Validation of a pain mechanism classification system (PMCS) in physical therapy practice

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The objective of this study was to validate the clinical application of a pain mechanism classification system (PMCS) in clinical practice. We analyzed data abstracted from the medical records of patients who were treated in the outpatient clinics of a large urban rehabilitation hospital in Chicago. We hypothesized that there would be good agreement between the PMCS determined by trained therapists and the PMCS category assigned based on a computer-generated statistical model using patients' signs and symptoms. Using cluster analysis, when we assumed five groups, 97% of patients could be classified. Sensitivity and specificity results with 95% confidence intervals were calculated for the categories using the physical therapist assigned categories (PMCS) as the criterion standard. Sensitivity for four of the five categories (inflammatory, ischemia, peripheral neurogenic, and other ranged from 72.0 to 83.1%). For the central mechanism, sensitivity was much lower at 15%. Specificity for the five categories ranged from 72.4% (ischemia) to 98.8% (central). This study provides empirical support for recent findings in the literature that the peripheral components of a PMCS can be implemented consistently in an outpatient pain clinical practice.

Keywords: Pain, Pain mechanisms, Classification, Validity, Physical therapy

Introduction

Pain is a multifaceted experience with differing physiological mechanisms representing mechanical, cognitive, emotional, and social dimensions. Musculoskeletal pain has physical, neurological, cognitive, and psychoemotional causes.¹⁻⁶ When only structure or pathoanatomy are considered as causes of musculoskeletal pain, and all other potential causes are not considered, problems may arise in determining the diagnosis, staging the disorder, deciding appropriate treatment, and predicting outcomes.⁷ This may lead to overutilization of resources, inaccurate diagnoses, ineffective interventions, and poor patient outcomes.⁸⁻¹⁰

Pain mechanism classification systems (PMCSs) have been introduced into the diagnostic process for pain practitioners such as physical therapists (PTs) and physicians.¹¹⁻¹³ The clinical indicators of nociceptive,

peripheral neuropathic, and central mechanisms have been used to classify patients' reports of pain.¹¹ Classification systems improve the ability to diagnose, select appropriate interventions or referrals, and guide communication.¹⁴⁻¹⁷ The routine use of a PMCS in clinical practice could aid pain practitioners in developing screening and monitoring tools, clinical decision making regarding selection of intervention strategies (e.g., manual therapy, exercise, modalities, cognitive behavioral therapy), and utilization of intervention algorithms and prediction rules. As a result, practitioners could more effectively identify patients who are at risk of unnecessarily high service utilization, poor outcomes, and/or both.¹⁸ Early identification of patients with central mechanisms can facilitate realistic expectations for outcomes, appropriate allocation of resources, and where appropriate, redirection to other services such as psychology. Theoretical support exists for the pain mechanism classification system; however, there is little empirical evidence available to support the use of the system to facilitate consistency in

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decision-making. A preliminary inter- and intra-examiner reliability study concluded that two therapists reliably diagnosed the dominant pain mechanism of patients with low back and leg pain, but concluded that a study with a larger sample of patients with multiple independent examiners was needed.¹² Evidence for discriminative validity of the classification system was established for categories of nociceptive, peripheral neuropathic, and central sensitization with a larger population of patients.¹³ The PMCS described by Gifford and Butler¹⁹ was modified and implemented into PT practice within the outpatient clinics of a rehabilitation hospital during the last 11 years.¹⁵ The PMCS divides pain into six categories based on mechanisms described in the pain literature: nociceptive inflammatory, nociceptive ischemic, peripheral neurogenic, central sensitization, and affective and motor autonomic.¹⁹ Further analysis of the use of the PMCS was warranted to determine its validity in outpatient PT clinical practice.

Methods

Pain mechanism classification system

A modified PMCS used was a combination of Gifford and Butler's first reported PMCS and the system created at the Rehabilitation Institute of Chicago¹⁹. Subjective clinical signs and symptoms were used to classify the patients into one of the PMCS categories using standardized forms in the electronic medical record (Table 1). The treating therapists were responsible for classifying and reporting the patients' dominant pain mechanism on initial evaluation. Clinicians documented additional clinical data in a text format in the electronic medical record (EMR). Areas of the EMR where clinicians utilized text format were coded if the information that was documented related to the patients' reports of pain. Text that was not related to the patients' reports of pain was not used in analysis. Following data extraction from the EMR and prior to analysis, we grouped the pain mechanisms of central sensitization,

Table 1 Signs and symptoms of PMCS pain mechanisms

Nociceptive inflammatory
• Location: clearly localized
• Onset: typically within 2 weeks or recent flare-up of chronic condition
• Usually rapidly resolving with predictive soft tissue healing guidelines
• Descriptors: swollen, stiffness, crackling, dull ache or throb
• Frequency: constant or intermittent
• 24-hour behavior: AM and PM increase; as day goes on better, diurnal pattern
• Pain is associated with cardinal signs of inflammation (i.e. swelling, redness, heat)
• Pain of recent onset (less than 12 weeks)
• Medications: responds to simple NSAIDs, and Ice
• Pain associated with a 24-hour behavior change, diurnal pattern
Nociceptive ischemia
• Location: localized
• Frequency: intermittent
• Descriptors: Fatigue, weakness or tightness
• Injury greater than 12 weeks or gradual onset
• Clear, proportionate mechanical/anatomic nature to aggravating and easing factors
• Usually with predictive soft tissue healing guidelines, may need to initiate remodeling guidelines
• Worse typically after prolonged activity, no pain at rest
• Plateaus in healing remain unchanged in course of this episode
• Doesn't respond as well to NSAIDs or Ice
• Usually intermittent with movement/mechanical provocation
• Onset: no apparent reason — positional or cumulative or greater than 21 days after connective tissue injury=remodeling
• 24-hour behavior: worse in PM or after activity or position for 1–3 hours. AM typically better
Peripheral neurogenic
• Location: localized to dermatome or cutaneous nerve field
• Frequency: constant or intermittent
• Descriptors: deep aching, cramping-muscle; burning, parasthesia, sharp, stinging
• Pain variously described as burning, shooting, sharp, aching or electric-shock-like, numbness, tingling, weakness
• History of nerve injury, onset may be within 12 weeks, if beyond healing time frames may be pathology or mechanical compromise
• Less responsive to simple analgesia/NSAIDs
Central
• Onset: chronic >4 months — after normal healing time
• Descriptors: no consistency, use graphic and irritable. Pain can be of high severity and unpredictable nature
• Major distinguishing factor for affective pain is pain as a result of psychological trauma, i.e. major trauma, abuse, neglect, and accident — may be job-related
• 24-hour behavior: erratic, not consistent, may report stress is a big factor
• No relationship between stimulus and response — common latency effect with movement exam
• Pain disproportionate to the nature and extent of injury or pathology
• Widespread, non-anatomical distribution of pain
• History of failed interventions (medical/surgical/therapeutic)
• More constant/unremitting pain.
• Night pain/disturbed sleep.
• Complaints of swelling, spasticity, tone, discoloration of skin, skin, and hair sensitivities may have immune, GI, endocrine, parasympathetic and sympathetic systems symptoms/complications

affective and motor autonomic into a single ‘central’ mechanism given the low frequency of patients who could be classified into these mechanisms. We hypothesized that there would be good agreement between the PT-assigned PMCS and the PMCS category assigned by the statistical model based on patient signs and symptoms. Therefore, patients’ dominant mechanisms were classified as inflammatory, ischemic, peripheral neurogenic, or central. Patients who were classified as having multiple pain mechanisms were labeled as ‘other.’

Study design and setting

Secondary data analysis was performed on the medical records of patients who were treated in the outpatient clinics of a large urban rehabilitation hospital in Chicago, IL, USA. The study was approved by the Northwestern University Institutional Review Board.

Participants

Study participants included patients with pain seeking PT treatment and the PTs employed at an outpatient clinic of a rehabilitation hospital between the years of 2009–2010 who provided this treatment.

Patients

Patient data were extracted from the electronic medical records. We included the records of patients with data collected at start and end of care if the same PT completed both the initial and discharge documentation. Records were excluded for patients who reported no pain on initial evaluation, or whose primary reason for seeking therapy was based on a functional limitation, such as a balance limitation or urge incontinence, rather than a limitation of function secondary to pain. Records of patients were included if the patient was treated by a therapist trained in the PMCS who consented to the study. We acquired a total of 39 900 records from patients discharged in calendar years 2009–2010, of which 18 808 records met the inclusion criteria. Of the 18 808 patients included in analyses, 56% were female and the mean age was 45.8 years (standard deviation: 22.4; range: 0.5–101). Primary pain location was not defined in 10 612 records because the primary therapist did not record this in the specific data field we used to define pain location. These records were not included in the analysis. Pain location may have been recorded in a free-text data field instead of in the box marked primary pain location.

PTs

For this study, we sought to examine the agreement of the PMCS category assigned by trained PTs and the category assigned by a statistical model. Musculoskeletal PTs practicing in the outpatient clinics at a rehabilitation hospital implemented a modified PMCS, which was delivered through a PT education and training program based on the clinical criteria

utilized in this system. We gathered characteristics of the treating therapists by survey because these data are not included in patient records. All PTs working in outpatient settings within the rehabilitation hospital system who treated patients in 2009–2010 were asked to participate in the study by completing the survey. PTs were consented and contacted in person, via mail, or via email. Fifty-four out of 144 PTs (37.5%) consented and returned the survey. The consenting PTs treated 78% of the patient record sample.

PTs were asked to report the following information:

- amount of musculoskeletal pain mechanism classification training at the rehabilitation hospital;
- amount of experience with the McKenzie Method of Mechanical Diagnosis and Therapy;
- number of Neuro-Orthopedic Institute training courses (0, 1, or >1 course);
- therapist years of experience;
- therapist entry and highest level of physical therapy degree achieved;
- therapist certification by the American Board of Physical Therapy Specialties
- Any or other specific pain training courses (labeled as ‘Other’).

PTs were trained in using the modified classification system through either an in-person or an online training program. The training program at the hospital was developed by a team of neurological and orthopedic physical and occupational therapists who specialized in the management of musculoskeletal pain. This training program curriculum was based on clinician experience, scientific literature and general consensus. Training was provided through a variety of formats that could be matched to the therapists’ learning style and availability. PTs independently read a pain manual (approximately 200 pages), completed a 4-hour online presentation, or attended a 1- or 2-day continuing education course provided by staff. Physical therapists were assigned into one of four training level categories: untrained (received no formal training on the PMCS), low (received exposure to the PMCS through interactions with work colleagues), moderate (completed a self-study of the PMCS manual and course work), or advanced (attended the 1- to 2-day continuing education pain course provided by staff). These training categories represent the therapist level of exposure to the PMCS material, as instructed through the hospital’s outpatient education and training programs.

Statistical analysis

Descriptive statistics were used to characterize the patients and the therapists. Cluster analysis was used to assign patients into a pain mechanism category based on the descriptors listed in Table 1 using information documented in the patient record. By comparing measures of inter-individual proximity in multivariate space, cluster analysis assigns patients to

clusters that maximize both intra-group homogeneity and inter-group heterogeneity. We constrained our analyses by assuming that the sample would divide into a minimum of one pain mechanism category, and a maximum of six categories, testing every integer from one through six. The minimum allowed for the possibility that no pain mechanism differences existed in the sample, while the maximum represents every possible combination of individual pain mechanisms. We used raw, untransformed isotope data and squared Euclidean distance as the inter-individual proximity measure for all analyses.

The data split best into five pain mechanism categories, based on the degree of overlap between the clustering methods. The one-, two-, three-, and four-group clustering models were rejected due to high degrees of within-cluster heterogeneity, which limited their utility in precise pain mechanism reconstruction and were inconsistent with substantial variability within and between populations in the sample. The six-group model was rejected because it produced a lower rate of overlap between hierarchical and *k*-means case assignments than did the three and four group clustering regimes. Assuming four groups, the unweighted pair-group method with arithmetic mean (UPGMA) using the average hierarchical and *k*-means methods assigned 95% patients to clusters in the same way. When we assumed five groups, UPGMA and *k*-means also classified 97% of patients the same way to the same clusters. Among all such comparisons, the latter had the highest rate of consistency between clustering methods. Patients who were classified by the cluster analysis and the therapist as having multiple pain mechanisms were labeled as 'Other'.

We report the results in a cross-tabulation table to show how often the categories assigned by the PTs were also selected by the statistical model. Using the PT-assigned categories as a 'criterion standard,' we calculated sensitivity and specificity values for each category. We considered the PT-assigned categories as the 'criterion standard,' because clinicians have the benefit of observing patient behaviors and comments that may not be documented consistently in medical records. Therefore, we considered that the clinician

had more complete information on which to base their decision. Sensitivity refers to how often the test will be positive if a person has a condition (true positive rate). For this study, we calculated sensitivity as the number of patients assigned to a category by the statistical model divided by the number of patients assigned to the category by PTs. Specificity refers to how often the test will be negative if a person does not have the condition (true negative rate). For this study, we calculated specificity as the number of patients not assigned to the category by the statistical model divided by the total number not assigned to the category by PTs. The data analysis for this paper was generated using SAS/STAT software, Version 9.4 of the SAS System for Windows (SAS Institute Inc., Cary, NC, USA)

Results

Of the patient records included in our analyses, the most common primary pain locations were lower back (40.8%), knee (12.5%), neck (10.5%), shoulder (10.0%), and hip (7.2%). Less than 3% of the patients listed multiple pain locations, which included general pain, secondary, or additional pain location categories. Individuals with multiple pain locations were included in the data analysis. Among the 24 PTs who completed the survey and were trained (moderate or advanced groups), 92% were female and reported having received some level of PMCS training education. Demographics of the therapists trained in the PMCS system are reported in Table 2.

Sensitivity for four of the five categories (inflammatory, ischemia, peripheral neurogenic, and other mechanisms) ranged from 72 to 83.1%. For the central mechanism, sensitivity was much lower at 15.7%. Specificity for the five categories ranged from 72.4% (ischemia) to 98.8% (central) (Table 3). We found good agreement between the statistical model-pain mechanism categories and the treating therapist PMCS categories for four (inflammatory, ischemia, peripheral neurogenic, and other mechanisms) out of five categories in patients classified by the 24 PTs trained in the PMCS system. Kappa estimate calculated at 0.50 (95% confidence limit: 0.49–0.51). Table 3 provides sensitivity, specificity, positive and negative

Table 2 Characteristics of the therapists trained in pain mechanism classification system

Characteristics	
Gender	2 males, 22 females
Entry level PT degree	10 BA/BS, 8 MPT/MSPT, 6 DPT
Years of experience	Mean=15.70; SD 9.3
NOI training	10 had prior coursework, 5 had taken more than 1 course by David Butler
Other course work	19/24 had in addition taken 'other pain coursework'
Mechanical training	15 taken MDT Training A–D, four of which had certification in MDT
Postgraduate degree	2 post graduate DPTs, 6 postgraduate Masters
Clinical specialization	10 orthopedic clinical specialists, 1 neurological clinical specialist, 1 geriatric clinical specialist, and 3 women's health clinical specialists

Note: MDT: mechanical diagnosis and therapy; NOI, Neuro Orthopedic Institute.

predictive value results with 95% confidence intervals for the categories using the statistical model compared to the PT assigned categories as the 'criterion standard'.

Table 4 provides the cross-tabulation of computer generated pain categories and those assigned by the trained therapists. Among the 1749 patients assigned to the inflammatory category by the treating PTs, 1260 (72%; 69.8–74.1%) were assigned to this same category by the statistical model. For the 6470 patients who were classified as having ischemia by the PTs, 5379 (83.1%; 82.2–84.0%) were classified into the same group by the statistical model. For the peripheral neurogenic category, 734 (75.1%; 72.2–77.7%) of the 978 patients were classified by the statistical model. For the central mechanism, PTs assigned 4664 patients into this category, but fewer than half (734) were assigned to this same category by the statistical model (15.7%; 14.7–16.8%). For the other category, PTs assigned 4947 patients into this group, and 3724 (75.3%; 74.1–76.5%) were assigned to this same group by the statistical model. Positive predictive value ranged from 44.4% (42.5–46.2%) for inflammatory pain to 81.2% (78.5–79.8%) for central mechanisms. The negative predictive value ranged from 78.0% (77.4–78.7%) for central pain to 96.9% (96.7–97.2%) for inflammatory pain mechanisms.

Discussion

These results provide support for our hypothesis that there would be good agreement in PMCS assignment between therapists trained in a PMCS and a statistical model based on patient signs and symptoms. The objective was to determine if PTs in a clinical setting could classify patients presenting with musculoskeletal pain into a classification system upon initial evaluation. In utilizing any classification system, it is important to determine whether large numbers of therapists can accurately apply the system in clinical practice and if enough therapists will utilize the system with consistency. Examining diagnostic accuracy, however, requires a comparison or criterion measure. Clinicians presumably integrate a multitude of patient factors, injury-related factors, and other considerations, many of which are observed but not documented during the evaluation, to reach a diagnosis. We used the cluster analysis to create computer-generated categories based on these characteristics, which are

available in the EMR. Cluster analysis allowed us to generate categories of classification based on documented signs and symptoms for musculoskeletal pain, including neuromuscular conditions. This study, on a large scale, provides empirical support for recent findings in the literature that a PMCS can be implemented consistently in clinical practice by a group of trained practitioners. The PTs in this study diagnosed peripheral pain mechanisms with good agreement to the statistical model; however, they diagnosed central mechanisms far more frequently than the statistical model on the initial visit. We believe that this may have occurred because therapists could observe the patients' psychosocial clinical characteristics, and perhaps other factors (whether recorded or not), which were not available for use in the statistical model. The question still remains whether distinguishing between the pain mechanisms of central sensitization, affective and/or motor autonomic mechanism is possible. For this study, the central mechanism category included all three central mechanisms, as the sample did not exhibit sufficient variability to permit more distinct classification.

Smart *et al.*¹¹ reported that expert clinicians are able to differentiate the clinical criteria of the nociceptive, peripheral neurogenic, and central categories. We chose to investigate the inflammatory and ischemia nociceptive mechanisms separately because the treatment, patient education, and outcomes for these two mechanisms are distinct. Smart *et al.*¹² demonstrated moderate inter- and intra-examiner agreement in a pain classification system between two clinicians investigating those with low back pain disorders. Later, Smart *et al.*¹³ provided evidence for the discriminative validity of a cluster of clinical signs and symptoms when 15 therapists applied the same system.

Our study examined the classification of all patients seeking care for pain-related conditions from 24 therapists with varying levels of education and experience who worked in different locations within one rehabilitation hospital system. Our analysis builds on previous work and provides a finer understanding of differences between the nociceptive pain mechanisms of inflammatory and ischemia. Additionally, it supports the use of a PMCS for patients with low back pain, as well as other body regions, multiple impairments and diagnoses by utilizing

Table 3 Sensitivity, specificity, positive, and negative predictive values for clinician-rated mechanism category and computer-generated mechanism category (N=18 808)

	Sensitivity (95% CI)	Specificity (95% CI)	Positive predictive value	Negative predictive value
Inflammatory	72.0% (69.8–74.1%)	90.7% (90.3–91.2%)	44.4% (42.5–46.2%)	96.9% (96.7–97.2%)
Ischemia	83.1% (82.2–84.0%)	72.4% (71.6–73.2%)	61.2% (60.2–62.3%)	89.1% (88.4–89.7%)
Peripheral neurogenic	75.1% (72.2–77.7%)	95.5% (95.2–95.8%)	47.6% (45.0–50.1%)	98.6% (98.4–98.8%)
Central	15.7% (14.7–16.8%)	98.8% (98.6–99.0%)	81.2% (78.5–83.8%)	78.0% (77.4–78.7%)
Other	75.3% (74.1–76.5%)	92.7% (92.2–93.1%)	78.6% (77.3–79.8%)	91.3% (90.8–91.8%)

larger samples of therapists and patients. One distinct feature of our study was the inclusion of records for all patients who reported musculoskeletal pain diagnosed by a PT with pain mechanism classification training. Therefore, patients in the current study may have had comorbidities, including neurological or nervous system involvement, diabetes, or pregnancy, as opposed to patients in the Smart *et al.*'s¹³ study who were selected using more strict criteria. The current study's larger, more heterogeneous sample provides evidence for the external validity of the PCMS when used in a primarily orthopedic outpatient setting. Initial classification was made based on the primary complaint of musculoskeletal pain and specific characteristics of each pain mechanism inclusive of multiple diagnoses/comorbidities. The therapist and the statistical model classified each patient that received outpatient treatment. We believe that further study of pain mechanisms should be explored in other clinical settings (day rehabilitation/inpatient rehab), and specifically determine if it is possible to differentiate the central mechanisms of central sensitization, affective and motor autonomic with a more thorough EMR template. This study strengthens scientific support for the discriminative validity between inflammatory and ischemic nociceptive, and peripheral neurogenic pain mechanisms. It is our desire to further evaluate the relationships between therapists who classified patients with pain mechanisms using the PMCS *versus* treatment of patients in routine clinical practice without utilization of a classification system. Assessment of treatment outcomes in comparison of these two populations would provide additional empirical evidence supporting use of the PMCS.

Smart *et al.*¹² suggested that clinicians might have difficulty identifying psychosocial risk factors from the clinical interview. We found that trained PTs differentiated central mechanisms from other peripheral mechanisms for one-quarter of their patients during initial assessment, while the combined central pain category represented only 5% of the records in the statistical generated model. This difference may represent misclassification by the statistical model with poor sensitivity for identifying central pain

mechanisms from the available patient, injury, and other variables included in the cluster analysis. Conversely, the cluster analysis may have misclassified patients with central pain symptoms into the peripheral categories if the data extracted from the EMR did not sufficiently characterize the psychosocial signs and symptoms associated with central pain, or if inconsistent patient behavior on initial assessment did not immediately support a central classification by the computer. The ability to document qualitatively in an open ended (free-text) box may have limited the ability of the cluster analysis to identify those with central mechanisms, because therapists may have chosen to write more information about patients with central mechanisms in an additional comments section. Thus, the signs and symptoms associated with the central categories were not available for analysis in the data extracted for the cluster analysis. In addition, the therapists observed the patients' verbal and non-verbal interactions to assist classification of central mechanisms.

One explanation for misclassification by the PTs rests with the ability to create a provisional classification during the initial examination, or in subsequent visits. The trained PTs had 45 minutes to evaluate a patient on the initial visit, during which the patient may not disclose the extent to which he or she faces psychosocial issues. Patients might not initially reveal the psychosocial concerns related to the signs and symptoms of central pain categories until later in their therapy course. We feel that confirming a classification of a central mechanism may take multiple visits even if it is suspected earlier in assessment. Thus, knowledge and skill in identifying pain mechanism characteristics, administering and interpreting instruments that assess for psychological issues (e.g. Patient Health Questionnaire, Pain Anxiety Symptom Scale, Fear Avoidance Behavior Questionnaire), which could be contributing to symptoms of central mechanisms, will provide the information to support assignment of appropriate central pain mechanism classification. Patients can have multiple pain mechanisms that do not act in isolation, for example both peripheral pain mechanisms and significant central mechanisms with psychosocial

Table 4 Cross-tabulation of clinician-rated mechanism category and computer-generated mechanism category*

Computer-generated category	PT-assigned category					Total
	Inflammatory	Ischemia	Peripheral neurogenic	Central	Other	
Inflammatory	1260 (72%)	545	168	715	150	2838
Ischemia	226	5379 (83.1%)	38	2163 (46.4%)	978	8783
Peripheral neurogenic	169	470	734 (75.1%)	150	19	1542
Central	38	38	19	734 (15.7%)	75	903
Other	56	38	19	903	3724 (75.3%)	4740
Total	1749	6470	978	4664	4947	18808

factors could occur concurrently. We specifically asked the practitioners to identify at the time of evaluation what mechanism was dominating the patient's episode of care. In a psychosocial screen, we would argue that someone with a peripheral mechanism (e.g. peripheral neurogenic) would have a low risk on psychosocial measures. On another visit, if the patient with underlying peripheral neurogenic pain mechanisms was undergoing a major depressive or catastrophic event, the therapist could screen and identify a higher risk and address the mechanism that is most dominant to the patient's pain and functional limitation. The patient may have contextual factors that limit his or her ability to participate and function, or may have a body function and structure issue that is dominating and needs to be addressed. The classification will depend on which category is dominating.

An unexpected finding in the research analysis was the good agreement between the PT classification and the statistical model for the 'Other' category, which identifies multiple pain mechanisms. Exploration of the classification of, treatment for, and outcomes resulting for patients with multiple mechanisms could enhance the specificity and sensitivity of the PMCS.

Limitations

Trained PTs classified some patients into both peripheral and central mechanisms categories. These patients with complex presentations were included in the cluster analysis, because we felt that this group is most at risk to develop a central dominating mechanism, which is consistently seen in clinical practice. Classifying the dominating mechanism at the time of initial evaluation could be difficult when multiple mechanisms were suspected, typically resulting in a classification to the 'other' category. Although both the statistical model and the therapists were able to determine when multiple mechanisms were present, it was difficult to assess from our study whether there was agreement on the dominant mechanism, which likely would influence further evaluation and treatment that day. We do not know whether PTs who did not consent to the study, or their patients, differed from those who consented. It may be premature to reference the PTs as the gold standard, but the trainers and creators of the PMCS system would be the group most likely to be the reference standard for this study. Our accuracy statistics were based on an assumption that the PMCS classification system was correct and attempted to refute that hypothesis through a computer's attempt to validate that response.

Conclusions

This study provides evidence for the validation of the classification of outpatients with reports of pain as a

primary problem on initial assessment using a PMCS, particularly for patients presenting with nociceptive inflammatory and ischemic pain mechanisms. This secondary analysis of patient data demonstrated good agreement between trained PTs' classification of patients for peripheral pain diagnoses using a PCMS and a classification system generated through cluster analysis, based on patients' signs and symptoms. This study allowed us to understand that peripheral nociception can be subcategorized consistently; however, further research is needed to determine whether subcategories of central mechanisms can be classified consistently in our practice setting specifically, and across practice settings.

Disclaimer Statements

Contributors Melissa Kolski, Krista Van Der Laan, and Annie O'Connor were responsible for study design; obtaining funding; IRB, informed consent, logistic, administrative, and technical support and data collection, data interpretation; drafting the paper, critical revision, and final approval of the article. Anne Deutsch and Allan Kozlowski were responsible for study design and IRB drafting/approval, methodology, data collection, interpretation, critical paper revision. Anne Deutsch also aided in obtaining funding. Junghwa Lee was responsible for data analysis, collection/interpretation, critical paper revision, and methodology. Melissa Kolski is the guarantor and responsible for final approval of the article.

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