

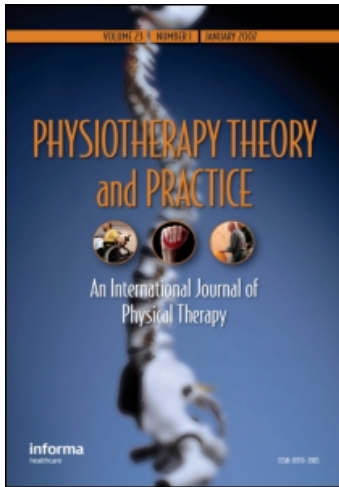
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### Centralization of symptoms and lumbar range of motion in patients with low back pain

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## Centralization of symptoms and lumbar range of motion in patients with low back pain

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*This quasi-experimental repeated measures study examined the relationship between centralization of symptoms and lumbar flexion and extension range of motion (ROM) in patients with low back pain. Rapid and lasting changes in lumbar ROM have been noted with centralization of symptoms. However, no study has objectively measured the changes in lumbar ROM occurring with centralization. Forty-two adult subjects (mean age, 45.68 years; SD = 15.76 years) with low back pain and associated lower extremity symptoms were followed by McKenzie trained physical therapists. Subjects' lumbar ROM was measured at the beginning and end of each patient visit by using double inclinometers, and pain location was documented. Subjects were grouped as 1) centralized, 2) centralizing, or 3) noncentralized for comparisons of symptom and ROM changes. Data were analyzed by using multivariate analysis of variance and one-way analysis of variance. Significance was set at 0.05. A significant difference was found between initial and final mean extension ROM in the centralized and centralizing groups ( $p = 0.003$ ). No significant difference was found in the noncentralized group ( $p < 0.05$ ). Subjects ( $n = 23$ ) who demonstrated a change in pain location during the initial visit also showed a significant ( $p < 0.001$ ) change in extension ROM, whereas patients with no change in pain location ( $n = 19$ ) did not ( $p = 0.848$ ). Lumbar extension ROM increased as centralization occurred.*

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### Introduction

Low back pain (LBP) has been a common and expensive problem within our society (Anderson, 1999; Hart, Deyo, and Cherkin, 1995). Various characteristics of LBP have been identified in the literature in the past decades. Reduced lumbar range of motion (ROM) is a clinical finding in patients with LBP that has been used to assist in determining the degree of

impairment (AMA, 2001). A common rehabilitation objective in patients with LBP has been to attempt to restore ROM which may, or may not, ultimately lead to an improvement in function.

McKenzie (1981) observed the centralization phenomenon and developed clinical theories about its properties. Centralization is the apparent movement of symptoms from a distal location to a more proximal location in response to specific repetitive end-range exercises or positioning

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(McKenzie, 1981, 1999). McKenzie (1981) classified LBP patients into three syndromes by the patient's symptom response to end-range movements and sustained positions. The three syndromes are 1) postural, 2) dysfunction, and 3) derangement. Although the syndromes have a number of distinct characteristics, one of the principal differentiating factors between the syndromes is that centralization occurs in response to repeated end-range movements in the derangement syndrome, but not the other syndromes (McKenzie, 1999). McKenzie (1981) theorized that the application of repeated, end-range movement or end-range sustained positioning caused the nucleus pulposus to distort opposite to the pressure applied. McKenzie (1999) proposed that nuclear movement away from the innervated annular wall would move referred symptoms from a distal to a more proximal location and increase ROM. Signs of centralization or abolishment of pain established a directional preference for the prescription of exercise (Donelson, Grant, Kamps, and Medcalf, 1991; McKenzie, 1999).

The literature supports the value of identifying centralization during patient examination using McKenzie methods; however, no literature was found showing objective changes in ROM occurring with centralization (Donelson, April, Medcalf, and Grant, 1997; Donelson, Silva, and Murphy, 1990; Karas et al, 1997; Long, 1995; Sufka et al, 1998). It has been suggested that it would be clinically helpful to objectively quantify outcomes with centralization (Di Fabio, 1999). Donelson, Silva, and Murphy (1990) noted "simultaneous improvement" with lumbar ROM when the subject's symptoms centralized but did not formally study the relationship. Additional studies have supported that lumbar ROM can improve with McKenzie treatment techniques (Clare, Adams, and Maher, 2007; Kopp et al, 1986; Nwuga and Nwuga, 1985; Ponte, Jensen, and Kent, 1984), however, documentation of the relationship of increased ROM and centralization has not been established.

If a correlation between increased ROM and signs of centralization could be established, characteristics of the centralization phenomenon would be further defined. The associated clinical parameter (ROM) could be objectively measured and would be another potential indicator of the derangement syndrome. McKenzie and

May (2003) noted that changes in ROM should accompany or precede change in symptom location. If this correlation were to be established and ROM changes were the initial change noted in the examination process, signs of centralization might well be expected to follow. This correlation between centralization and changes in ROM might then be used to confirm appropriate treatment. The exercises that produced centralization and/or positive ROM changes would indicate the directional preference of treatment. Objective increase in ROM could justify the continuation of those specific treatments that restored ROM while symptoms centralized and abolished.

The purpose of this study was to determine if a relationship existed between changes in ROM and centralization of symptoms. This was studied in two ways. Signs of the centralization process during treatment of a population of patients with LBP were compared to changes in ROM over a short period of treatment. Signs of centralization also were compared to ROM changes during the initial assessment and treatment visit to assess how rapidly these symptom changes might take place. We hypothesized that lumbar ROM would increase as centralization occurred, and we expected to find no significant changes in lumbar ROM when centralization did not occur.

## Methods

This study was a quasi-experimental, repeated measures design to examine the relationship between changes in lumbar ROM and centralization of symptoms using the McKenzie method of mechanical diagnosis and therapy. The University of Texas at El Paso Institutional Review Board approved the study.

## Examiners

Physical therapists who were Credentialed or Diplomaed by the McKenzie Institute were solicited from its membership list to collect data for this study. Clinicians with this background were chosen to ensure a general standardization of examination and treatment. Physical therapists (two Credentialed, two Diplomaed) from

four outpatient clinics submitted data for the study. Raters demonstrated consistency in measuring lumbar range of motion through assessment of individuals on two consecutive days. No significant differences were found between measurements ( $t = -0.33$ ,  $p = 0.46$ ). However, these raters were dispersed across the United States and were not able to assess the same individuals; thus, interrater reliability was not determined.

## Subjects

Patients aged 17 years and older with LBP and associated referred pain who had been referred for physical therapy treatment were screened as potential subjects. Referred pain was defined as reported pain distal to central LBP (Area Zero) on the body grid chart (Figure 1). Consecutive patients with LBP and referred pain that met the following criteria comprised the study population: 1) presented without history of back surgery or spinal fractures within the last 6 months; 2) had no history of spinal fusion or diagnosed spinal instability; 3) were not pregnant; and 4) had no current history of acute systemic infection, active inflammatory disease, or malignancy. Subjects who met the above criteria were invited to participate in this study and gave written consent prior to participating. The examiners questioned patients concerning gender, the number of previous LBP episodes, whether the pain was constant or intermittent,



whether there was any neurological deficit (defined as motor deficit, sensory deficit, reflex changes, or dural signs), and if the episode of LBP was covered by workman's compensation (Table 1). A total of 42 subjects with LBP participated in the study.

## Materials

A standardized McKenzie lumbar examination form and a body grid chart (Figure 1) adapted from the Donelson, Grant, Kamps, and Medcalf (1991) patient data recording form were used to evaluate each subject including location of the most distal symptom. Werneke, Hart, and Cook (1999) were able to show high agreement between raters with similar training to the raters of this study when using a very similar body grid chart and assessing the most distal symptom ( $\kappa = 0.92$ – $1.0$ ). They were also able to agree at a high level ( $\kappa = 0.96$ ) concerning changes in pain location over time. All participating clinics were provided with at least two inclinometers (Universal Inclinometers, Performance Attainment Associates, St. Paul, MN, USA). The double inclinometer method has been shown to be a reliable (Gill et al, 1988; Keeley et al, 1986; Mayer, Tencer, Kristoferson, and Mooney, 1984; Portek, Percy, Reader, and Mowat, 1983; Reynolds, 1975; Salisbury and Porter, 1987) and valid (Mayer, Tencer, Kristoferson, and Mooney, 1984; Saur et al, 1996) method to measure active lumbar ROM.

Code # _____	Start of Care: _____	Workers Comp: _____
	Onset Date: _____	Litigation: _____
	# of previous episodes: _____	Age: _____
	Neurological Deficits: Y/N	Gender: M/F
	Pain: Constant/Intermittent	

<p><b>Day 1: Pre-Treatment</b></p>  <div style="border: 1px solid black; padding: 5px; margin-top: 10px; width: fit-content;">       Date: _____        Flexion ROM: _____        Extension ROM: _____     </div>	<p><b>Day 1: Post-Treatment</b></p>  <div style="border: 1px solid black; padding: 5px; margin-top: 10px; width: fit-content;">       Date: _____        Flexion ROM: _____        Extension ROM: _____     </div>
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**Figure 1.** Data collection form with modified Donelson body grid.

**Table 1.** Patient characteristics at initial examination.

Characteristic	Male	Female	Total
<i>n</i>	13	27	42 <sup>+</sup>
Age (yr)			
Mean	47.7	41.9	45.7
Range of ages	(36–66)	(17–77)	(17–77)
Previous episodes			
Mean	4.15	3.48	3.81
Range of no. of episodes	(0–11)	(0–11)	(0–11)
Patients' pain			
Intermittent	6	14	20
Percent	(54.5)	(51.9)	(47.6)
Constant	7	11*	18*
Percent	(53.8)	(44.0)	(45.0)
Neurological deficit			
Yes	2	2	4
Percent	(15.4)	(7.4)	(9.5)
No	11	25	38
Percent	(84.6)	(93.6)	(90.4)
Number subjects on Workman's Compensation:			
Percent	6 (54.5)	5 (17.2)	11 (36.0)

<sup>+</sup>Gender not disclosed for two patients; data considered in overall results only.

\*Two females without pain characteristic reported.

## Procedures

Prior to initiation of examination and treatment, the clinician marked the subject's most distal, current, reported symptom location on the body grid. The spine was then exposed for inclinometer placement. Written instruction to apply a double inclinometer measurement method in standing as outlined by Williams et al (1993) was provided to each clinician. Adhesive dots were placed over the T12-L1 interspace and over S2 and used as landmarks for measurement. The T12 landmark was located by following the costal margin to the spine (Chen et al, 1997). The S2 landmark was then found at the level of the posterior superior iliac spines (Hoppenfeld, 1976).

The inclinometers were zeroed prior to each measurement, and placement over the adhesive dots was maintained during movement. The clinician read both inclinometers at the point of maximal extension or flexion. The reading of the lower inclinometer was subtracted from the reading of the upper inclinometer to obtain

lumbar ROM. Prior to the extension ROM measurement; subjects performed three extension movements to voluntary end range in standing for warm-up. The subjects were asked to extend as far as possible, stopping when no further movement was available or at the point where discomfort/pain prevented further movement. One lumbar extension ROM measurement was obtained and recorded. Next, the subjects performed three lumbar flexion warm-ups, and one measurement of flexion ROM was obtained and recorded. Again, the subjects were asked to flex as far as possible, stopping when no further movement was available or at the point where discomfort/pain prevented further movement.

Once the initial ROM measurements were taken, the McKenzie examination and treatment proceeded. The treatment decisions were left to the similarly trained (McKenzie) therapists. The therapists were free to apply what they considered to be appropriate therapy based on their examination and evaluation; this included whatever

home program of exercise and restriction they deemed appropriate. All volunteers who met study criteria were admitted to the study; thus, no attempt was made to restrict patients to those presenting with only the derangement syndrome. At the end of each treatment, the most distal symptom was documented on the body grid, and the subject's extension and flexion ROM were remeasured.

The same data collection protocol was used for the each ensuing visit. Clinicians attempted to have the first follow-up visit within 24 hours to observe any changes that might have accompanied treatment. Each subject was followed for a maximum of six visits over 3 weeks.

Subjects were classified into three groups by the researchers after data collection based on the location of the most distal reported symptom. The classification was based on the reported pretreatment location of the most distal symptom at the first visit and the reported posttreatment location of the most distal symptom at the final visit. The three groups were 1) centralized, 2) centralizing, or 3) noncentralized. The centralized group (group 1) consisted of subjects with LBP whose initial distal symptoms were located on the body grid distal to the area marked "Zero," and that moved proximally and were abolished or moved proximally and remained in the central low back (body grid area "Zero"). The centralizing group (group 2) consisted of subjects with LBP whose initial distal symptoms were located on the grid outside the area marked "Zero" and thereafter moved to a more proximal location, but never abolished nor reached area "Zero" on the body grid. The centralizing group demonstrated that the process of centralization was occurring but may not have been complete because centralization may take place over several days to weeks (McKenzie and May, 2003). If the most distal symptom location did not change or peripheralized from the initial visit, the subject was classified in the noncentralized group (group 3).

Data from the initial visit were collected and analyzed separately to assess if the centralization and ROM changes could be discovered early in the process of assessment and treatment.

## Data analysis

Data collection was done by unblinded therapists from the various clinics. The data analysis

was conducted independently of the data collection by the authors with assistance from University of Texas at El Paso Statistics Lab.

Multivariate analysis of variance (MANOVA) was used to determine if there was a difference in the overall change in mean flexion and mean extension ROM measurements. If the omnibus difference was significant, analysis of variance (ANOVA) with associated post hoc tests was used to determine individual differences between groups. Descriptive data were analyzed with Fisher's exact two-tailed test. Significance was set at 0.05.

The centralized group (group 1), the centralizing group (group 2), and the noncentralized group (group 3) made a total of three groups for statistical analysis. Two dependent variables were used for comparisons: 1) change in mean flexion ROM and 2) change in mean extension ROM.

Repeated measures ANOVA analysis was used to compare initial and final ROM day 1 measurements for subjects who reported a change in pain location during the initial visit. The same analysis was used by comparing initial and final day 1 ROM measurements for the subjects ultimately categorized as centralized (group 1) and centralizing (group 2).

## Results

The patients' characteristics at initial examination are summarized in Table 1. Subject ages ranged from 17 to 77 years with a mean age of 45.7 years. The number of treatments ranged from two to six visits over a period of 3 weeks. Thirty subjects were categorized as centralized (group 1), three subjects were categorized as centralizing (group 2), and nine subjects were categorized noncentralized (group 3).

Statistical analysis (one-way ANOVA) showed that there was no difference among the three groups' age ( $F=0.43$ ;  $df=2,38$ ;  $p=0.656$ ). Gender was reported for 27 female and 13 male subjects but was not disclosed for 2 subjects. The distribution of gender in the three groups was not significant by Fisher's exact two-tailed test ( $p=0.236$ ). Eleven subjects were on worker's compensation. Five of these subjects were classified as centralized (group 1) and six were noncentralized (group 3).

Four subjects reported neurological deficits. The subjects with neurological deficits were

**Table 2.** Initial and final mean flexion and extension measurements.

Variable	Subject group*		
	Centralized (1) ( <i>n</i> = 30)	Centralizing (2) ( <i>n</i> = 3)	Non-centralized (3) ( <i>n</i> = 9)
Initial flexion	38.16° ± 13.46	57.0° ± 12.12**	32.22° ± 16.41
Final flexion	45.76° ± 9.96	54.67° ± 18.58	35.44° ± 12.22
Initial extension	11.5° ± 8.23	10.0° ± 10.0	12.44° ± 7.07
Final extension	29.47° ± 10.37	29.33° ± 9.81	19.11° ± 10.65***

\*Values are means ± standard deviation.

\*\**P* = 0.040.

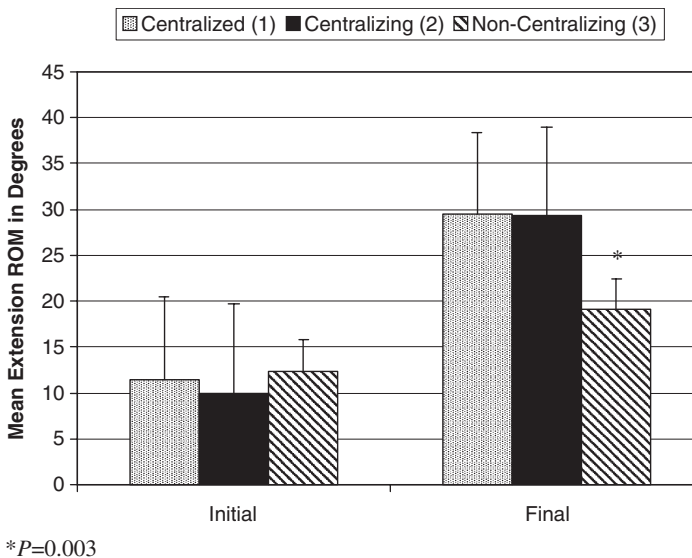
\*\*\**P* = 0.003.

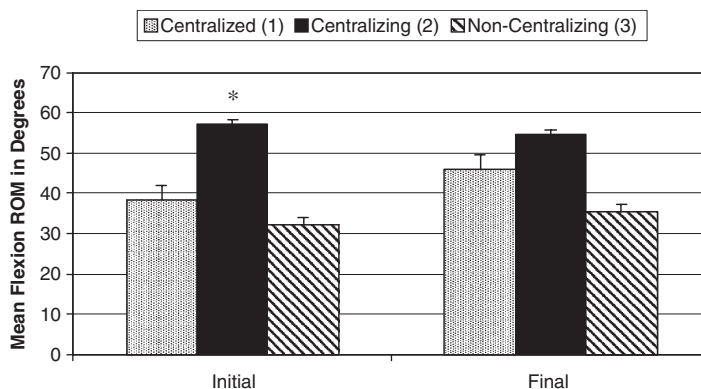
evenly distributed among the three groups (one in centralized, one in centralizing, and two in noncentralized). The distribution of the number of previous episodes of LBP was not significant by Fisher's exact two-tailed test (*p* = 0.482) across the groups.

Fourteen subjects reported no previous episodes of LBP, 16 subjects reported one to five previous episodes, and 10 subjects reported at least 10 prior episodes of LBP. Data were missing for the number of previous episodes on two subjects. The number of treatments received by each group was equivalent (*p* = 0.391).

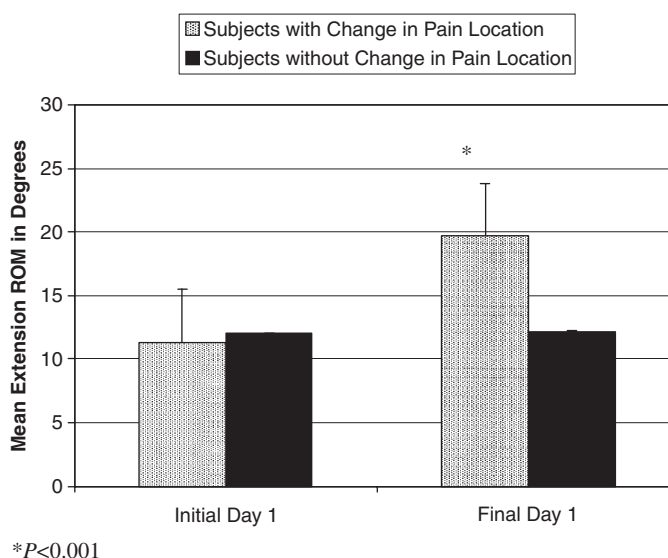
Initial extension ROM measurement across groups was equivalent (*p* = 0.897). However, the initial flexion ROM measurement of the centralizing group was significantly different from the other two groups (*p* = 0.040) (Table 2).

The omnibus difference in initial and final ROM measurement was significant (*F* = 2.78; *df* = 4,76; *p* = 0.032). When further analyzed by one-way ANOVA, the difference in extension ROM measurement was significant (*F* = 6.78; *df* = 2,39; *p* = 0.003) (Figure 2), although the difference in flexion ROM measurement was not significant (*F* = 1.25; *df* = 2,39; *p* = 0.298) (Figure 3). By least

**Figure 2.** Comparison of initial mean extension range of motion to final mean extension range of motion.



**Figure 3.** Comparison of initial mean flexion range of motion to final mean flexion range of motion.

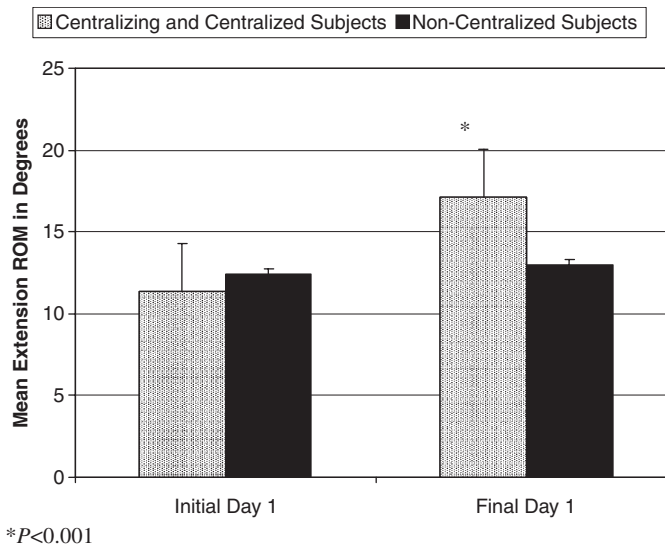


**Figure 4.** Comparison of initial mean extension range of motion to final mean extension range of motion day 1 for subjects with and without change in pain location.

significant difference multiple comparison procedure, a mean difference was significant in extension for the centralized group (18.0 deg; SD=9.1;  $p=0.001$ ) and centralizing group (19.3 deg; SD=5.1;  $p=0.027$ ) when both groups were compared to the noncentralized group (6.7 deg; SD=5.4).

Repeated measures ANOVA analysis of subjects ( $n=23$ ) who demonstrated a change in pain location during the initial visit showed a significant ( $F=45.59$ ;  $df=1,22$ ;  $p<0.001$ ) change in extension ROM comparing initial measurements (11.3 deg; SD=7.4) to final

day 1 measurements (19.7 deg; SD=9.2). While patients with no change in pain location ( $n=19$ ) did not show a significant change ( $F=0.038$ ;  $df=1,18$ ;  $p=0.848$ ) when comparing the same initial (12.0 deg; SD=8.7) and final (12.2 deg; SD=9.8) first visit measurements (Figure 4). Range of motion changes during the initial visit were also analyzed for those subjects who were ultimately categorized as centralized (group 1) and centralizing (group 2). The combined groups ( $n=33$ ) showed significant mean change ( $F=23.40$ ;  $df=1,32$ ;  $p<0.001$ ) in extension



**Figure 5.** Comparison of initial mean extension range of motion to final mean extension range of motion day 1 for centralizing and centralized subjects, and noncentralized subjects.

ROM following assessment and treatment on the first day (initial: 11.4 deg; SD = 8.2; final: 17.2 deg; SD = 10.7), whereas the noncentralizers ( $n = 19$ , group 3) did not ( $F = 2.70$ ;  $df = 1, 8$ ;  $p = 0.139$ ) (initial: 12.4 deg; SD = 7.1; final: 13.0 deg; SD = 6.9) (Figure 5).

## Discussion

The significant difference between the initial and final extension ROM for the centralized (1) and centralizing (2) groups confirmed a positive relationship between the process of centralization and increasing extension ROM. The authors expected this finding based on the appropriate application of the extension principle (extension exercises and positioning) for treatment for the more commonly occurring posterior derangement syndrome (May 2006; McKenzie and May, 2003). There was no significant change in the initial vs. final mean extension ROM in the noncentralized group (3) as hypothesized.

The mean difference in final flexion for all three groups was not significantly different. A possible reason for this finding is that May (2006) and McKenzie and May (2003) reported that patients who are extension responders far

outnumber those who are flexion responders. Extension responders would initially have been given extension exercises and flexion restrictions by the treating therapists. The reverse would be true for flexion responders but were not among the subjects of this study. Restoration of flexion ROM in the patients who were extension responders may have occurred later in the treatment process than the period covered by this study. In addition, when asked to flex for the purpose of measurement, they may have been apprehensive concerning the possible provocation of symptoms.

McKenzie's centralization phenomenon has been noted in studies (Delitto et al, 1993; Donelson, April, Medcalf, and Grant, 1997; Donelson, Grant, Kamps, and Medcalf, 1991; Donelson, Silva, and Murphy, 1990; Erhard, Delitto, and Cibulka, 1994; Karas et al, 1997; Kilby, Stigant, and Robert, 1990; Kopp et al, 1986; Long, 1995; Sufka et al, 1998; Werneke and Hart, 2001, 2003; Werneke, Hart, and Cook, 1999; Williams, Hawley, McKenzie, and van Wijmen, 1991) utilizing a mechanical approach such as repeated movement testing. The presence of centralization in the examination/treatment process has been a predictor of good patient outcomes with both acute and chronic spine pain (Donelson, Sukva, and Murphy, 1990; Long, 1995; Sufka et al, 1998).

Sufka et al (1998), and Werneke, Hart, and Cook (1999) demonstrated that practitioners have shown high levels of agreement on the existence of centralization. Fritz, Delitto, Vignovic, and Busse (2000) reported that even physical therapist students with little clinical experience were proficient in recognizing centralization. Further definition of the characteristics of the centralization phenomenon such as this relationship to changing ROM should make it even easier to recognize.

Werneke, Hart, and Cook (1999) defined centralization in a stricter way, as the lasting abolishment of the most distal symptoms initially noted in the first visit in response to repeated movements, with the remaining symptoms being sequentially abolished at each appointment in response to repeated movements. However, McKenzie and May (2003) state that although centralization may be noted in the examination process, it can take place over several days and in severe cases when patients have referred or radiated symptoms into the lower leg, centralization may take place over several weeks. In the present study, a total of 33 of 42 (79%) subjects were either in the centralized group (1) or the centralizing group (2). Upon completion of the first treatment session, 22 of the 33 (67%) subjects reported some centralizing of symptoms. Centralization was deemed to be in process because the most distal symptom had moved from a distal area on the body grid to a more proximal location (Donelson, Silva, and Murphy, 1991). Therefore, changes in pain location occurred with the first treatment session for a majority of the subjects in the centralized and centralizing groups. This finding confirms the clinical observation of McKenzie (1981) and McKenzie and May (2003) and the claim of Donelson, Silva, and Murphy (1990) that rapid changes in pain location may occur in the derangement syndrome. We carried our investigation out to six visits (within 3 weeks), if required, to include the slower responding patients. Werneke, Hart, and Cook (1999) reported that if centralization had not occurred by the seventh visit, further improvement was not a likely outcome.

In addition to the rapid changes in pain location that occurred, rapid, significant changes in ROM were also observed. Analysis of the 23 of the 42 subjects (55%) who demonstrated a

change in pain location during the initial visit showed a significant change in extension ROM following the assessment and treatment vs. the extension ROM at intake (Figure 4). Range of motion changes during the initial visit were also analyzed for those subjects who were ultimately categorized as centralized (group 1) and centralizing (group 2). These two groups also showed significant change in extension ROM following assessment and treatment on day 1 while the noncentralizers (group 3) did not (Figure 5). This supports the claim by McKenzie and May (2003) that centralization and ROM increases occur concurrently and rapidly.

McKenzie and May (2003) reported that with respect to the derangement syndrome, centralization “should be accompanied or preceded by improvements in the mechanical presentation i.e., range of movement and/or deformity” (McKenzie and May, 2003, p 292). In the present study 19 patients did not report a change in pain location during the first visit. Of those, two subjects (11%) demonstrated an increase in ROM on the first day. Both of those subjects ultimately were classified as centralized (group 1). That would mean that 6% of the subjects classified as centralized ( $n = 30$ ) showed an increase in ROM but no change in symptom location during the first treatment, supporting this statement.

## Limitations

Confirming the correlation between centralization and increasing ROM in a larger number of subjects would be desirable for potentially greater generalization of the results to the population as a whole. Measurement of the examiners' interrater reliability would strengthen the findings.

Centralization of symptoms has been shown to indicate better outcomes as previously mentioned (Donelson, Silva, and Murphy, 1990; Long, 1995; Sufka et al, 1998). Our data cannot be used to confirm that phenomena because no functional outcome data were collected in this study.

Waddell (2004) reported that patients who are compensated for injuries respond less well to pain management and rehabilitation than those who are not. In the current study 11 subjects were on worker's compensation. Five of these subjects were classified as centralized and six were

noncentralized. There were nine total subjects in the noncentralized group. Sixty-six percent of the noncentralized group was on worker's compensation, compared to 17% in the centralized group. The argument might be raised that compensation affected the results of the grouping; however, this was a small number of subjects and should be confirmed in a larger study.

## Conclusion

This study has shown that as symptoms centralize, lumbar extension ROM significantly increases. Lumbar extension ROM did not significantly change in noncentralized subjects. No changes in lumbar flexion ROM were noted with centralization or noncentralization. The study also has confirmed that the cardinal sign of centralization occurs rapidly and in conjunction with, or in a few cases preceded by, rapid, significant change in ROM.

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