Pain pattern classification and directional preference are associated with clinical outcomes for patients with low back pain

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ABSTRACT

Pain Pattern Classification (PPC) and Directional Preference (DP) have shown merit as reliable and predictable clinical solutions to help reduce the burden posed by low back pain (LBP). We conducted a prospective, observational cohort study to verify the association between PPC, DP, and clinical outcomes. We hypothesized that (1) patients who demonstrated DP Centralization (CEN) would have lower pain intensity and disability at follow-up than patients who demonstrated Non-DP Non-CEN, and (2) the prevalence of DP at first examination would be lowest for patients with chronic LBP and are greater than 65 years old. First examination and follow-up data were completed by 639 patients. Clinical outcome measures, including pain intensity and disability, were collected at first examination and follow-up. Baseline comparisons were made between groups with first examination data only and groups with first examination data and follow-up data. A Pearson's chi-squared test was used to determine differences in prevalence rates for the categorical variables, and two-sample *t*-tests were used for the continuous variables. A Turkey's range test was used to determine differences in follow-up pain intensity and disability for LBP dual-classifications. Multiple regression was used to investigate DP prevalence considering risk adjusted factors. Overall prevalence of DP was 84.5% and prevalence was lowest for patients with sub-acute symptoms. No significant difference existed for the prevalence of DP for patients based on age. Patients classified as DP CEN had, on average, 1.99 pain intensity units less than patients classified as Non-DP Non-CEN at follow-up. Patients classified as DP CEN had, on average, 3.43 RMDQ units less than patients classified as Non-DP Non-CEN at follow-up. These findings support previous reports, verifying the association between LBP dual-classification schemes and clinical outcomes.

KEYWORDS

Lumbar spine; low back pain; centralization; directional preference; McKenzie

Introduction

Low back pain (LBP) is a human and economic burden. LBP is one of the top health care expenditures and the second most common cause of disability for adults in the United States [1–3]. Health care stakeholders are seeking economic solutions [4]. Subsequently, LBP classification by way of mutually exclusive sub-groups which have a predictable set of clinical and cost-related outcomes has been made a research priority [5–7].

The predictive potential of Pain Pattern Classification (PPC) and Directional Preference (DP) may provide the framework to assist management of individuals affected by LBP. Historically, the development of a PPC and DP framework evolved due to concerns related to the accuracy of assessment and documentation of the presence of Centralization (CEN) and DP. Until recently, no standardized, operationally defined measure of CEN and DP has existed. Many systematic reviews and randomized controlled trials have investigated the utility of CEN and DP without consideration of how CEN and DP were defined. These investigations have found CEN and DP to

be as high as 89% [8]. Only one other prospective, cohort study by Werneke et al. has investigated the effect of a strict, standardized, operational definition of CEN and DP for patients with LBP [9]. This study found prevalence of CEN to be 41% and DP to be 60% in patients with LBP impairments. Poorly defined measures may have led to inaccurate representations of CEN and DP, and raises concerns about the accuracy of systematic review and comparative effectiveness research findings.

Compared to previous measurement methods for the presence of CEN, PPC, and DP are physical examination measures which more precisely identify and quantify change in behavior of the signs and symptoms associated with LBP [9–13]. Determinants of PPC and DP require strict, operational definitions to classify LBP by way of a cause and effect assessment process based on the principles of Mechanical Diagnosis and Therapy (MDT) [14]. In MDT assessment, patients are asked to repeat and/or sustain uni-directional, end-range movements while their symptomatic and movement baselines are recorded. Werneke et al. have described this

novel PPC and DP classification procedure elsewhere [11]. Briefly, change in patients' location of symptoms, pain intensity, and/or other movement baselines characterize the type of LBP, guide treatment, and inform prognosis [14–19]. PPC and DP may accompany one another, yet, they are not synonymous. For example, CEN, a PPC, always accompanies DP; however, DP does not always accompany CEN. Werneke describes three common observed findings when recording PPC: CEN, Non-Centralization (Non-CEN), and not able to be classified (NC) [8]. The finding of Non-CEN includes patients whose resting symptoms do not move proximally toward the midline of the spine, do not change, or move distally away from the spine during examination. The finding of NC consists of patients who do not have symptoms at rest during the beginning of the physical examination. It has been recommended that PPC and DP should be combined to create five dual-classification schemes: (1) DP CEN, (2) DP Non-CEN, (3) DP NC, (4) Non-DP Non-CEN, and (5) Non-DP NC.

Only one other study has examined the relationship between PPC and DP dual-classification schemes and clinical outcomes for patients with LBP [9]. As many of the previous investigations regarding CEN and DP have not typically used a strict, operational definition for CEN and DP, the purpose of this study is to verify the association between dual-classification schemes and clinical outcomes for patients with LBP using a strict, operational definition by way of PPC and DP as described by Werneke et al. This investigation found that CEN and DP were associated with favorable outcomes, and were more prevalent among younger patients with acute symptoms. Therefore, we seek to verify these findings in our population. We hypothesize that (1) patients who demonstrate DP CEN will have lower pain intensity and disability at follow-up than patients who demonstrate Non-DP Non-CEN, and (2) the prevalence of DP at first examination will be lowest for patients that have chronic LBP and are greater than 65 years old.

Methodology

We conducted a prospective, observational cohort study. We analyzed data collected from 1006 consecutive patients who presented to outpatient, private practice clinics with primary complaints of non-specific LBP (see Figure 1). The Florida Agricultural and Mechanical University Institutional Review Board for Protection of Human Subjects and the Florida State University Institutional Review Board for Protection of Human Subjects approved the project. The study did not include any change in routine clinical practice, and patient informed consent was not required for the analysis and reporting of data.

Ten providers participated in the study (mean age: 39 years, range: 27–64; 30% females; mean years of clinical experience: 13.5). All providers participated

Figure 1. Flow of participants entering and included in the study.

throughout five private practice, outpatient orthopedic settings in Florida, Alabama, Oklahoma, South Carolina, and New York. Six providers were certified in MDT and four held their diploma in MDT. Two providers were Board Certified Orthopedic Clinical Specialists. All providers attained, at least, a bachelor's degree in physical therapy and four held their Doctor of Physical Therapy. Patients were included in the study by the managing provider if they presented with complaints of non-specific LBP with or without radiation into the lower extremities. Patients were excluded from the study if they had lumbar spine surgery within the preceding 12 months. All but three providers collected data from the patients throughout the study period (February 2014–May 2015). Two providers were unable to continue data collection after April 2014 and a third after February 2015.

Providers collected patient reported and clinical examination responses at first examination, regularly throughout the care episode, and at discharge. The managing providers were responsible for determining and reporting inclusion, exclusion, and discharge status. Two primary patient-reported outcomes were assessed: pain intensity and patient self-reported disability via the Numeric Pain Rating Scale (NPRS) and the Roland Morris Disability Questionnaire (RMDQ), respectively. Pain intensity reported by the patient within 'the last few days' was assessed using an 11-point NPRS ranging from 0 ('No Pain') to 10 ('Worst Pain Imaginable'). Childs et al. reported that a two-point pain intensity unit change represents clinically meaningful change that exceeds the bounds of measurement error [20]. The RMDQ is a patient self-report questionnaire for LBP and is scored by summing the number of items checked by the patient (e.g. 'Because of my back and/or leg pain, I use a handrail to get upstairs'). The score can vary ranging from 0 to 24. Ostelo et al. reported a minimally important change in

the RMDQ score of five points (out of 24) or 30% from the baseline score [21]. Both the 11-point NPRS and the RMDQ have been shown to be acceptable clinical measures for patients with non-specific LBP [22].

Two primary physical examination variables were collected by the managing providers at first examination: PPC and DP. PPC consisted of three categories: CEN, Non-CEN, and NC. Patients' LBP presentations were categorized by the managing provider into one of the three PPC schemes as described by Werneke et al. [11] Providers classified patients by quantifying observed changes in the patient's symptom location during the physical examination. Patients were asked to indicate the location of their symptoms, in a standing position, by shading in on a body diagram before and after physical examination testing. Providers determined and recorded the patient's LBP PPC via an overlay template.

Patients' LBP was classified by the managing providers as having DP as described by Werneke et al. [9] at first examination if it exhibited any of the following (1) CEN, (2) a decrease in the patient's most relevant distal pain by at least two pain intensity units, (3) an increase in lumbar spine range of motion via a bubble inclinometer, (4) an improvement in the patient's aberrant lumbar spine movement described by Hicks et al. [23], (5) patient-reported improvement in their range of motion (e.g. patients often stated 'it feels better'), (6) improvement in the patients neurological signs (i.e. improvement in lower extremity reflexes, lower extremity myotomes by one manual muscle test grade, sitting Slump Test, and/or lower extremity dermatomes), and (7) improvement in a patient's pain with a specific functional task by at least two pain intensity units (e.g. lifting a box, squatting, or other functional based lumbar spine movement).

Patient characteristics were collected at first examination by the managing providers through patient self-report methods. The following continuous variables were measured: Age, Medication for Condition, Symptom Acuity, Previous Surgery, Fear-Avoidance Beliefs at first examination, pain intensity at first examination, RMDQ at first examination, and Number of Comorbid Conditions. The following categorical variables were measured: Gender, Facility, Provider, Previous History of Condition, Imaging, Payer, Exercise History, and Referral Type.

Patient-reported outcomes and physical examination data were collected by the managing provider at first examination, regularly throughout the care episode, and at discharge through patient self-report and provider-reported methods. Patients were asked to complete self-report measures (i.e. the NPRS and the RMDQ) by the managing provider immediately before the first examination, at regular intervals immediately after follow-up examinations, and then at discharge.

Our primary aim was to analyze the association between DP CEN and Non-DP Non-CEN, and report prevalence of classification groups. The dual-classification schemes recommended by Werneke et al. were

as follows: (1) DP CEN, (2) DP Non-CEN, (3) DP NC, (4) Non-DP Non-CEN, and (5) Non-DP NC. To determine prevalence rates, we used Pearson's chi-squared tests to determine differences in prevalence rates for the categorical variables, and used two-sample *t*-tests for the continuous variables. To determine differences in follow-up pain intensity and disability, we used Turkey's range test (i.e. one of the pairwise comparison methodologies) for patients who were classified as DP CEN, DP Non-CEN, DP NC, Non-DP Non-CEN, and Non-DP NC at first examination. We utilized a multiple regression methodology to investigate DP prevalence considering Age, Gender, Facility, Provider, Symptom Acuity, Medication for Condition, Previous History, Imaging, Previous Surgery, Number of Comorbid Conditions, Payer, Exercise History, Referral Type, RMDQ at first examination, Fear-Avoidance Beliefs at first examination, and pain intensity at first examination.

Prior to the start of the study, participating providers and supporting administrative personnel received three, one-hour training sessions regarding data collection and management practices. Providers were advised to review a standard operating procedure developed by our research network. The document included detailed instructions on study procedures, operational definitions of the constructs being measured, and sample case study vignettes. Providers in the study were advised to use scripted introductions and standardized procedures when administering self-report questionnaires and physical examination tests.

Results

1006 consecutive patients entered the clinic during the study period. 66 patients did not start data collection resulting in a participation rate of 93%. Reasons for not commencing data collection included: Late for Appointment (26.9%), Seen on a Single Occasion and Provided with a HEP Only (17.8%), Other (16.4%), Cognitive Deficits (9.0%), Language Difficulties (7.5%), Contraindication and Referred Back to Physician/Specialist (6.0%), Refused (6.0%), Reading Ability (4.5%), Blind or Impaired Vision (1.5%), Increased Pain (1.5%), Out of Paperwork (1.5%), and Unrelated Medical Problems (1.5%). The characteristics of the study participants are displayed in Table 1.

Compared to patients with first examination and follow-up data ($n = 639$; 68% completion rate), patients with first examination data only ($n = 301$) had more chronic symptoms (Symptom Acuity: $\chi^2 = 11.5$, $df = 2$, p -value = 0.003), were taking more medication (Medication for Condition: $\chi^2 = 4.0$, $df = 1$, p -value = 0.046), had more imaging (Imaging: $\chi^2 = 8.0$, $df = 2$, p -value = 0.02), had more referrals from Other (Referral Type: $\chi^2 = 18.9$, $df = 3$, p -value = 0.0003), had more comorbidities (Number of Comorbid Conditions: $\chi^2 = 11.4$, $df = 3$, p -value = 0.01), had a higher proportion of HMO-based insurance

Table 1. Patient characteristics.

Characteristics	First examination only (n = 301)	First examination and follow-up data (n = 639)
Age (y)	51.6 ± 15.5 (14–92)	51.5 ± 17.4 (6–94)
Missing	0.3%	1.6%
Gender		
Male	44.5%	45.7%
Female	55.2%	54.3%
Missing	0.3%	0.0%
Symptom acuity		
Acute (0–2 weeks)	17.9%	22.7%
Sub-Acute (3–11 weeks)	25.9%	32.5%
Chronic (≥12 weeks)	55.8%	43.7%
Missing	0.3%	1.1%
Surgical history		
None	91.0%	93.3%
1 or More	7.0%	5.0%
Missing	2.0%	1.7%
Medication for condition		
None	38.9%	47.3%
1 or More	57.1%	51.6%
Missing	4.0%	1.1%
Imaging		
None	45.2%	54.6%
1	39.5%	33.3%
2 or More	14.3%	10.7%
Missing	1.0%	1.4%
Exercise history		
1 or 2 times per week	20.3%	23.6%
At least 3 times per week	37.2%	40.7%
Seldom or not at all	36.2%	32.7%
Missing	6.3%	3.0%
Referral type		
Primary care	50.2%	58.2%
Specialist	15.3%	15.2%
Self	7.3%	10.6%
Other	27.2%	15.6%
Missing	0.0%	0.3%
Number of comorbid conditions		
None	16.3%	22.5%
1	25.9%	23.6%
2 or 3	29.9%	36.0%
4 or more	21.3%	14.9%
Missing	6.7%	3.0%
Payer		
Auto	2.0%	1.9%
Health maintenance organization (HMO)	70.1%	57.0%
Medicaid	1.3%	0.6%
Medicare part B	6.3%	7.8%
Patient private pay	0.3%	0.2%
Preferred provider organization (PPO)	16.6%	28.2%
Workers' compensation	0.7%	1.7%
Other	2.7%	2.5%
Missing	0.0%	0.2%
Fear-avoidance beliefs		
High Fear	49.8%	45.4%
Low fear	41.9%	49.3%
Missing	8.3%	5.3%
RMDQ first examination	9.1 ± 6.2 (0–24)	7.8 ± 5.2 (0–23)
Missing	7.3%	5.5%
Pain Intensity first examination	5.8 ± 2.5 (0–10)	5.7 ± 2.4 (0–10)
Missing	2.7%	0.5%

(Payer: $\chi^2 = 20.8$, $df = 7$, p -value = 0.004), and were more disabled (RMDQ at First Examination: $t = 3.2$, $df = 463$, p -value = 0.002). Reasons for not completing follow-up data collection were: Lost to Follow-Up (88.7%), Other (4.6%), Unrelated Medical Problems (2.3%), Contraindication and Referred Back to Physician/Specialist (1.3%), Increased Pain (1.0%), Insurance Coverage (0.7%), Language Difficulties (0.7%), Family or Work Conflict (0.3%), and Pain Management (0.3%).

Table 2. Prevalence of directional preference and pain pattern at first examination (n = 639).

	CEN	NC	Non-CEN	Missing	Total
DP	19.3	16.4	33.2	15.6	84.5
Non-DP	0.0	6.3	5.5	1.6	13.3
Missing	0.3	0.3	0.3%	1.3	2.2
Total	19.6	23.0	38.9	18.5	100.0

Table 3. Prevalence of directional preference and pain pattern vs. acuity (n = 639).

	Acute	Sub-Acute	Chronic
DP	73 (66, 80)	62 (55, 68)	73 (68, 78)
DP & Cen	18 (12, 25)	21 (16, 27)	18 (14, 23)
DP & NC	18 (12, 24)	15 (10, 20)	17 (13, 22)
DP & Non-Cen	37 (29, 45)	25 (20, 31)	37 (32, 43)
Non-DP	6 (2, 10)	16 (11, 21)	11 (7, 15)
Non-DP & NC	5 (1, 8)	9 (5, 13)	5 (2, 8)
Non-DP & Non-Cen	1 (0, 3)	7 (4, 11)	6 (3, 9)
Missing	21	22	16

Notes: Chi-square P -value = 0.04.

Values are proportions (percent) of patients or prevalence rates (95% confidence interval).

Table 4. Prevalence of directional preference and pain pattern vs. Age (n = 639).

	<45 y	45–65 y	>65 y
DP	71 (64, 77)	69 (63, 74)	67 (60, 75)
DP & Cen	22 (16, 28)	23 (18, 27)	10 (5, 15)
DP & NC	20 (15, 26)	12 (9, 16)	19 (13, 25)
DP & Non-Cen	28 (22, 35)	34 (28, 39)	39 (31, 46)
Non-DP	11 (7, 16)	13 (9, 17)	10 (6, 15)
Non-DP & NC	8 (4, 12)	5 (3, 8)	6 (2, 10)
Non-DP & Non-Cen	3 (1, 6)	7 (4, 10)	5 (1, 8)
Missing	18	19	22

Notes: Chi-square P -value = 0.004.

Values are proportions (percent) of patients or prevalence rates (95% confidence interval).

We converted the following continuous variable to categories: Age – <18 y, 18–44 y, 45–65 y, and >65 y; Symptom Acuity – Acute (0–2 weeks), Sub-Acute (3–11 weeks), and Chronic (≥12 weeks); Surgical History – None and 1 or More; Medication for Condition – None and 1 or More; Number of Comorbid Conditions – None, 1, 2 or 3, and 4 or More; Imaging – None, 1, and 2 or More; Fear-Avoidance Beliefs – Low Fear (<14) and High Fear (≥14).

Dual-classification schemes were categorized as follows: DP CEN, DP Non-CEN, DP NC, Non-DP Non-CEN, and Non-DP NC. The prevalence of DP was 84.5%. The prevalence of CEN, Non-CEN, and NC were 19.6, 38.9, and 23.0%, respectively (see Table 2). A significant difference existed for the prevalence of DP of patients with sub-acute symptoms (see Table 3). No significant difference existed for the prevalence of DP for patients based on age (see Table 4).

We analyzed the effect of PPC and DP on pain intensity and disability at follow-up. Patients classified as DP CEN had, on average, 1.99 pain intensity units less than patients classified as Non-DP Non-CEN at follow-up (see Table 5). Patients classified as DP CEN had, on average,

Table 5. Follow-up Pain Intensity Index Pair Comparison (n = 639).

Comparison group	Reference group	Mean difference	95% CI	P-value
DP & NC	DP & Cen	0.24	[-0.47, 0.94]	0.89
DP & Non-Cen	DP & Cen	0.61	[0.01, 1.20]	0.04
Non-DP & NC	DP & Cen	-0.01	[-0.97, 0.95]	1.00
Non-DP & Non-Cen	DP & Cen	1.99	[0.98, 3.00]	0.00
DP & Non-Cen	DP & NC	0.37	[-0.27, 1.01]	0.51
Non-DP & NC	DP & NC	-0.25	[-1.23, 0.74]	0.96
Non-DP & Non-Cen	DP & NC	1.75	[0.72, 2.79]	0.00
Non-DP & NC	DP & Non-Cen	-0.62	[-1.52, 0.29]	0.34
Non-DP & Non-Cen	DP & Non-Cen	1.39	[0.42, 2.35]	0.00
Non-DP & Non-Cen	Non-DP & NC	2.00	[0.78, 3.22]	0.00

Note: The Mean Difference was calculated by subtracting the mean change in NPRS score from first examination to follow-up for the Comparison Group from the mean change in NPRS score from first examination to follow-up for the Reference Group (Reference Group mean change minus Comparison Group mean change = Mean Difference).

Table 6. Follow-up disability index pair comparison (n = 639).

Comparison group	Reference group	Mean difference	95% CI	P-value
DP & NC	DP & Cen	1.09	[-0.44, 2.61]	0.29
DP & Non-Cen	DP & Cen	1.33	[0.05, 2.61]	0.04
Non-DP & NC	DP & Cen	-0.23	[-2.31, 1.85]	1.00
Non-DP & Non-Cen	DP & Cen	3.43	[1.30, 5.56]	0.00
DP & Non-Cen	DP & NC	0.24	[-1.14, 1.62]	0.99
Non-DP & NC	DP & NC	-1.32	[-3.47, 0.83]	0.44
Non-DP & Non-Cen	DP & NC	2.34	[0.15, 4.53]	0.03
Non-DP & NC	DP & Non-Cen	-1.56	[-3.54, 0.42]	0.20
Non-DP & Non-Cen	DP & Non-Cen	2.10	[0.08, 4.13]	0.04
Non-DP & Non-Cen	Non-DP & NC	3.66	[1.05, 6.27]	0.00

Note: The Mean Difference was calculated by subtracting the mean change in RMDQ score from first examination to follow-up for the Comparison Group from the mean change in RMDQ score from first examination to follow-up for the Reference Group (Reference Group mean change minus Comparison Group mean change = Mean Difference).

3.43 RMDQ units less than patients classified as Non-DP Non-Cen at follow-up (see Table 6). Post hoc analysis of the effect of PPC and DP on pain intensity and disability at follow-up revealed that patients classified as Non-DP NC had, on average, 2.00 pain intensity units less than patients classified as Non-DP Non-Cen at follow-up, and patients classified as Non-DP NC had, on average, 3.66 RMDQ units less than patients classified as Non-DP Non-Cen at follow-up. The average time to discharge for patients with DP and Non-DP was 33.8 and 35.0 days, respectively.

Discussion

Our primary findings in this investigation were (1) patients who demonstrated DP-CEN had lower pain intensity and disability at follow-up than patients who demonstrated Non-DP Non-Cen, and (2) DP prevalence was lowest for patients with sub-acute symptoms and no significant difference existed for the prevalence of DP for patients based on age.

Consistent with a previous report, more patients were classified as exhibiting DP than CEN. Overall prevalence of DP and CEN were 84.5% and 19.6%, respectively. The

high prevalence of DP was not surprising due to its broad, more encompassing operational definition. Interestingly, the prevalence of DP was lowest for patients with sub-acute symptoms and DP prevalence did not exhibit significant differences across age groups. This finding was inconsistent with our hypothesis of the prevalence of DP being lowest for patients who have chronic LBP and are greater than 65 years old. A systematic review by May and Aina found that CEN was less prevalent in patients with chronic symptoms and who were older among 62 studies [8]. Werneke et al. reported a decrease in prevalence rates of DP as symptoms became more chronic and age increased [9]. Differences in DP prevalence rates across studies may have contributed to this finding. DP was significantly more prevalent (84.5%) in this investigation compared to the investigation reported by Werneke et al. (60%) [9]. Furthermore, the definition of CEN and DP used may have contributed to this inconsistency. Our study used a strict, operational definition of CEN by way of PPC and specifically defined DP constructs. Therefore, comparisons between investigations may be limited due to the methodology used to determine the presence of CEN and DP. Future studies should measure CEN and DP by way of the aforementioned standardized, operational definition to enable comparability between trials.

Based on a previous investigation, we sought to verify the association between DP CEN and Non-DP Non-Cen. Patients who exhibited DP CEN had a significant minimally important difference in pain intensity and disability compared to patients who exhibited Non-DP Non-Cen. This finding was consistent with our hypothesis and confirmed a previous report indicating that CEN is generally associated with a favorable prognosis [9]. Post hoc analysis revealed another consistency with a previous report; the NC classification was also associated with favorable outcomes, and our analysis indicated that Non-DP NC demonstrated a significant minimally important difference in pain intensity and disability compared to patients who exhibited Non-DP Non-Cen. The NC group consisted of patients who did not exhibit symptoms at baseline during the first examination and may have exhibited other physical examination findings not captured by PPC and DP. Patients who do not exhibit symptoms at rest during the physical examination typically have a lower severity of illness and, therefore, their condition may be more amenable to recovery. In addition, certain factors related to the type of DP may influence outcome. Patients' LBP presentation may manifest differently and still be considered DP. Future studies should investigate the association between DP specific manifestations (e.g. quantifiable changes in ROM, neurological signs, and/or pain intensity units) and clinical outcomes for patients classified as NC. We suspect that certain DP specific constructs may be more or less associated with clinical outcomes and could provide insight for providers to more accurately predict recovery.

There are several important considerations relative to our findings. The results of our investigation may not be generalizable to providers without advanced training. Providers in this study had high levels of training in MDT. We encourage other providers with varying levels of training to test the external validity by conducting this type of investigation. Practiced-Based Evidence investigations, like this one, attempt to determine causation by examining associations between robust patient characteristics, treatment processes, and outcomes during typical, everyday practice [24–32]. We encourage others to perform similar, repeat investigations which could strengthen the validity of these findings and/or provide insight for re-engineering gold-standard practices [33].

Patients were classified by the managing provider via PPC and DP upon their first examination only; however, we were not able to determine if individuals that exhibited Non-CEN transferred to CEN on subsequent re-examinations. Therefore, the prevalence of CEN could have been higher. Furthermore, we were only able to analyze the clinical outcomes collected at the most recent follow-up and therefore, could not determine long-term effects. Detailed interventions during the study period were not recorded; however, providers in the study were trained to deliver interventions that attempted to elicit DP and/or CEN through end-range, repeated, and/or sustained movements in one spinal direction. Individually tailored interventions guided by DP and CEN have been associated with rapid improvement and superior clinical outcomes when compared to generic exercise programs [34]. Therefore, overall group improvement may, in fact, be related to individually tailored interventions via the PPC and DP guiding framework. However, we are unable to determine if the outcomes achieved were due to the prognostic value of the system, the treatment performed, or a combination. Patient characteristics and other external factors, such as intervention characteristics, affect treatment outcomes, and all three types of data are important so as to discern if the outcomes achieved are due to the interventions performed or the individual patient characteristics. Future studies should consider investigating the correspondence between dual-classification schemes and detailed interventions. We did not report on the initial pain intensity and disability at first examination for each sub-group, and further studies should consider reporting pain intensity and disability magnitude of change as well as baseline values to make more clinically meaningful interpretations.

Conclusion

Our primary findings in this report corroborate previous research and may assist providers in making predictions of clinical outcomes for patients with LBP by using a standardized, operational definition of CEN and DP. Our data suggests that (1) patients who demonstrated DP-CEN had lower pain intensity and disability

at follow-up than patients who demonstrated Non-DP Non-CEN, and (2) DP prevalence was lowest for patients with sub-acute symptoms and no significant difference existed for the prevalence of DP for patients based on age. Those interested in CEN and DP should employ a strict, operational definition to facilitate complete, accurate, and precise representations of incidence, prevalence, and predictive utility.

Disclaimer statements

Contributors

RJY conceived and designed the study, obtained funded and ethics approval, analysed the data, wrote the article in whole/part, and revised the article. MT analysed and reported the data. AO wrote the article in part. MW collected and analysed the data, and wrote the article in part. JT collected and analysed the data.

Disclosure statement

No potential conflict of interest was reported by the authors.

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