Initial pain and disability characteristics can assist the prediction of the centralization phenomenon on initial assessment of patients with low back pain

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ABSTRACT

Objectives: Determine whether the achievement of the centralization phenomenon on initial assessment of patients with low back pain (LBP) can be predicted by history and physical examination variables.

Methods: Ninety patients referred to physical therapy due to LBP completed pain, disability, and fear-avoidance questionnaires, followed by a complete history and a physical examination based on mechanical diagnosis and therapy principles. Patients were subsequently classified as centralizers or noncentralizers. Univariate, followed by multivariate analysis was performed to identify history and physical examination variables that predicted the occurrence of the CP. Factors retained in the multivariate analysis were used to develop a clinical prediction rule (CPR).

Results: Twenty-eight patients (31%) were classified as centralizers immediately following assessment. Three predictors were retained in the multivariate analysis: (1) modified Oswestry Disability Index score lower than 33%; (2) intensity of the most distal symptom lower than 6/10; and (3) back pain equal to or greater than leg pain. The resultant CPR indicated the presence of all three variables increased the post-test likelihood of the CP to 57%.

Discussion: The findings of this study suggest the CP may be considerably more likely in less severe cases of LBP characterized by lower disability, lower intensity of distal symptoms, and a greater back-versus-leg pain intensity. Pending future validation, the CPR developed in this study may aid decision making regarding the initial management strategy of patients with LBP.

KEYWORDS

Low back pain; mechanical diagnosis and therapy; centralization phenomenon

Introduction

Mechanical diagnosis and therapy (MDT) is a widely used treatment approach for patients with low back pain (LBP) [1]. This approach uses repeated lumbar movements in specific directions (i.e. flexion, extension) in order to affect a positive change in patient's status. The best indicator of such positive change is a proximal migration of symptoms, also known as the centralization phenomenon (CP) [2]. Several studies suggest treatment by repeated lumbar movements in the direction producing the CP is associated with superior outcomes compared with various other interventions [3–6]. Furthermore, the CP, in and of itself, has been previously associated with a more favorable outcome among patients with LBP [2,7].

The assessment procedure aimed at producing the CP may be quit lengthy as it involves repeated lumbar movements in one or more directions of movement. Combined with the fact that the prevalence of the CP during a single assessment session has been previously reported as low as 17% [8], it seems valuable

time and effort may often be spent only to find the CP was not produced. Therefore, clinicians using the MDT approach may gain from an improved ability to a priori predict the likelihood of the CP.

Previous literature suggests the CP is more likely to occur among younger patients, in more recent onset LBP, and in the presence of lower levels of pain-related fear [8–10]. Several other factors, however, may also possess predictive potential for the CP. As the distribution of symptoms varies considerably among patients with LBP [11], and because the CP is predicated on a change in symptom distribution, it is possible that the initial distribution of symptoms possesses some predictive value for the CP. A previous study indicated patients classified to treatment by repeated lumbar movements were more likely to present with symptoms radiating into their lower extremities [12], suggesting a possible link between the CP and a more distal distribution of symptoms. However, the direct association between symptom distribution and the occurrence of the CP has not been previously established.

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Furthermore, since the CP has been previously associated with prognosis in patients with LBP [2,7], it is likewise possible that several other prognostic factors may be associated with the presence of the CP as well. Accordingly, LBP intensity [13], back-related disability [14], level of fear-avoidance behavior [14], the presence and extent of associated leg pain or the presence of signs of nerve root compression (NRC) [15–17], may also carry a predictive value for the CP. Finally, as a presentation consistent with greater leg-versus-back pain has been previously suggested to be the best indicator of lumbar NRC [18], this pain characteristic may also carry a predictive value for the CP.

When the likelihood of an outcome event is relatively low, its occurrence is dependent upon multiple factors, and its achievement requires considerable time and effort, clinical prediction rules (CPR) may be of most value [19]. Clinical prediction rules are decision-making tools aimed to assist clinicians in determining the likelihood of an outcome based on the presence or absence of specific predictors. A CPR for determining the likelihood of the CP may help promote a more efficient management of patients with LBP by suggesting which patients are more likely to gain from treatment by repeated lumbar movements. Therefore, the purpose of this study was to develop a preliminary CPR for predicting the likelihood of the CP among patients with LBP.

Methods

The study was approved by the Institution Review Board of XXXXXXXX, and all participants signed an informed consent form prior to participating in any of the procedures of the study.

Participants

Ninety consecutive patients (49 females) with an average $\pm$ SD age and body mass index of 47.2 ± 11.6 years and 26.7 ± 5.1 , respectively, who were referred by an orthopedic surgeon to an outpatient physical therapy clinic between January and December 2016 due to a main complaint of LBP, were recruited for this study. Participants were included if they were 18–65 years old with a main complaint of LBP with or without associated lower extremity symptoms. Participants presenting with signs suggesting NRC (i.e. decreased myotomal strength, diminished sensation in a dermatomal distribution, or diminished/absent Patellar and/or Achilles deep tendon reflexes) were included in the study. Potential participants were excluded if their subjective examination suggested the presence of ‘red flags’ (i.e. a history of malignancy, extensive use of corticosteroid medications, the presence of urinary/bowel retention, or the presence of fever associated with their LBP). Participants were also excluded if they

were pregnant, if they previously underwent surgery of the lumbar spine, or if they had a pending compensation claim associated with their LBP. Participants screening and recruitment into the study are summarized in Figure 1.

Examiner

A single physical therapist with over 8 years of experience in the management of musculoskeletal conditions performed all data collection procedures for this study. This therapist has completed all formal education offered by the McKenzie Institute (parts A–D), and has been incorporating MDT principles in his practice for over 2 years prior to commencing data collection for this study.

Procedure

Following informed consent, participants completed several questionnaires including demographic information, the Modified Oswestry Disability index (MODI) [20], the Fear-Avoidance Beliefs Questionnaire (FABQ) [21], and an 11-point (0–10) Numeric Pain Rating Scale (NPRS) [22], where ‘0’ represents ‘no pain’ and ‘10’ represents ‘extremely severe pain’. Participants then underwent a standardized history including a description of the distribution and nature of their symptoms, aggravating and relieving factors, duration, mode of onset, and previous interventions received for their current complaint. This was followed by testing for the presence of signs of NRC based on myotomal strength, dermatomal pin-prick sensation, Achilles and Patellar deep tendon reflexes, the straight leg raise and femoral nerve test [23]. Participants were then asked to assume a standing position for 1 min prior to completing a pretest body diagram (Figure 2). Participants were asked to shade in all areas of symptoms and verbally state their intensity. If symptoms were not provoked by standing, participants were asked to assume a sitting position for one additional minute before completing the pretest body diagram. If no symptoms were provoked following one minute of sitting, participants were excused from the study. The pretest body diagram was scored between 1 and 6 based on a transparent overlay template (Figure 2).

Mechanical diagnosis and therapy assessment

Immediately following the completion of the pretest body diagrams, participants underwent a standardized assessment of repeated lumbar movements and/or end-range positioning according to MDT principles [24]. The assessment followed three main principles: (1) assessment began in a standing position using repeated lumbar extension movements unless a clearly visible lateral shift deformity was observed. Extension was performed

Figure 1. Numeric overlay template (transparent) used to score the pre- and post-test body diagrams.

first as it is the direction of movement most commonly producing the CP [7]. When a lateral shift deformity was present assessment began with lateral movements (i.e. standing side-glides). (2) When symptom distribution was central or bilateral-symmetrical, only sagittal-plane movements were used (i.e. extension or flexion). Alternatively, when symptom distribution was unilateral or bilateral asymmetrical, lateral movements were also explored if sagittal-plane movements failed to produce the CP. (3) Movement tests were first performed actively, while patient and examiner overpressure

Figure 2. Flow diagram of participant screening and recruitment.

were added when patient status was unchanged by active movements alone.

At the conclusion of the MDT assessment (when the participant's verbal report suggested the CP has occurred, or after all movement directions were exhausted) participants assumed a standing or sitting position for one additional minute before completing a post-test body diagram documenting the distribution and intensity of their symptoms following the MDT assessment.

Independent (predictor) variables

The following variables served as potential predictors for the CP:

Age: analyzed as a continuous variable.

Symptom distribution: based on the pretest body diagram, symptoms were rated as 'proximal' when located in areas 1–2 of the overlay template, 'intermediate' when located in areas 3–4, or 'distal' when located in areas 5–6.

Overall pain intensity: based on the NPRS which averages the intensity of the current pain, maximal, and minimal intensity of pain over the previous 24 h [25].

Intensity of the most distal symptom: the intensity of the most distal symptom marked on each pretest body diagram was verbally rated on an 11-point (0–10) scale.

Back-versus-leg pain intensity: for this variable, symptoms marked in areas 1–3 were considered as

back pain, while symptoms marked in areas 4–6 were considered as leg pain. The intensity of the worst symptom within areas 1–3 was compared with that of the worst symptom within areas 4–6, in order to classify participants as having back pain greater than or equal to leg pain, or having leg pain greater than back pain. By convention, participants with no symptoms in areas 4–6 were classified as having back pain equal to or greater than leg pain.

Presence of nerve root compression: based on the presence of two or more signs of NRC (e.g. decreased ankle plantar-flexor strength and diminished Achilles deep tendon reflex) [23].

Duration of symptoms: categorically rated as acute (<30 days), subacute (30–89 days), or chronic (≥ 90 days).

Fear-avoidance beliefs: based on the score of each subscale (physical activity and work) of the Hebrew version of the FABQ [21].

Back-related disability: based on the score of the MODI [20].

Outcome measure

The primary outcome measure for this study was the presence or absence of the CP following MDT assessment. The CP was considered to have occurred when the score of the post-test body diagram was lower by ≥ 1 points compared with that of the pretest body diagram. The inter-rater reliability for determining the CP based on this procedure was previously reported as excellent ($k = 0.96$ – 1.0) [26].

Statistical analysis

Data were summarized using descriptive statistics with measures of central tendency and dispersion for continuous variables and frequency counts for categorical variables.

Logistic regression analysis was used for the primary purpose of the study. Based on previous literature, recruiting 10 participants for every predictor variable assessed was deemed sufficient [27], resulting in a total sample size of 90 participants. In order to further minimize the risk of overfitting, we initially performed a univariate analysis including T-tests and Chi-square tests for continuous and categorical variables, respectively, in order to assess for associations between each predictor and the CP. The level of significance for this analysis was $P \leq 0.10$ in order to prevent the exclusion of potential predictors of the CP. Continuous variables demonstrating significant associations with the CP were further analyzed using receiver operator characteristic (ROC) curves in order to detect the most accurate cutoff value for predicting the CP.

Variables demonstrating a significant univariate association with the CP were entered into

a forward multivariate stepwise logistic regression model. A significance level of $P \leq 0.05$ was required to enter the model and a significance level of $P > 0.10$ was used to remove a variable. Variables retained in the regression model were then used to develop the CPR for predicting the likelihood of the CP. Sensitivity, specificity, and likelihood ratio (LR) with their corresponding 95% confidence intervals (CIs) were calculated for each individual predictor, as well as the various combinations of predictors retained in the regression model. All statistical analyses were performed using SPSS statistical package (Version 16).

Results

Twenty-eight participants (31.1%) demonstrated the CP following MDT assessment. Table 1 summarizes the univariate association between the CP and each hypothesized predictor variables. Participants demonstrating the CP reported a significantly lower pain intensity (NPRS score 3.7 versus 4.4, $P = 0.09$), lower level of back-related disability (MODI score 27.9% versus 34.8%, $P = 0.01$), lower intensity of the most distal symptom on the pretest body diagram (3.4 versus 4.9, $P < 0.01$), and a greater likelihood of experiencing back pain $\geq$ leg pain (96.4% versus 82.3%, $P = 0.09$). As 'intensity of the most distal pain' (from the pretest body diagram) and 'overall pain intensity' (NPRS) were moderately correlated (Pearson $r = 0.62$, $P < 0.01$), we elected to include only 'intensity of the most distal symptom' in the multivariate analysis. As this variable represents the pain intensity at the outset of the assessment for CP, we believed it was more likely to predict its' likelihood than the average pain over the preceding 24 h (i.e. the NPRS).

The ROC curve analyses indicated the best cutoff thresholds for discriminating between participants with and without the CP were a MODI lower than 33.0% and an intensity of the most distal symptom lower than 6/10.

Table 2 presents the findings of the logistic regression analysis. All three variables (MODI $< 33\%$, intensity of the most distal symptom $< 6/10$, and back pain $\geq$ leg pain) were retained in the final model (Chi-square = 24.25, $df = 3$, $P < 0.001$, Naglekerke $R^2 = 0.33$). Table 3 presents the frequency of the CP based on each of the predictors retained in the logistic regression, while Table 4 presents the sensitivity, specificity, LR and post-test probability of the CP based on the presence of different numbers of predictor variables. The presence of all three predictors was associated with the greatest LR (2.90), and a post-test probability for the presence of the CP equaling of 57% (Table 4).

Table 1. Demographic, history, and physical examination variables among the entire sample, participants with and participants without the CP.

Variable	All participants	Participants demonstrating the CP (N = 28)	Participants not demonstrating the CP (N = 62)	P value
Sex (female), n (%)	49.0 (54.4%)	15.0 (53.6%)	34.0 (58.8%)	0.91
Age, years	47.0 ± 12.0	47.8 ± 12.6	46.9 ± 11.2	0.78
BMI, kg/m ² *	26.7 ± 5.1	26.8 ± 5.6	26.6 ± 4.9	0.88
Education, (postsecondary), n (%)	22.0 (24.4%)	9.0 (32.1%)	13.0 (21.0%)	0.25
Smoker, n (%)	25.0 (27.8%)	5.0 (17.9%)	20.0 (32.3%)	0.16
Duration, days				0.62
0–30	24.0 (26.7%)	8.0 (28.6%)	16.0 (25.8%)	
31–90	21.0 (23.3%)	8.0 (28.6%)	13.0 (21.0%)	
≥91	45.0 (50.0%)	12.0 (42.9%)	33.0 (53.2%)	
Symptom distribution: ^a				0.38
Proximal	41.0 (45.6%)	15.0 (53.6%)	26.0 (41.9%)	
Intermediate	21.0 (23.3%)	7.0 (25.0%)	14.0 (22.6%)	
Distal	28.0 (31.1%)	6.0 (21.4%)	22.0 (35.5%)	
Signs of NRC, n (%)	9.0 (10.0%)	2.0 (7.1)	7.0 (11.3%)	0.72
MODI (0–100)	32.6 ± 13.5	27.9 ± 7.8	34.8 ± 14.9	0.01
NPRS (0–10)	4.2 ± 1.9	3.7 ± 1.4	4.4 ± 2.0	0.09
FABQ-PA (0–24)	14.9 ± 4.7	13.9 ± 4.2	15.3 ± 4.9	0.21
FABQ-W (0–42)	18.6 ± 11.0	16.6 ± 11.8	19.5 ± 10.8	0.24
Intensity of the most distal symptom (0–10)	4.4 ± 2.2	3.4 ± 1.5	4.9 ± 2.3	<0.001
Back-versus-leg pain intensity (back pain ≥ leg pain), n (%)	78.0 (86.7%)	27.0 (96.4%)	51.0 (82.3%)	0.09

*Body mass index.

^aProximal: lumbar; Intermediate: buttock/thigh; Distal: calf/foot**Table 2.** Predictors of the CP based on the multivariate logistic regression.

Predictor	Coefficient	Odds ratio	95% CI	P value
MODI < 33%	1.70	5.48	1.72–17.42	0.004
Back pain ≥ leg pain	2.18	8.84	0.99–78.33	0.05
Intensity of the most distal symptom < 6/10	2.43	11.37	1.37–94.45	0.02

Discussion

A preliminary CPR for predicting the likelihood of CP following a single assessment session has been developed. The predictor variables comprising this CPR suggest the CP is more likely to occur in less severe cases of LBP, characterized by a lower level of disability, and pain characteristics which are generally considered to be less concerning from a medical perspective [18,28,29].

As both lower levels of disability, as well as the CP have been previously found to predict a better prognosis among patients with LBP [2,7,13], the predictive ability of back-related disability seems reasonable. Although back-related disability is likely to result from a multitude of factors, it may also reflect the amount of underlying tissue damage. Consequently, lower levels of disability may suggest

a greater potential for a more rapid change in symptom distribution following repeated lumbar movements.

The association between the intensity of the most distal symptom and the CP may be due to the very definition of the CP. As the CP is considered to have occurred when the most distal symptom is completely abolished, this may be more likely to occur when the intensity of this symptom is lower to begin with. If spinally referred symptoms are the result of abnormal tissue stress within the spinal canal, as suggested by McKenzie and May [24], a lower intensity of referred symptoms may indicate a lower level of tissue disruption, which may be more amenable to immediate changes following repeated lumbar movements.

Finally, as greater intensity of leg-versus-back pain has been previously associated with the presence of lumbar NRC [18,30], the opposite presentation (back pain ≥ leg pain) is more likely to imply a less severe lumbar condition, which may be more amenable to a rapid change in symptom distribution as well.

The frequency of the CP in the present study was somewhat in between the frequency found in previous studies using similar methods for determining the CP (31.1% versus 17–40% previously [8,9,31]). Unlike two of these studies [8,9], neither age nor the

Table 3. Accuracy statistics for each individual predictor.

Predictor	Sensitivity (95% CI)	Specificity (95% CI)	+LR (95% CI)	–LR (95% CI)
MODI score < 33%	0.82 (0.63, 0.93)	0.50 (0.37, 0.62)	1.60 (1.20, 2.20)	0.40 (0.20, 0.80)
Intensity of distal symptom < 6/10	0.96 (0.81, 0.99)	0.32 (0.21, 0.45)	1.40 (1.20, 1.80)	0.10 (0.00, 0.80)
Back pain ≥ leg pain	0.96 (0.82, 1.00)	0.18 (0.09, 0.29)	1.20 (1.00, –1.30)	0.20 (0.03, 1.50)

Table 4. Sensitivity, specificity, positive likelihood ratio, and post-test probability of the CP based on the presence of different numbers of predictor variables.

No. of predictor variables present	Sensitivity (95% CI)	Specificity (95% CI)	Positive likelihood ratio (95% CI)	Post-test probability of the CP
3	0.75 (0.55, 0.89)	0.74 (0.62, 0.85)	2.90 (1.80, 4.70)	57%
≥2	1.00 (0.88, 1.00)	0.24 (0.14, 0.37)	1.30 (1.20, 1.50)	37%
≥1	1.00 (0.88, 1.00)	0.02 (0.04, 0.09)	1.02 (0.90, 1.10)	32%
0	0.00 (0.00, 0.12)	0.98 (0.91, 0.99)	0.00 (0.03, 17.00)	0%

duration of symptoms were associated with the likelihood for the CP. This is agreement with another recent investigation utilizing similar definition of the CP. Although a direct comparison is not possible, it seems participants in the studies reporting these associations exhibited higher initial pain and disability levels compared with participants in the current sample. Furthermore, although all studies utilized an MDT assessment approach, it is likely some variability in the assessment procedures still existed due to the multiple examiners involved in most previous studies. One possible advantage of the current investigation is the use of a single examiner which likely contributed to a more uniform assessment procedure.

The CPR derived in the present study may help guide the physical therapy management of patients with LBP. Given a 57% post-test probability for the CP in the presence of all three predictors, clinicians may feel more confident choosing repeated lumbar movements as their initial management strategy. However, in the absence of any of the predictors, and the associated post-test probability of 0%, clinicians may initially opt for an alternative management strategy.

Study limitations

The current investigation has several limitations. As with any CPR, the current rule must first undergo validation in a separate sample before it can be recommended for use in clinical practice. Second, our findings are limited to the prediction of the CP during a single evaluation session. While, it is certainly possible some patients that do not demonstrate the CP during initial assessment will go on to do so on subsequent sessions [32], we believe attaining the CP during the initial assessment of a patient is far more likely to instill clinician and patient confidence in the outcome of repeated lumbar movements. Consequently we believe the ability to predict the CP on initial patient assessment is of utmost importance.

Third, the predictive ability of any model is only as good as the predictors selected for analysis. Except for fear-avoidance beliefs, which has been previously associated with the CP [10], several other psychosocial variables such as pain coping style, psychiatric

comorbidity, and satisfaction with employment that have been previously related to prognosis among patients with LBP [14,16,33,34], could have helped increase the predictive ability of our model. The inclusion of these variables should be considered in future studies. Forth, as some have suggested larger sample sizes may need to be used for logistic regression analysis [35], the potential for a type I error cannot be ruled out based on our sample size. Finally, as the examiner collecting data on all predictors also performed the MDT assessment and determined the presence/absence of the CP, examiner bias cannot be ruled out. Nevertheless, the use of a highly standardized MDT assessment procedure, and the strict criteria used for determining the presence of the CP, minimize the potential for such bias in our view.

Conclusion

A preliminary CPR for predicting the likelihood of the CP has been developed. The predictors comprising the CPR suggest the CP is more likely to occur in less severe cases of LBP. Pending future validation, the CPR developed in this study may help clinicians decide when to use repeated lumbar movements as their initial management strategy and when to opt for an alternative management option.

Disclosure statement

No potential conflict of interest was reported by the authors.

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