and torso were within the opening of the MRI system. The surface coil was secured to the lumbar region with adhesive straps.

Following subject positioning within the MRI system, a series of sagittal-plane "localizers" were obtained to ensure that the image plane captured the vertebral bodies of all lumbar vertebrae. Once the image plane was determined, a static sagittal view of the lumbar spine was obtained in the resting position.

Table 1.
Characteristics of the Study Participants in Each of the Intervention Groups

Characteristic	$\overline{X}$±SD for the Following Group:		P
	PA Mobilization (n=15; 8 Women, 7 Men)	Press-up (n=15; 11 Women, 4 Men)	
Age (y)	30.2±7.9	32.3±9.6	.523
Height (cm)	175.7±11.3	171.2±8.4	.224
Weight (kg)	71.6±14.5	68.1±12.3	.477
Body mass index (kg/m²)	23.0±3.0	23.3±4.0	.846

Each subject then performed a single press-up (to the subject's self-determined end range) and held the position for 3 seconds. A sagittal-plane image of the spine was obtained in the end-range position.

Intervention. Once the pretreatment pain and MRI evaluations were completed, each subject was randomly assigned to either a passive segmental mobilization (PA mobilization) group or an exercise (press-up) group. Both interventions were administered by a physical therapist with 18 years of manual therapy experience and certification as an Orthopaedic Clinical Specialist by the American Board of Physical Therapy Specialties. This investigator (RFL) was unaware of the findings of the baseline MRI and pain ratings.

Subjects assigned to the PA mobilization group (n=15; Tab. 1) were treated with the methods described by Maitland et al.[18] The premise behind this approach is that treatment should be focused on the specific lumbar segments that demonstrate restricted movement and in which pain is reproduced upon graded movements.[30–33] It is believed that the motion of the entire lumbar spine should improve when motion in the most limited or painful segment is increased.

The subject's position for the mobilization intervention was prone on a treatment table with a small pillow under the abdomen. First, the investigator applied PA pressure to the spinous process of each lumbar vertebra using 1 or 2 small-amplitude movements (grade I).[18] For each level, subjects were asked to report whether they perceived discomfort similar to that experienced while bending backward during standing. If the subjects did not report any discomfort from the pressure at a particular vertebral level, then the investigator proceeded to the next higher grade of movement, using slightly larger amplitudes (grades II–IV).[18] Once the vertebral level at which the pressure reproducing lumbar discomfort with standing extension was identified, the intervention commenced.

Initially, the PA mobilization intervention consisted of graded oscillations applied to the most painful lumbar segment. Three bouts of 40-second oscillations were applied to this segment at a rate of approximately 1 to 2 Hz and at the highest amplitude tolerated without the reproduction of symptoms. Following mobilization of the most painful segment, 2 bouts of 40-second oscillations (up to grade IV but short of symptom reproduction)[18] were administered to each of the remaining lumbar vertebral levels. The total time for the PA mobilization intervention was approximately 10 minutes.

Of the 15 people treated, 4 reported pain at L5, 5 reported pain at L4, 2

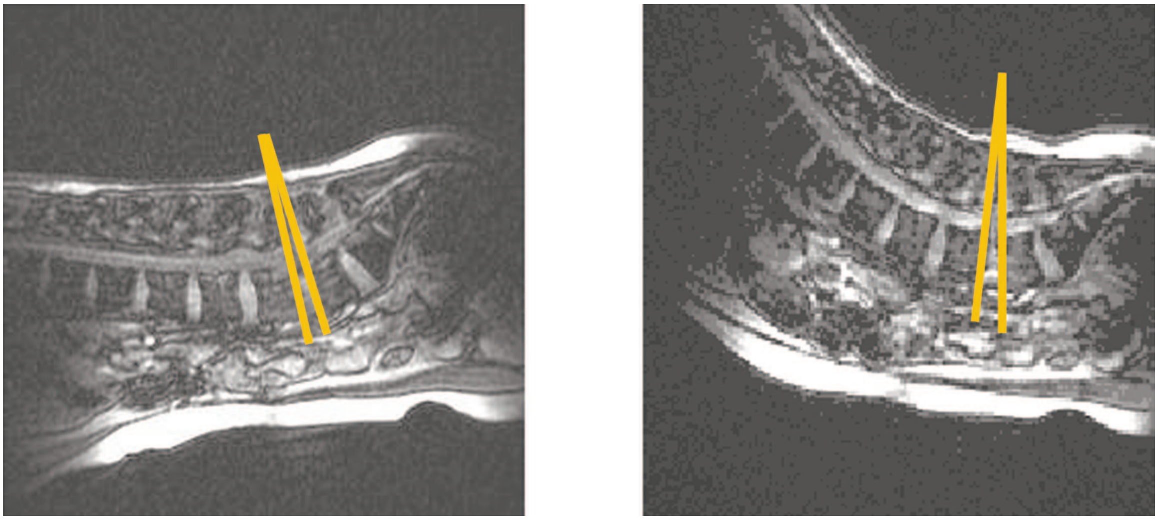

Figure 2.
From the images of the press-up assessment, the intervertebral angle was measured as the angle formed by lines defining the end-plates of adjacent vertebrae during the press-up assessment. Intersegmental lumbar motion was defined as the difference between the intervertebral angle measured in the resting position (left) and the intervertebral angle measured on the end-range image (right).

reported pain at L3, and 1 reported pain at L2. Pain could not be localized to 1 segment in one subject, so each of the 5 lumbar segments was mobilized with 2 bouts of 40-second oscillations (grade IV).[18] The treated levels were not recorded in 2 subjects. Following the intervention, the subjects were asked to rate their pain with the procedure described for the preintervention assessment.

Subjects assigned to the press-up group (n=15; Tab. 1) were treated with the methods described by McKenzie and May.[19] As part of this intervention, subjects were asked to perform a press-up maneuver as far as possible without reproducing lumbar pain with standing extension.

The subject's initial position was the same as that used during MRI (ie, prone on a treatment table). In brief, the subject used the arms to press the top half of the body upward into spinal extension, while the pelvis was allowed to sag with gravity and remain on the treatment table. The subject was instructed to move from the prone position to maximum pain-free lumbar extension over the course of 5 seconds. The end-range position was held for 5 seconds before the subject returned to the starting position. A total of 10 repetitions were performed. During each repetition, the subject was encouraged to move slightly higher, within the limits of discomfort. If, at the completion of the 10 repetitions, the subject's level of pain was the same or lower, a second and third series of press-up maneuvers were performed. All subjects were able to successfully complete 30 repetitions. Each subject's treatment time was approximately 10 minutes.

Posttreatment pain and MRI assessments. Immediately following the intervention, pain and MRI assessments were repeated with the same procedures as those described above. The investigator coordinating the MRI assessment was unaware of each subject's treatment group assignment.

Image Analysis

Prior to analysis, all images were transferred from the MRI system console to a Macintosh G3 computer.[†] For the purposes of this study, only the images containing the vertebral segments at rest and at the end range of the press-up maneuver were analyzed.

Sagittal-plane intervertebral angles (lumbar spine) were measured with National Institutes of Health Image software.[‡] The intervertebral angle was measured as the angle formed by lines defining the end-plates of adjacent vertebrae (Fig. 2). Segmental lumbar motion (ie, extension) was defined as the difference between the intervertebral angles measured on the resting and end-range images (Fig. 2).

Because it was not possible to replicate the exact resting position of the lumbar spine for the posttreatment MRI assessment, the pretreatment resting position was used to calculate motion during both pretreatment and posttreatment assessments. Therefore, the change in

[†] Apple, 1 Infinite Loop, Cupertino, CA 95014.
[‡] National Institutes of Health, 900 Rockville Pike, Bethesda, MD 20892.

Table 2.
Pain Scores

Group or Parameter	Pain Score, $\bar{X}$±SD		Average Change
	Before Intervention	After Intervention	
PA mobilization	4.1±1.7	2.4±1.8	1.7±2.1
Press-up	4.0±2.1	2.8±1.5	1.2±1.4
Collapsed group average	4.0±1.9	2.6±1.7[a]	1.4±1.8

[a] Significant main effect for time ($P<.001$).

Table 3.
Total Lumbar Extension

Group or Parameter	Total Lumbar Extension (°), $\bar{X}$±SD		Average Change
	Before Intervention	After Intervention	
PA mobilization	20.2±5.2	23.8±6.5	3.6±5.0
Press-up	22.2±3.9	24.9±6.0	2.7±5.1
Collapsed group average	21.2±4.7	24.3±6.1[a]	3.1±4.9

[a] Significant main effect for time ($P=.004$).

segmental extension following the intervention was defined as follows: (posttreatment end-range vertebral angle − pretreatment resting vertebral angle) − (pretreatment end-range vertebral angle − pretreatment resting vertebral angle).

As calculated with this equation, a positive value indicated an increase in extension for a particular functional spinal unit, whereas a negative value indicated a decrease in extension. Total lumbar extension was quantified by summing the intervertebral motion at each of the 5 functional units of the lumbar spine. The investigator doing all image analysis was unaware of each subject's treatment group assignment.

Measurement reliability. To establish the intratester reliability of the proposed measurements, dynamic MR images were obtained from 5 volunteers who were healthy on 2 separate occasions (1 week apart). Intraclass correlation coefficients were found to be excellent, ranging from .95 to .99 for all subjects. The standard error of measurement ranged from 0.40 to 0.66 degrees.

Determination of statistical power. Data from a previous publication[28] indicated that the intersubject variability with respect to intersegmental motion in people who were healthy was moderate. However, it was anticipated that the variability in the tested population would be 50% greater. Therefore, all power calculations took this increased variability into consideration. Furthermore, all power calculations were based on an alpha level of .05 for a one-tailed test. Given 15 subjects per treatment group, the chances of detecting a 25% decrease in pain response and a 25% increase in lumbar segmental extension were 85% and 98%, respectively, for both interventions.

Data Analysis

Differences between the treatment groups in pain and total lumbar extension were compared over time by use of a 2×2 analysis of variance (ANOVA) (group × time) with repeated measures. If significant interactions were observed, then the individual main effects were considered separately. Statistical analyses were performed with SPSS software, version 11.0.[§] All significance levels were set at $P<.05$.

Results

The ANOVA results for average pain scores revealed a significant main effect for time ($F=23.274$; $df=1,14$; $P<.001$; Tab. 2). When averaged across both treatment groups, average pain scores (SD) were lower after intervention than before intervention (2.6±1.7 versus 4.0±1.9). No significant group effect or group × time interaction was observed. On average, subjects in the PA mobilization group reported a posttreatment pain score of 2.4±1.8, which did not differ significantly from the posttreatment pain score of 2.8±1.5 reported by subjects in the press-up group.

The ANOVA results for average total lumbar extension revealed a significant main effect for time ($F=11.764$; $df=1,14$; $P=.004$; Tab. 3). When averaged across both treatment groups, average lumbar extension was greater after intervention than before intervention (24.3°±6.1° versus 21.2°±4.7°). No significant group effect or group × time interaction was observed. On average, subjects in the PA mobilization group demonstrated 23.8±6.5 degrees of lumbar extension, which did not differ significantly from the posttreatment lumbar extension of 24.9±6.0 demonstrated by subjects in the press-up group.

Discussion

Spinal mobilization and press-up exercises are common interventions used by physical therapists to decrease back pain and increase lumbar motion. The results of the present study found both interven-

[§] SPSS Inc, 233 S Wacker Dr, Chicago, IL 60606.

tions to be equally effective in reducing pain with standing extension and increasing lumbar extension following a single treatment session. On average, subjects reported a 41% reduction in pain following PA mobilization and a 30% reduction in pain following the press-up exercise. The pain reduction achieved following both interventions (PA mobilization=1.7±2.1; press-up exercise=1.2±1.4) was statistically significant, but the clinical meaningfulness of these changes is questionable.[34]

The 41% reduction in pain following lumbar PA mobilization in the present study is consistent with that reported in previous investigations.[20,21] For example, Chiradejnant et al[20] reported a 36% reduction in pain following two 1-minute bouts of spinal mobilization in subjects with nonspecific low back pain. Goodsell et al[21] also studied the effects of PA mobilization on nonspecific low back pain and reported an average pain reduction of 33%. The 30% reduction in pain following the press-up intervention in the present investigation is slightly below the range reported previously (33%–88%).[22–25] However, this difference is likely attributable to the fact that the subjects in previous studies performed press-up exercises over multiple sessions and the follow-up time for pain reassessment ranged from 2 to 6 weeks following the initiation of treatment.

On average, total lumbar extension motion increased 3.6 degrees following PA mobilization and 2.7 degrees following the press-up exercise. Although these changes are statistically significant, the clinical relevance of such small changes in motion is questionable. However, when viewed as a percent change in lumbar extension, respective gains of 17.8% and 11.7% with PA mobilization and the press-up exercise were observed. This finding is in contrast to those of Chiradejnant et al[20] and Goodsell et al,[21] who did not find a significant increase in extension following PA mobilization. Our results support the work of McCollam and Benson,[35] who reported a 7.1% increase in lumbar extension, as measured with 2 fluid-based inclinometers. However, there are several important differences between the study of McCollam and Benson[35] and the present study. First, in the former study, PA mobilization was applied to an asymptomatic population. Second, in the former study, the intervention consisted of three 1-minute bouts of PA mobilization applied to L3, L4, and L5 (9 minutes total). In contrast, subjects in the present study typically received 2 minutes of PA mobilization at one vertebral level.

The effects of the press-up intervention on spinal extension in the present study differed from those in previous investigations.[22,24] Using a magnetic tracking device, Elnaggar et al[22] found no changes in total lumbar sagittal-plane motion following a press-up exercise. Separate measurements of spinal extension were not reported. Because magnetic tracking systems detect spinal motion via sensors attached to the skin overlying the spinous processes, the reliance on surface contact to detect angular displacement and the sliding of skin over the spinous processes may have prevented the detection of changes in angular motion.

Although our study did not address the mechanism by which pain and motion were influenced by the 2 interventions, it is interesting to consider what changes may have occurred during both treatment procedures. Both mechanical and neurophysiological mechanisms have been described to explain pain reduction and improved mobility following joint motion or mobilization, and it is conceivable that both mechanisms played a role in the findings of the present study. For example, passive motion has been reported to selectively stretch contracted tissues without damaging healthy adjacent tissues.[1] In addition, repetitive movements are thought to distribute synovial fluid over the articular cartilage and disk, resulting in less resistance to motion.[36] With less resistance to motion, subjects may have felt free to move and thus may have experienced less pain.

In addition to the mechanical explanation as to how mobilization and exercise may influence pain and motion, recent studies have suggested a neurophysiological explanation. For example, dorsal horn activation (as measured with functional MRI) from a painful stimulus has been shown to decrease following joint mobilization.[37] This finding could explain the observations of several authors who have reported that passive movements applied to either the spine[38,39] or the extremities[40–42] elevated pain thresholds to various mechanical stimuli. In addition, a study of the Hoffman reflex demonstrated a transient attenuation of alpha motor neuron excitability following mobilization.[43] If the motion produced by the press-up maneuver during the pretreatment MRI assessment was limited by protective muscle guarding, then a reduction in alpha motor neuron excitability may have decreased the guarding response and thus allowed more movement during the posttreatment MRI assessment.

In order to explore the relationship between changes in pain and changes in lumbar extension motion for subjects enrolled in the present study, a *post hoc* correlation analysis was performed. When participants in both groups were combined, a statistically significant relationship was found ($r=-.37$, $P=.04$). The negative correlation indicated that greater decreases in pain were associated with greater increases in lumbar extension. Although this finding supports the link between pain and joint motion, the strength of this relationship was relatively weak. It also should be noted that cause-and-effect relationships cannot be inferred by such an analysis.

Several limitations of our study need to be acknowledged. First, the relatively small change in total lumbar extension following PA mobilization and the press-up exercise in the present study may have been related to the age and activity level of the subjects. Our participants were young and physically active. Because spinal motion is known to decrease with age, mobilization applied to a population with less spinal motion may have resulted in greater increases in spinal motion after intervention. Second, the strict inclusion criteria used in the present study limit the generalizability of the results to all low back pain populations. For example, subjects who have both back pain and leg pain and who report centralization of symptoms with extension exercises may have responded more favorably to the press-up intervention.[44–46] Third, only the immediate effects of the 2 interventions were considered in the present study; therefore, long-term gains in motion and pain reduction cannot be assumed. Fourth, our study design lacked a sham group to account for any potential placebo effect that may have occurred with either of the interventions. In addition, a sham group would have controlled for any potential improvements in pain or motion attributable to the testing procedure itself and would have been useful in establishing the test-retest stability of the MRI measurements. Last, the inability to exactly reproduce the pretreatment resting position for the posttreatment MRI assessment may have influenced the results of the present study. These limitations should be considered in the design of future investigations in this area.

Conclusion

The immediate effects of PA mobilization and a press-up exercise were examined in people with nonspecific low back pain. Following the intervention, subjects in both groups reported significantly less pain with standing extension. Additionally, both PA mobilization and the press-up exercise resulted in a significant increase in lumbar extension. There were no significant differences in pain and lumbar extension between the 2 interventions studied. Our findings suggest that both PA mobilization and press-up exercises can have an immediate effect on symptoms and lumbar motion in people with nonspecific low back pain.

Dr Powers, Dr Kulig, and Dr Landel provided concept/idea/research design. Dr Powers, Mr Beneck, and Dr Landel provided writing. Dr Powers, Dr Kulig, Dr Landel, and Dr Fredericson provided data collection. Dr Powers, Mr Beneck, and Dr Kulig provided data analysis. Dr Powers provided fund procurement and facilities/equipment. Dr Fredericson provided subjects. Dr Powers and Dr Fredericson provided institutional liaisons. Dr Powers and Dr Kulig provided project management and consultation (including review of manuscript before submission).

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