A preliminary analysis of outcomes and end range procedures used to achieve centralization in people with low back pain

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ABSTRACT

Objectives: To investigate the relationship between clinical outcome and the types of end range procedures used to achieve centralization in a sample of patients with low back pain (LBP) and/or peripheral symptoms.

Methods: Small sample retrospective analysis of an observational cohort. Patients with LBP who centralized during initial visit at two physical therapy clinics were recruited to participate. The types of end range procedures used to achieve centralization were documented during each office visit and a chart review was performed after 4 weeks. Outcomes were determined by improvement in the Oswestry Disability Index (ODI) score after 4 weeks. Statistical analysis determined the association between the types of end range procedures and outcomes.

Results: Thirty-one patients gave consent to participate. Nineteen patients met inclusion criteria and were included in data analysis. After 4 weeks, the improvement in mean ODI scores was 15.89 ± 16.28 . Differing end range procedures were used to achieve centralization within this cohort. The types of end range procedures used to achieve centralization were not significantly associated with outcomes.

Discussion: The results observed in this study promote exhausting many different types of end range procedures to determine if centralization can be achieved. Limiting the end range procedures used to assess centralization may fail to identify patients who can achieve centralization and subsequently have positive clinical outcomes. Larger cohort studies investigating relationships between outcomes and the types of end range procedures used to achieve centralization would contribute to management of people with LBP.

Level of Evidence: 4.

KEYWORDS

Centralization; centralization assessment; outcomes; prognosis; end range procedures; back pain; treatment classification systems

Introduction

The incidence of low back pain (LBP) is considered of epidemic proportions throughout the world and is a common condition for which patients are treated in physical therapy clinics [1–4]. It was reported that 20% of 31 million patient visits to medical providers in the United States for LBP within a single year were referred to physical therapy for intervention [5]. Physical therapy practice guidelines identify centralization assessment as an essential physical examination component for managing patients with LBP but are limited in describing the magnitude of procedures used to assess centralization [1]. The types and extent of physical examination procedures used to assess centralization vary in clinical practice [6–8] which generates the potential for incomplete and/or inaccurate centralization assessment. Centralization is defined as a rapid or immediate reduction/abolition of symptoms (LBP and/or referred lower extremity) that demonstrate a distal to central pattern in response to a specific physical examination procedure [9]. End range procedures are operationally defined in

this study as those test movements or positions used to achieve centralization or determine if a directional preference is present. Directional preference refers to the phenomenon of preference for postures and movements that decrease, abolish, or centralize symptoms and/or produce a mechanical response that is lasting [9]. Although directional preference includes centralization, this study examined centralization only.

If centralization is achieved, and based on the end range procedures used to achieve centralization, individualized directional exercises are recommended as an intervention to reduce/abolish the patient's symptoms [1,10,11]. Patients who centralize are more likely to have positive clinical outcomes. Strong evidence [12–14] and moderate evidence [15,16] was identified by systematic review to support an association between centralization and outcomes [17]. Despite well-documented evidence recognizing the importance of determining a patient's ability to centralize, there is less consensus for recommendations relating to the type and extent of end range procedures chosen to accurately assess centralization [1].

A variety of end range procedures used to assess centralization have been described [10,18]. Each end range procedure involves positioning the patient in either a weight bearing (standing/sitting) or a non-weight bearing (prone/supine/quadruped) position and then loading the spine in a single plane of movement (flexion, extension or side glide) or a complex plane of movement (combination of two or more planes, i.e. extension with side glide) while using different movement patterns (repetitions or a sustained hold at end range.) In addition, manual overpressure may be applied to the lumbar spine during the end range procedure. Symptom response is assessed during each end range procedure to determine if centralization occurred [10,18]. Comprehensive assessment of centralization using a variety of end range procedures that include different weight bearing/non-weight bearing positions, movement planes, movement patterns and with/without manual force application is foundational to the Mechanical Diagnosis and Therapy® (MDT) treatment classification approach for managing patients with LBP [10,17,18]. MDT® advocates exploring all reasonable end range procedures in a limited number of visits in order to fully determine a patient's ability to demonstrate centralization of symptoms [10].

Physical therapy practice guidelines and treatment classification algorithms published in the literature recommend centralization assessment to manage patients with LBP but are not explicit in promoting comprehensive exploration of all reasonable end range procedures to assess centralization [1,19,20]. The extent and choice of end range procedures chosen to assess centralization varies among practicing clinicians managing this patient population [6–8]. It is reasonable to conclude, the perceived 'prognostic outcome value' of a specific end range procedure may influence the clinician's choice of which end range procedures are chosen to assess centralization. In studies that have investigated prognostic variables among patients treated with the MDT® approach, the relationship between outcomes and types of end range procedures used to achieve centralization was not determined [11,15,21,22]. Understanding the relationship between outcomes and the different types of end range procedures may improve consistency in the approach to centralization assessment among clinicians.

Objective

To investigate the relationships between clinical outcomes and the types of end range procedures used to achieve centralization of symptoms in a sample of patients with LBP and/or referred lower extremity pain.

Methods

Study design

Small sample retrospective analysis of an observational cohort. Data relating to the types of end range procedures

used to achieve centralization were observed and documented during each physical therapy visit for 4 weeks. Data were collected during a period of 26 months. This study was approved by the institutional review board at NOVA Southeastern University.

Participating physical therapists

Three state licensed physical therapists credentialed (Cert. MDT) in Mechanical Diagnosis and Therapy® by the McKenzie Institute International (MII) participated in this study. Clinical experience among the three physical therapists ranged from 5 to 27 years.

Subjects

Patients with LBP and/or referred lower extremity symptoms and who were able to achieve centralization during physical examination were recruited for participation at two outpatient physical therapy clinics. Inclusion criteria were patients 18 years of age or older with an ODI score greater than or equal to 25 during the initial visit. Patients were excluded if history/medical findings represented 'red flags' or contra-indications to physical therapy. Planned sample size of 90 was established a priori as part of a different study designed to develop a prediction rule to identify different clinical variables, including end range procedures, that are prognostic of clinical outcomes. The sample size was determined by consideration of prevalence, number of predictor variables and the risks associated with failure to correctly identify the relevant clinical circumstance [23–27].

Measurements

Modified Oswestry Disability Index

The modified Oswestry Disability Index (ODI) was used as the clinical outcome measurement in this study and is a valid self-report assessment of disability in patients with LBP [28–30]. The modified ODI consists of 10 questions that assess a patient's ability to perform daily activity due to back pain. The final score is expressed as a value of 0–100, with 100 representing severe debilitating symptoms and disability from LBP and 0 representing no pain or disability.

Clinical outcomes – dependent variable

The dependent variable for this study was clinical outcome, measured by calculating the change in ODI scores between the initial visit and the 4 week visit for each patient. Improvement in mean ODI scores was calculated for the entire cohort as well as for each predictor variable group.

End range procedures – predictor variables

The predictor variables for this study were the types of end range procedures used to achieve centralization

during the initial physical therapy visit [10]. The different types of end range procedures used to assess centralization were organized within the following categories: (1) weight bearing status of the test positions (weight bearing, non-weight bearing); (2) test positions (standing, lying, or other positions); (3) movement plane of the test position (single or complex plane); (4) movement pattern of the test positions (sustained hold or repetitions); and (5) the use of overpressure to the lumbar spine. Table 1 describes the terms relating to the types of end range procedure categories included in this study.

Procedures

Patients with LBP and/or radiating lower extremity symptoms were recruited for this study during their initial visit at one of the participating physical therapy clinics. If screening criteria was met and centralization was observed, the physical therapist asked the patient if they would consider participating in this study. Patients providing consent agreed to allow the treating physical therapists to collect observational data during the initial 4 weeks of physical therapy intervention and for the principal investigator to perform a chart review after 4 weeks. Data relating to the types of end range procedures used to achieve centralization were documented in the patient's chart during each office visit.

Centralization was assessed during all visits using procedures consistent with MDT® principles. The treating physical therapist chose the specific types of end range procedures as clinically indicated for each patient. The ODI was completed during the initial visit and fourth week visit. A chart review was completed after four weeks of physical therapy and data were organized for statistical analysis by the principal investigator. The methodology of this study was completely observational

and did not manipulate physical therapy assessment and/or intervention procedures.

Data analysis

Relationships between the types of end range procedures used to achieve centralization (predictor variables) and clinical outcome (dependent variable) were analyzed in this study. Descriptive statistics were determined for age, gender, and symptom presentation at the initial visit for all patients. Clinical outcome for each patient was calculated by measuring improvement of the ODI score between the initial visit and the fourth week visit. The mean improvement of the ODI scores at 4 weeks was determined for the entire cohort as well as for each predictor variable sub-group (the different types of end range procedures used to achieve centralization.) Kruskal–Wallis H and Mann–Whitney U tests were used to determine if there was a significant difference ($p < 0.05$) in mean improvement of the ODI scores at 4 weeks among the different types of end range procedures used to achieve centralization. Association between each different type of end range procedure used to achieve centralization and the improvement of the mean ODI scores at 4 weeks for the entire cohort was identified and assessed for significance by Spearman's rank-order correlation. The descriptive frequencies of successful and less successful clinical outcomes among the different types of end range procedures used to achieve centralization were assessed. An ODI improvement score of ≥ 10 after 4 weeks was chosen as minimum threshold representing successful improvement [31]. Accuracy statistics (sensitivity, specificity, and likelihood ratios) with the corresponding 95% confidence interval (CI) were planned for end range procedures that demonstrated a significant relationship with clinical outcomes.

Table 1. End range procedure terms.

	Description
<i>Weight Bearing Terms</i>	
Non-Weight Bearing (NWB)	An end range procedure performed with the patient in either supine, prone or quadruped to achieve centralization
Weight Bearing (WB)	An end range procedure performed with the patient in either standing or upright sitting to achieve centralization
<i>Test Position Terms</i>	
Standing position	An end range procedure performed with the patient in a standing position to achieve centralization
Lying position	An end range procedure performed with the patient in either prone or supine to achieve centralization
Sitting position	An end range procedure performed with the patient in upright seated position to achieve centralization
Quadruped position	An end range procedure performed with the patient in a quadruped (hands/knees) position to achieve centralization
<i>Plane of Movement Terms</i>	
Single Plane	An end range procedure that isolates trunk movement to only one movement plane (sagittal, frontal or transverse) to achieve centralization
Complex Plane	An end range procedure that combines trunk movement in two or more planes (sagittal, frontal or transverse) to achieve centralization
<i>Movement Pattern Terms</i>	
Sustained Hold	An end range procedure performed by statically holding the end-range movement for 30 s or longer to achieve centralization
Repetitive End Range Movement (RERM)	An end range procedure performed by moving from the neutral to end-range position repetitively to achieve centralization
<i>Overpressure Terms</i>	
Overpressure	An end range procedure performed with manual over-pressure applied to the lumbar spine to achieve centralization

Results

Thirty-one patients agreed to provide informed consent. Two subjects discontinued physical therapy treatment for unknown reasons. Ten subjects had ODI scores less than 25 and were excluded from data analysis. The remaining 19 subjects consisted of 15 females and four males with a mean age of 54.73 years were included in data analysis. At the initial visit, two patients presented with LBP only, 11 patients presented with LBP and radiating symptoms proximal to the knee, five presented with LBP and radiating symptoms distal to the knee, and one patient presented with radiating lower extremity symptoms distal to the knee without LBP. Patient recruitment was for a period of 26 months.

Patients achieved centralization using many types of end range procedures that included different combinations of weight bearing positions, test positions, movement planes, and movement patterns. During the initial visit; five patients centralized only in a lying position, four patients centralized only in a standing position, seven patients centralized in both standing and lying positions, and three centralized in other test positions. In the plane of movement category; four patients centralized only using a complex plane of movement, while 13 centralized only in a single plane of movement during the initial visit. The frequencies for each of the end range procedure categories investigated in this study are presented in Table 2.

The mean ODI score for the entire cohort was 41.26 ± 12.11 at the initial visit and 25.37 ± 13.42 at

the 4 week visit. Overall, the ODI scores improved by 35.26% with the mean improvement in ODI scores at 4 weeks equal to 15.89 ± 16.28 . Non-parametric tests demonstrated no significant differences ($p < 0.05$) in the improvement of ODI scores at 4 weeks between any of the different types of end range procedures used to achieve centralization. The significance for the different types of end range procedures using the Kruskal–Wallis H test were as follows; $p = 0.86$ within the weight bearing category, $p = 0.90$ within the test position category, $p = 0.43$ within the plane of movement category, and $p = 0.22$ within the movement pattern category. The mean improvement in ODI score after 4 weeks for each type of end range procedure used to achieve centralization is displayed in Table 2.

The types of end range procedures used to achieve centralization were analyzed for univariate relationship with clinical outcomes. Spearman R testing identified moderate to very weak correlations (-0.399 to 0.338) between clinical outcomes and the types of end range procedures. None of the correlations between clinical outcomes and the types of end range procedures were determined to be significant ($p < 0.05$). Table 3 lists the correlation coefficients and significance (p value) of the relationship between outcome and each type of end range procedure used to achieve centralization. Accuracy statistics were not calculated secondary to the absence of statistically significant predictor variables.

The descriptive frequencies of successful and less successful clinical outcomes of the different types of

Table 2. Type of end range procedures and mean improvement of clinical outcomes.

Types of End Range Procedures	N	Clinical Outcomes - improvement in mean ODI score at 4 weeks ($\pm$ SD)
<i>Weight Bearing Category</i>		
Centralize in NWB only during initial visit	6	17.00 ($\pm$ 10.71)
Centralize in WB only during initial visit	6	15.33 ($\pm$ 22.11)
Centralize in both WB and NWB during initial visit	7	15.43 ($\pm$ 17.04)
Significance of difference between weight bearing groups		$p = 0.86^*$
<i>Test Position Category</i>		
Centralize only in lying position during initial visit	5	16.40 ($\pm$ 11.87)
Centralize only in standing position during initial visit	4	16.00 ($\pm$ 27.76)
Centralize in both lying and standing positions during initial visit	7	15.43 ($\pm$ 17.04)
Centralize in other positions during initial visit	3	16.00 ($\pm$ 8.72)
Significance of difference between test position groups		$p = 0.90^*$
<i>Plane of Movement Category</i>		
Centralize only in single plane of movement during initial visit	13	19.54 ($\pm$ 17.50)
Centralize only in complex plane of movement during initial visit	4	10.00 ($\pm$ 8.49)
Centralize in both single and complex plane of movement during initial visit	2	4.00 ($\pm$ 16.97)
Significance of difference between plane of movement groups		$p = 0.43^*$
<i>Movement Pattern Category</i>		
Centralize only with sustained hold during initial visit	7	22.57 ($\pm$ 17.73)
Centralize only with RERM during initial visit	5	16.80 ($\pm$ 12.21)
Centralize with both sustained hold and RERM during initial visit	7	8.57 ($\pm$ 16.32)
Significance of difference between movement pattern groups		$p = 0.22^*$
<i>Overpressure Category</i>		
Centralize only with overpressure during initial visit	1	0.00 ($\pm$ 0.00)
Centralize without overpressure during initial visit	18	37.22 ($\pm$ 33.81)
Significance of difference between overpressure groups		$p = 0.20^\dagger$

*Kruskal–Wallis H Test; † Mann–Whitney U Test.

Table 3. Correlation between types of end range procedures and clinical outcomes.

Type of Directional Exercise	Clinical Outcomes - improvement in ODI score at 4 weeks	
	Correlation Coefficient*	Significance (<i>p</i> -value)
<i>Weight Bearing Category</i>		
Centralize in NWB only during initial visit	0.114	0.64
Centralize in WB only during initial visit	-0.104	0.67
Centralize in both WB and NWB during initial visit	-0.010	0.97
<i>Test Position Category</i>		
Centralize only in lying position during initial visit	0.019	0.94
Centralize only in standing position during initial visit	0.003	0.99
Centralize in both lying and standing positions during initial visit	-0.022	0.93
Centralize in other positions during initial visit	0.003	0.99
<i>Plane of Movement Category</i>		
Centralize only in single plane of movement during initial visit	0.338	0.16
Centralize only in complex plane of movement during initial visit	-0.192	0.43
Centralize in both single and complex plane of movement during initial visit	-0.257	0.29
<i>Movement Pattern Category</i>		
Centralize only with sustained hold during initial visit	0.309	0.20
Centralize only with RERM during initial visit	0.098	0.69
Centralize with both sustained hold and RERM during initial visit	-0.399	0.09
<i>Overpressure Category</i>		
Centralize only with overpressure during initial visit	NA**	NA**
Centralize without overpressure during initial visit	NA**	NA**

Notes: No *p* values were identified as significant (*p* < 0.05) in any of the directional exercise categories.

*Spearman's rho; **Not tested – only one patient centralized with overpressure.

Table 4. Frequencies of successful and less successful clinical outcomes for the different types of end range procedures used to achieve centralization.

Types of End Range Procedures	'Successful' (number of patients ODI improved by ≥10)	'Less Successful' (number of patients ODI improved by <10)
<i>Weight Bearing Category</i>		
Centralize in NWB only during initial visit	5	1
Centralize in WB only during initial visit	3	3
Centralize in both WB and NWB during initial visit	4	3
<i>Test Position Category</i>		
Centralize only in lying position during initial visit	4	1
Centralize only in standing position during initial visit	2	2
Centralize in both lying and standing positions during initial visit	4	3
Centralize in other positions during initial visit	2	1
<i>Plane of Movement Category</i>		
Centralize only in single plane of movement during initial visit	9	4
Centralize only in complex plane of movement during initial visit	2	2
Centralize in both single and complex plane of movement during initial visit	1	1
<i>Movement Pattern Category</i>		
Centralize only with sustained hold during initial visit	5	2
Centralize only with RERM during initial visit	2	3
Centralize with both sustained hold and RERM during initial visit	5	2
<i>Overpressure Category</i>		
Centralize only with overpressure during initial visit	0	1
Centralize without overpressure during initial visit	12	0

end range procedures used to achieve centralization are shown in Table 4. Among the five patients who

centralized only in a lying position during the initial visit, four had ODI scores that improved ≥ 10 after 4 weeks.

Two of the four patients who centralized only in a complex plane of movement during the initial visit had ODI scores that improved ≥ 10 after 4 weeks.

Discussion

There is a paucity of studies that have investigated the relationship between outcomes and the types of end range procedures used to achieve centralization. The trends observed in this study introduce the concept that individual types of end range procedures may not be related to outcomes. Clinical outcome scores of the different types of end range procedure categories were not significantly different. In addition, none of the individual end range procedure categories demonstrated a significant correlation with clinical outcomes.

The absence of a significant relationship supports the MDT® concept that comprehensive assessment of all end range procedures, which includes repeated/sustained end range movements in a variety of movement planes and in both weight bearing and non-weight bearing test positions, is required to accurately determine if centralization can be achieved [10]. The trends observed in this study also suggest no one individual end range procedure should be considered more or less 'clinically valuable' than any other end range procedure in determining a patient's ability to centralize.

A widely known classification system, the Treatment-Based Classification (TBC) model, was developed for managing patients with LBP and recognized the clinical role of centralization assessment [32,33]. However, the TBC model described more of a 'screening' approach to assess centralization with end range procedures that were limited by the types of test positions, planes of movement, and movement patterns utilized [32,33]. In more recent studies [19,20], the TBC model was modified to promote additional end range procedures to assess centralization but still remains limited compared to the comprehensive approach recommended by MDT® principles and procedures.[10]

End range procedures used to assess centralization may vary in clinical practice. Physical therapists trained in MDT® utilize a comprehensive approach to centralization

assessment which involves testing using many different end range procedures (weight bearing positions, test positions, plane of movement, movement patterns and/or use of overpressure) at each physical therapy visit [10]. If a patient is unable to centralize in one position, then MDT® principles advocate exhausting all reasonable types of end range procedures for up to three visits before determining whether the person may centralize. Other physical therapists may utilize less comprehensive approaches to centralization assessment. For example, a physical therapist may assess centralization only in a standing position during trunk range of motion (ROM) testing. If centralization does not occur and no additional end range procedures are considered, then the patient's ability to centralize may not have been assessed accurately. This concept is illustrated by the results of this study and displayed in Figure 1. Five patients in this study centralized in a lying position only. Four of these patients had a positive outcome (ODI score improved by >10 points [31].) If centralization was assessed only in a standing position as a component of trunk ROM testing, then these patients would not have benefited from subsequent directional exercise intervention.

Similarly, 4 patients in this study centralized only in a complex plane of movement as shown in Figure 2. Two of these patients had positive outcomes (ODI score improved by >10 points.) If centralization was assessed only in a single plane of movement (flexion, extension or side bending) during trunk ROM testing then these patients would not have benefited from directional exercise intervention. Although it was more common for patients to centralize in a single plane compared to those who centralized in a complex plane among this study's cohort, there was no significant differences in outcomes between the two groups. This observation suggests, neither single plane or complex plane end range procedures should be considered to have more or less 'clinical value' in determining if a patient is able to centralize.

Treatment classification systems targeting optimal care for LBP is viewed as advantageous by physical therapists however, perceived and/or logistical barriers often prevent full implementation of classification system recommendations into daily practice [6–8]. Practice

Figure 1. Scatter plot demonstrates five of 19 patients centralized only in a lying test position during the initial visit. Four of these patients had positive outcomes (ODI improvement > 10). These patients would not have benefited from directional exercise intervention if centralization assessment procedures were performed only in standing test positions.

Figure 2. Scatter plot demonstrates four of 19 patients centralized only in a complex plane of movement during the initial visit. Two of these patients had positive outcomes (ODI improvement > 10). These patients would not have benefited from directional exercise intervention if centralization assessment procedures were limited to single plane end range procedures.

guidelines recognize centralization as a classification system for people with LBP but do not explicitly promote the extent and choice of end range procedures that may be required for this phenomenon to occur [1]. It is reasonable to conclude many factors contribute to limiting the types of end range procedures used to assess centralization in clinical practice. Examples may include an absence of MDT® credentialing training, learning to assess centralization through ‘on the job training’ from therapists who may or may not be MDT® credentialed, incorrectly assigning more clinical utility to one type of directional exercise, or simply choosing to dedicate clinical time and resources to other treatment approaches to manage this patient population.

The trends observed in this study present the need to further investigate the role of comprehensive centralization assessment within treatment classification systems designed to manage patients with LBP.

Limitations

The findings of this study was limited by sample size and methodology. The small sample size limits statistical interpretation and prohibits generalizability of these findings in clinical practice. The maximum age for inclusion to participate in this study was not limited. Data collection were found to be more challenging than anticipated by the investigators. Participating physical therapists commented that it was not uncommon for patients to be reluctant to allow researchers to review their clinical chart. In addition, the extra time required to recruit patients and document data during an already busy clinic schedule limited the sample size. Because of these and potentially other factors, data collection were prolonged and sample size was far smaller than planned. Although patients were experiencing acute episode of LBP, the study did not document the descriptive characteristics differentiating between recurrent vs. new episodes, time since onset, etc., for each patient.

Feedback from participating physical therapist also revealed sample selection bias. The physical therapists tended to recruit patients that they felt would be a ‘good’

centralizer or have favorable outcomes. Another limitation of this study was an assumption that the MDT® trained therapists followed similar clinical reasoning, while assessing a patient’s ability to centralize. Future methodology of studies designed to investigate the relationship of outcomes and the types of end range procedures used to achieve centralization should standardize assessment procedures.

Conclusion

The types of end range procedures used to achieve centralization were not associated with clinical outcomes in this sample. This finding supports the MDT® recommendation to assess centralization using many different types of end range procedures in patients with LBP and/or referred lower extremity symptoms. Abbreviated screening procedures that limit the types of end range procedures used to assess centralization may result in failing to accurately identify patients who are able to achieve centralization and attain positive clinical outcomes. The small sample size and methodology of this study limit generalizability of these results. However, the trends observed in this study illustrate the need to further investigate; (1) the relationship between clinical outcomes and the types of end range procedures used to achieve centralization and, (2) inclusion of comprehensive centralization assessment procedures within treatment classification systems targeted at effective management of patients with LBP. Non-MDT trained clinicians should consider exploring strategies to expand the ‘comprehensiveness’ of the centralization assessment procedures they choose to use in clinical practice. Regardless of the extent of MDT training, clinicians who treat people with LBP and peripheral symptoms should consider a multitude of positions, postures, and movements to determine if a person may demonstrate centralization and have a positive outcome.

Declaration of interest

The authors report no declaration of interest.

Ethics

The study protocol was approved by the institutional review board at NOVA Southeastern University.

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Disclosure statement

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