Association Between Centralization and Directional Preference and Functional and Pain Outcomes in Patients With Neck Pain

Researchers have suggested that classifying patients into subgroups based on clinical characteristics and matching these subgroups to management strategies improve patient outcomes of physical therapy interventions.5,10,26,37 Classification of patients with neck pain has been recommended as a research priority.5,16 Nevertheless, there is insufficient information regarding how to classify these patients to inform physical therapy interventions that optimize outcomes.

Two examination procedures used to classify patients with spinal pain have been studied: centralization (CEN) and directional preference (DP). These examination procedures, which are derived from Mechanical Diagnosis and Therapy methods, inform clinical decisions and guide patient management. A classification method that combines CEN and DP principles, called the “patient response method,” has subsequently been proposed and recommended for use with patients with nonserious lumbar spine pain.36

A number of studies have demonstrated that in relation to low back pain, CEN and DP are of clinical value. CEN has been shown to predict decreased disability,3,23,24,33–37 return to work,13,14,15,23,24,33 and reduced pain.23,24,33–37 In several studies, prescribing exercises matched to the patient’s DP has improved low back pain outcomes.2,20–21 In 1 study (level 3 evidence), the authors suggested that the patient response method delineated and improved the prediction of pain and function outcomes in patients with low back pain.36

CEN is operationally defined as spinal pain that is progressively abolished in a distal-to-proximal direction in response to therapeutic movement and positioning strategies, without consideration of intensity.24,26,34,37 DP is determined by whether spine and/or referred spinal pain located in the most distal body part decreases in intensity, abolishes, or centralizes, and/or whether subjects demonstrate an improvement in range of motion in response to a repeated-movement or positional-loading strategy.25 Individuals not meeting these criteria are considered

STUDY DESIGN: Retrospective cohort.
OBJECTIVES: In subjects with neck pain, the present study aimed (1) to describe the prevalence of centralization (CEN), noncentralization (non-CEN), directional preference (DP), and no directional preference (no DP); (2) to determine if age, sex, fear-avoidance beliefs about physical activity, number of comorbid conditions, or symptom duration varies among subjects who demonstrate CEN versus non-CEN and DP versus no DP; and (3) to determine if CEN and/or DP are associated with changes in function and pain.
BACKGROUND: CEN and DP are prevalent among patients with low back pain and should be considered when determining treatment strategies and predicting outcomes; however, these findings are not well investigated in patients with neck pain.
METHODS: Three hundred four subjects contributed data. CEN and DP prevalence were calculated, as was the association between CEN and DP, and age, sex, number of comorbid conditions, fear-avoidance beliefs, and symptom duration. Multivariate models assessed whether CEN and DP predicted change in function and pain.
RESULTS: CEN and DP prevalence were 0.4 and 0.2, respectively. Younger subjects and those with fewer comorbid conditions were more likely to centralize; however, subjects who demonstrated DP were more likely to have acute symptoms. Subjects who centralized, on average, had a 3.6-point (95% confidence interval: −0.3, 7.4) improvement in function scores, whereas subjects with a DP averaged a 5.4-point (95% confidence interval: 0.8, 10.0) improvement. Neither CEN nor DP was associated with pain outcomes.
KEY WORDS: cervical spine, functional rehabilitation, pain.

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to have non-CEN and no DP, respectively. The decision rules for judging CEN and DP are therefore similar but not synonymous. When CEN is present, DP must also be present. In contrast, DP might occur in the absence of CEN (eg, a patient’s lower-leg pain may decrease in intensity but not change in location with a specific repeated-movement or positional-loading strategy). CEN has also been shown to occur in the cervical spine. The prevalence of CEN, identified using the same operational definition described above, was reported to be 0.3, 0.4, and 0.2 in prior studies. In the latter study, prevalence decreased among more chronic and older subjects. The prevalence of DP among subjects with neck pain has not been reported in prior literature and remains unknown.

Several studies have addressed the predictive value of CEN, using the aforementioned definition, in subjects with cervical impairments. CEN has been shown to be predictive of reduced disability and pain. In 1 of these studies, however, CEN was not associated with changes in disability.

There are no studies that have examined the clinical effectiveness of DP or the patient response method in patients with cervical impairments. It is therefore unknown if subgrouping patients by pain responses using CEN and DP would improve the clinical interpretation of patient outcomes, as previously demonstrated in subjects with lumbar impairments. The present study adds to the current literature by examining the prevalence and characteristics of CEN and DP, and the association between changes in functional outcomes and pain responses based on categorization by CEN and DP, among patients with neck pain.

METHODS

This retrospective cohort study analyzed data from 328 subjects with neck pain who contributed data to Focus On Therapeutic Outcomes, Inc (Knoxville, TN), an international medical rehabilitation data-management company. Subjects represented a convenience sample of patients seen from July 2007 through December 2010 who had complete data and could be classified as having CEN or non-CEN at intake. Subjects with no pain or relevant referred symptoms immediately before repeated-movement testing were excluded from our sample because they were not eligible for categorization as CEN or non-CEN. These 328 subjects were classified and treated by 8 physical therapists (mean age, 43 years; range, 32-61 years; 8 male) who routinely utilized Mechanical Diagnosis and Therapy methods when treating patients with spinal pain. Four therapists had received additional postgraduate training and had credentials in Mechanical Diagnosis and Therapy. The average number of years of clinical experience was 16 (range, 9-41). Practice settings were diverse: 3 therapists were employed in hospital-based outpatient clinics, 4 therapists worked in 3 different private practices, and 1 therapist worked in 2 military orthopaedic outpatient clinics. Not all physical therapists collected data during the entire study period, as 3 physical therapists started data collection in the summer of 2009 and 4 were either transferred between clinics or had non-patient responsibilities that interrupted data collection.

Subjects were classified as having CEN or non-CEN at intake. These categories have been recommended for routine use and operationally described for patients with lumbar impairments. Briefly, patients were classified by quantifying changes in pain location observed during the initial physical therapy visit. At this time, they underwent a standard physical examination according to Mechanical Diagnosis and Therapy assessment methods, without consideration of symptom intensity, using a body diagram and numeric overlay template. This template has been previously described and shown to have acceptable reliability (κ = 0.9-1.0). Subjects were instructed by the examiner to shade in all areas on a body diagram where they were experiencing spinal pain and referred symptoms. Body diagrams were completed in sitting before and after end-range, repeated neck movements and/or positioning techniques. The overlay template was placed over the body diagrams, which allowed quantification of the anatomical location of pain. To be classified as having CEN, a reduction of at least 1 pain location after testing was required. If pain location increased or remained the same after repeated-movement tests, the
The subjects’ functional status was quantified at intake and discharge with the 36-item Functional Health Status (FHS-36) questionnaire, a physical function health status measure. The FHS-36 has been described in detail elsewhere. Measures range from 0 (low functioning) to 100 (high functioning) on a linear metric. Data support the empirical item hierarchy, unidimensionality, reproducibility of item calibrations, and content and construct validity of the FHS-36. In addition, 80% of the FHS-36 measures had standard errors of 2 or 3 FHS-36 units, or minimal detectable changes of 5 to 7 units. Furthermore, the FHS-36 was reported to be sensitive to functional change during treatment for patients with cervical impairments (effect size, 0.9).

Maximal pain intensity reported by the subject during the past 24 hours was assessed using an 11-point numeric pain rating scale, ranging from 0 (no pain) to 10 (worst imaginable pain). The numeric pain rating scale has been reported to be reliable and valid in this population, and has been shown to have a minimal detectable improvement of 4.1 points in subjects with cervical radiculopathy.

The Focus On Therapeutic Outcomes, Inc Institutional Review Board for the Protection of Human Subjects and the Rutgers, The State University of New Jersey Institutional Review Board approved this project. The requirement for informed consent was waived by both Institutional Review Boards.

Data Analysis
Data were analyzed using SAS Version 9.2 (SAS Institute Inc, Cary, NC). Descriptive statistics, the association between CEN and DP, as well as age, sex, number of comorbid conditions, FABQ-PA, and symptom duration were calculated. The association between each of these demographic measures and CEN and DP was evaluated using logistic regression analyses.

Linear regression models were used to evaluate the association between CEN and DP, and changes in function and pain levels. For these analyses, we calculated the prevalence of CEN and DP in
The prevalence of CEN and DP, both separately and together, is provided in Table 1. The prevalence of CEN and DP was 0.4 and 0.7, respectively. Among subjects with a DP, 84% exhibited a DP into extension. Because all subjects who demonstrated CEN also had a DP, when combining categorizations of CEN and DP, the largest group consisted of those who demonstrated both CEN and DP (prevalence, 0.4).

Descriptive statistics on subjects who contributed data on CEN and DP are provided in Table 2. Sex was not associated with CEN (P = .50; odds ratio [OR] = 1.18; 95% confidence interval [CI]: 0.73, 1.89) or DP (P = .53; OR = 0.85; 95% CI: 0.50, 1.43). Younger subjects (global P = .01; OR = 1.93; 95% CI: 0.92, 4.05 or OR = 2.91; 95% CI: 1.36, 6.21, depending on comparison) and subjects with fewer comorbidities (global P = .03; OR = 1.13; 95% CI: 0.58, 2.19 to OR = 2.47; 95% CI: 1.25, 4.85, depending on comparison) were significantly more likely to demonstrate CEN than older subjects and subjects with more comorbidities; however, age (global P = .32; OR = 1.08; 95% CI: 0.52, 2.25 or OR = 1.60; 95% CI: 0.74, 3.45, depending on comparison) and comorbidity (global P = .11; OR = 0.71; 95% CI: 0.36, 1.42 to OR = 2.49; 95% CI: 0.83, 7.44, depending on comparison) were not associated with DP. Conversely, symptom duration was not associated with CEN (P = .07; OR = 1.15;
The prevalence of CEN among subjects with neck pain in the present study and that reported in 3 prior studies\(^3\),\(^2\)\(^4\),\(^3\) ranges from 0.2 to 0.4. In our study, the prevalence of CEN was slightly higher (0.4), despite similar definitions of CEN. This variability in prevalence rates across studies is likely attributable to differences in the populations studied and the assessment methods used to measure CEN, as well as the exclusion from our analyses of those subjects who could not be classified. Ours is the first study to describe the prevalence of DP among subjects with neck pain. The difference in prevalence rates between CEN and DP was expected because of the additional criteria used to determine DP. At 0.7, determining DP has the potential to inform interventions for a substantial number of patients with neck pain. When pain responses were classified using the patient response method, the largest group was CEN and DP; however, a substantial percentage of patients (30%) were identified as having DP in the absence of CEN.

We hypothesized that when comparing CEN with non-CEN, and DP with no DP, there would be differences in age and symptom duration. In our study, age was associated with CEN but not with DP, whereas symptom duration was associated with DP but not with CEN. One other study has addressed the association between CEN and age and symptom duration in subjects with neck pain,\(^3\) the findings of which, in relation to age, are consistent with ours. However, in that study,\(^3\) subjects who demonstrated CEN were more likely to have acute symptoms than those with non-CEN. We also found that subjects with CEN had fewer comorbid conditions, but there were no

### TABLE 2

<table>
<thead>
<tr>
<th>Category of CEN and DP</th>
<th>CEN/DP, n</th>
<th>Non-CEN, n</th>
<th>Non-CEN/DP, n</th>
<th>Non-CEN/No DP, n</th>
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**Abbreviations:** CEN, centralization; DP, direction preference; FABQ-PA, Fear-Avoidance Beliefs Questionnaire physical activities subscale.

*See the FIGURE for categorization information (n = 302).
differences in the number of comorbid conditions among subjects with a DP. Differences in age, number of comorbid conditions, and symptom duration between categories of CEN and DP provide additional support for the assertion that CEN and DP represent different clinical entities.

We also hypothesized that CEN and DP would predict changes in functional outcomes and pain levels. When combined with treatments consisting of matched exercises and manual techniques, in our study, DP compared with no DP and CEN compared with non-CEN/no DP predicted changes in function but not pain. None of the categories of CEN or DP, including the patient response method, predicted pain outcomes.

In 3 other studies, investigators reported on the association between CEN and function and pain outcomes in patients with cervical impairments, using similar operational definitions for categorizing CEN. In 2 of these studies, results for subjects with low back pain were combined with those for subjects with neck pain. CEN was associated with a greater reduction in disability and pain in both studies. In the third study, CEN was associated with a greater reduction in pain but not with functional levels for subjects with cervical impairments. These studies differ from ours, in which CEN was not associated with changes in function or pain, except in relation to functional changes, and only when CEN was compared with non-CEN/no DP.

This is the first study to address characteristics of CEN and DP in subjects with neck pain in the same study. In relation to achieving a minimal detectable improvement in function of at least 5 points, our study results suggest that DP compared with no DP and CEN/DP compared with non-CEN/no DP predict functional outcomes.

The association between functional outcomes and CEN/DP and non-CEN/DP categories was not significant, suggesting that dividing DP into these 2 subcategories at intake may not be clinically useful. If a patient demonstrates a DP during the initial evaluation, further delineation for a CEN pain response does not appear useful to predict outcomes from physical therapy interventions. Therefore, evaluating patients with neck pain solely for DP as operationally defined in our study appears to be the best strategy of those addressed in this study to improve the interpretation of functional outcomes. Future studies are required to replicate our findings using larger sample sizes and long-term outcome assessments.

We excluded patients who had no pain or relevant referred symptoms immediately before repeated-movement testing. These subjects, although small in number (n = 22) compared to our original sample, might represent an important category of patients to identify for effective treatment strategies.

Because all subjects who demonstrated CEN or DP received matched treatments based on DP, our study results show that the categorizations of CEN and DP were associated with improvements in function when subjects with neck pain also received treatment based on DP. It is therefore possible that CEN and DP predict better functional outcomes irrespective of treatment. If research findings in the lumbar spine are generalizable to

| TABLE 3 | Mean Difference in Change in Function Score Based on Category of CEN and DP* |
| Univariate Model Mean Difference (n = 264)  | P Value | Multivariate Model Mean Difference (n = 264)  | P Value |
| CEN and DP versus non-CEN | 5.4 (1.4, 9.4) | .01 | 3.6 (0.3, 7.4) | .07 |
| DP irrespective of CEN versus no DP | 77 (29, 123) | <.01 | 5.4 (0.8, 10.0) | .02 |
| CEN and DP versus non-CEN and DP | 3.0 (-15.75) | .19 | 1.8 (-2.5, 6.2) | .41 |
| CEN and DP versus non-CEN and no DP | 8.9 (3.8, 14.0) | <.01 | 6.2 (1.3, 11.1) | .01 |

*Abbreviations: CEN, centralization; DP, directional preference.
†The reference group constitutes those who demonstrated CEN and/or a DP. A positive number indicates that subjects who demonstrated CEN and/or a DP had a greater improvement in function score, whereas a negative number indicates that these subjects reported a greater loss of function. Note that the categorization of a combination of CEN and no DP was not included because it is not clinically feasible, based on our operational definition, and therefore not observed.
‡Values in parentheses are 95% confidence interval.
§Controlling for age and symptom duration.

| TABLE 4 | Mean Difference in Change in Pain Score Based on Category of CEN and DP* |
| Univariate Model Mean Difference (n = 191)  | P Value | Multivariate Model Mean Difference (n = 191)  | P Value |
| CEN and DP versus non-CEN | 0.5 (-0.2, 1.1) | .20 | 0.4 (-0.3, 1.1) | .28 |
| DP irrespective of CEN versus no DP | 0.8 (0.0, 1.6) | .04 | 0.7 (0.0, 1.5) | .08 |
| CEN and DP versus non-CEN and DP | 0.2 (-0.9, 0.6) | .69 | 0.1 (-0.7, 0.9) | .75 |
| CEN and DP versus non-CEN and no DP | 0.9 (0.0, 1.7) | .05 | 0.7 (-0.1, 1.6) | .09 |

*Abbreviations: CEN, centralization; DP, directional preference.
†The reference group constitutes those who demonstrated CEN and/or a DP. A positive number indicates that subjects who demonstrated CEN and/or a DP had a greater reduction in pain score, whereas a negative number indicates that these subjects reported a greater increase in pain. Note that the categorization of a combination of CEN and no DP was not included because it is not clinically feasible, based on our operational definition, and therefore not observed.
‡Values in parentheses are 95% confidence interval.
§Controlling for age and symptom duration.
testing and treatment strategies involving repeated and progressive movements in a specific direction based on DP.

Despite these limitations, our study provides support for including DP in any treatment-based classification system for patients with neck pain, as it informs interventions that result in improved functional outcomes.

CONCLUSION

DP is a prevalent evaluation category that, when combined with treatments consisting of matched exercises and manual techniques, can be used to predict changes in function, but not pain, in patients with neck pain.

KEY POINTS

- **FINDINGS:** DP is a prevalent examination finding that predicts improvement in function when combined with treatments matched to the direction of the DP.

- **IMPLICATIONS:** The evaluation of DP should be a component of the physical therapy examination of patients with neck pain and, when present, should inform intervention strategies.

- **CAUTION:** Criteria for identifying and categorizing DP in patients with neck pain need further refinement.

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REFERENCES

14. Hart DL, Connolly JB. Pay-for-Performance for...


