McKenzie mechanical syndromes coincide with biopsychosocial influences, including central sensitization: a descriptive study of individuals with chronic neck pain

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ABSTRACT

Background: Mechanical diagnosis and therapy (MDT) aims to assess and classify patients into theoretically mutually exclusive subgroups, in order to direct treatment. However, the latest evidence for biopsychosocial influence–central sensitization (CS) and psychological distress–have not been assessed in conjunction with MDT.

Objectives: (1) Determine the percentage of patients categorized into the MDT subgroups; (2) characterize the biopsychosocial clinical profile (presence of CS and psychological distress); and (3) identify associations between pain, disability, and biopsychosocial influences among this cohort.

Methods: Eighty four patients with chronic neck pain were recruited by 10 certified MDT therapists using a convenience (consecutive) sampling method. Patients were evaluated using MDT principles and also completed an online survey to measure CS (using the Central Sensitization Inventory [CSI]), pain catastrophizing and kinesiophobia.

Results: The proportions of the subgroups derangement (DER), dysfunction, postural and ‘other’ were 74.4, 2.4, 1.2, 20.7%, respectively. CS was observed in 62% of our sample (CSI score ≥ 40). CS was also observed in 64.7% of patients of the DER subgroup. Almost half of our sample (47.8%) demonstrated the co-occurrence of CS and DER, while 38% presented with DER syndrome, CS, and kinesiophobia.

Conclusion: The majority of our patients were classified as DER; they also presented with high levels of CS and/or psychological distress. This suggests that MDT mechanical subgroups, particularly DER, can present with co-occurring biopsychosocial influences. Without assessing CS and psychological distress, MDT therapists may miss crucial information. Further research is required to determine the optimal management of patients presenting with mechanical and non-mechanical drivers of pain.

KEYWORDS

Mechanical diagnosis and therapy; central sensitization; chronic neck pain; classification

1. Introduction

Neck pain is a major health burden affecting 48.5% of the general population. It is a common reason for health professional consultation,^[1] including physical therapy (PT). For this population, classification models have been proposed^[2] and recommended by the clinical practice guidelines^[3] to enhance treatment outcomes by the stratifying of care. Patients are classified according to their clinical presentation into homogenous subgroups following evaluation, and then given a specific treatment.^[2] A recognized classification used for the treatment of neck pain is the mechanical diagnosis and therapy (MDT).^[4,5]

The MDT classification subdivides patients into three main mechanical syndromes: *derangement (DER)*, *dysfunction*, and *postural*. In the DER subgroup, symptoms improve and remain better following sustained posture

or repeated motions, called ‘directional preference’ (DP) exercise. Also unique to the DER is centralization: distal symptoms reduce or abolish in a proximal fashion toward the axial spine following DP exercise.^[4,5] The presence of centralization and DP are indicators of better outcomes.^[6,7] The other two mechanical subgroups (dysfunction and postural) are described in detail elsewhere; and mainly relate to nociceptive pain.^[4,5] Patients not classified in one of the three mechanical syndromes are classified into the *other* subgroup,^[4,5] which is further divided into distinct categories including red flags (e.g. cancer) and subgroups, which would receive different treatment approaches (e.g. chronic pain syndrome, post-surgery).^[8]

The majority of research on MDT classification has been limited to lumbar spine disorders;^[7] while very

little research exists on the cervical spine, especially persistent cases. Moreover, the influence of biopsychosocial factors in chronic neck pain, including both peripherally and centrally derived components, has been previously studied.[9] In fact, it has been hypothesized that the central nervous system can become sensitized, especially when in the presence of psychosocial factors.[10,11] This sensitization can amplify nociceptive (peripheral) inputs. For example, it can elicit a disproportionate pain to the extent of injury. However, the extent to which these factors influence the movement–symptom relationship (how spine movement influence/provoke symptoms) observed with DER is unclear.

The purpose of this study is to characterize MDT classification and biopsychosocial influences for patients presenting with chronic cervical pain. We aimed to: (1) determine the percentage of patients categorized into each MDT subgroup; (2) characterize the biopsychosocial clinical profile by testing for the presence of both abnormal pain processing (CS) and cognitive-emotional influences among patients with chronic neck pain. We hypothesized that this population would indeed present with biopsychosocial influences.[12] Lastly, we aimed to assess for associations between DER and biopsychosocial influences. While exploratory, we anticipated the presence of associations, particularly CS and/or psychosocial influences among individuals categorized to DER.

2. Methods

2.1. Design

A cross-sectional observational study was conducted on data collected between June 2016 to April 2017.

2.2. Participants

Patients with chronic neck pain were recruited. Potential participants had to (1) experience neck pain more than 6 months, with or without upper-extremity symptoms, (2) be 18 years or older, (3) be fluent in French or English and (4) have access to the internet via a web browser that supports LimeSurvey. The only exclusion criterion was the presence or suspicion of serious pathology (i.e. cancer, fracture) that would be a contra-indication to the evaluation.

2.3. Recruitment procedures

Patients were conveniently recruited through two strategies.

- (a) Recruitment via treating physiotherapists

One hundred thirty-six Canadian physiotherapists (PT) were contacted by e-mail via the McKenzie Institute Canada registry. Since the inter-tester reliability of this classification seems to be better when assessed by a trained MDT therapist,[13] we contacted by email therapists that received a standardized training to perform mechanical evaluation using MDT and that had achieved at least a level D postgraduate MDT training. PTs who accepted to participate were provided with study procedures via e-mail. Their tasks included identifying potential participants with chronic neck pain, recruiting them (give information about the project and obtain consent to provide the researchers with their assessment results) and completing their usual evaluation. The routine MDT evaluation procedure consisted of a subjective and objective part to rule out serious pathology and classify the patient into the proper MDT subgroup. To classify the patients, the therapist monitored changes in patients' symptoms in response to different positions and repeated cervical movements or sustained positions.

(b) Alternative recruitment of patients

As an alternative method to recruit more participants, patients were recruited directly using two strategies. (1) An advertisement poster with the researcher's contact information was displayed in key areas to recruit the patients directly. These areas included local newspaper, medical clinics, pharmacies, and social media. Interested patients would then contact the researcher for more information and set up a time for the assessment. (2) We also contacted patients from a list provided by *Le Centre d'expertise en gestion de la douleur chronique du CHUS (CEGDC)* (The center of expertise in management of chronic pain of the CHUS) to identify patients' eligibility. This list consisted of patients with chronic pain that agreed to be contacted for research purposes. Once a patient was deemed admissible, an evaluation with the trained therapist was scheduled. Participants recruited by this procedure were all assessed by one of the researchers (OTL).

2.4. Ethical consideration

Ethical approval was obtained in June 2016 by the Clinical Research Center of the *Centre hospitalier universitaire de Sherbrooke* (CRCHUS) (Project #2017-1417). All patient data were kept anonymous and confidential using an alphanumerical codification.

2.5. Variables

- (1) *MDT classification*: Per the assessment findings, patients were classified into one of the three mechanical syndromes (derangement, dysfunction, or postural) based on their symptomatic

responses to repeated end-range movement or sustained postures.[14] If the patient's clinical characteristics did not fit one of the three main syndromes, they were classified in the 'Other' subgroup. The 'Other' category included diagnoses such as stenosis, fracture, post-surgery, and chronic pain. The classification determined by the therapist, the presence of centralization phenomenon and the directional preference were collected from the MDT assessment form. This form is a standardized form created by the McKenzie Institute used by all MDT therapists (Appendix 1). These procedures were part of their regular assessment routine.

Using various questionnaires, other variables were collected, via an online survey tool, to describe important clinical characteristics associated with neck pain. These were the following:

- (a) Pain intensity and perceived disability were obtained using a standard Numeric Pain Rating Scale (NPRS) and the Neck disability index (NDI) questionnaire, respectively.[15]
- (b) Pain location, collected using a numeric body diagram used and described in previous studies. [16,17]
- (c) The presence and severity level of central sensitization were measured with the Central Sensitization Inventory (CSI);[18] a tool used to screen for patients having potential CS. This tool has been shown to have good test-retest reliability and internal consistency (Pearson's $r = 0.82$; Cronbach's $\alpha = 0.88$).[19] It also has good sensitivity (81%) when identifying patients with other central sensitivity syndromes (e.g. fibromyalgia) and acceptable specificity (75%) with a cut-off score of 40/100.[9,20] Patients with other central sensitivity syndrome (e.g. fibromyalgia) are believed to be highly linked to CS.[20] Recent research established CSI severity levels as follows: subclinical = 0–29; mild = 30–39; moderate = 40–49; severe = 50–59; extreme = 60+.[20]
- (d) *Cognitive-emotional drivers of pain*: Their presence was measured with the Tampa Scale of Kinesiophobia (TSK) and the Pain Catastrophizing Scale (PCS). The score of TSK ranges from 17 to 68 whereas the score of PCS ranges from 0 to 52. Previous research has established 37 as a cut-off score for TSK where patients scoring more than 37 were considered to have high fear of movement.[21] For PCS, a total score of 30 or more represents clinically relevant level of catastrophizing.[22] The TSK was used because it predicts poor pain outcomes [23,24] and the PCS showed strong association to more severe pain and emotional distress and was also associated with poorer rehabilitation outcomes.[22,25]

- (e) *sociodemographic information*: Patient's age, sex and duration of symptoms were collected via the online questionnaire.

2.6. Data acquisition procedures

Data were collected from (1) an online questionnaire completed by the participants; and (2) the MDT evaluation form completed by the assessing therapist. The therapists provided the patient's MDT evaluation form, identified with the alphanumeric identification number. Following the assessment, each therapist gave the patient an alphanumeric identification number and a link toward an online questionnaire (LimeSurvey). Through this online survey, the patients completed the self-administered questionnaires (CSI, TSK, PCS) as well as socio-demographic information. Our procedures did not alter in any way the therapist's assessment techniques/treatment and each patient's consent was obtained online prior to the completion of the questionnaires.

2.7. Statistical analysis

Descriptive statistics were used estimate the percentage of patients classified into each MDT classification, the presence of centralization and central sensitization in our sample population. Associations between the presence of DER, central sensitization and disability were evaluated using contingency tables and the chi-squared test. Alpha level was set at 0.05 for all analyses. Odds ratio were calculated to evaluate the strength of association between each variable. Linear regressions were then used to measure potential associations between age, pain intensity, duration of symptoms, central sensitization, kinesiphobia, and catastrophization. The PCS scale was further divided into its three subcategories (rumination, magnification, and helplessness) to measure association with central sensitization. Pain location was divided into six categories using methods described elsewhere and the average CSI score for each category was calculated.[17]

3. Results

3.1. Therapists and patients

One hundred and thirty-six (136) therapists were contacted to participate in the study, from which 10 therapists provided data (Figure 1). Practice settings consisted of private practices spread across Canada: three PTs worked in the province of Québec, three in Ontario, two in Alberta and two in New Brunswick. Four therapists had more than 10 years of experience in the MDT approach, all the therapists completed at least a *level D* MDT training and 9 out of 10 were certified in the approach. To certify in the approach, therapists needed to complete

Figure 1. Flow diagram.

parts A to D of the McKenzie courses and pass the certification exam. As for participants, eighty-four (84) patients met all admissibility criteria. However, not all participants provided complete answers to all questionnaires—missing data are outlined in Figure 1.

All participants' sociodemographic and main clinical characteristics are shown in Table 1. Our sample's mean age was 49.1 ± 16.6 years old where women composed 74% of our sample. At the time of the mechanical evaluation, the mean pain intensity on the 11-point scale NPRS was $5.4 \pm 2.1/10$. Eighty percent (80%) of our sample had neck pain for 12 months or more. The average self-reported disability score (NDI) was $9.8 \pm 7.7/50$ and the proportion of patients presenting with significant level of disability ($NDI \geq 20$) was 50.7%. Other patient's characteristics, such as activity level, mechanism of injury, level of education are also shown in Table 1. Patient's pain location distribution is shown in Figure 2. Only 6.1% reported central neck pain, while pain referred to the shoulder for 53% of the sample, and 41% reported pain referred to the upper limb (below shoulder).

3.2. MDT classification, centralization, and directional preference

MDT sub-group classification were obtained from 82 patients. MDT sub-classifications are provided in Figure 3(a) and (b). The large majority of patients were classified as DER (75.6%), followed by dysfunction; while the

predominant direction of preference was retraction/extension (93.4%). The proportion of patients showing signs of centralization in our sample was 15.8%, which consisted of 21.3% of patients presenting with DER.

3.3. Presence of central sensitization and cognitive-emotional drivers of pain

Seventy-one (71) patients provided data regarding central sensitization (presence and severity) by completing the CSI. The average CSI score in our sample was 45.7 ± 14.6 (median = 43) and values ranged from 19 to 81. The mean CSI scores for each pain location are shown in Figure 2. The average score of CSI was found to be the highest when pain was referred down the arm ($CSI = 54.7 \pm 12.1$). When defining distal neck pain as neck pain referring down the arm or more distally, no associations were found between distal neck pain and CS ($p = 0.137$). Although not statistically significant ($p = 0.379$), the mean CSI score appeared lower than 40 (38.3 ± 2.1) when the neck pain was only central, as opposed to when the neck pain was asymmetrical or referring distally (46.0 ± 14.9). Finally, there was a weak association between pain intensity (NPRS ≥ 5) and the presence of CS ($R^2 = 0.101$), indicating that in our sample, higher neck pain intensity scores may be associated with the presence of CS (Table 3).

We also observed that 62% ($n = 44$) of the patients in our sample had a score ≥ 40 on the CSI, indicating the presence of CS.[9] The CSI severity levels proposed

Table 1. Patient characteristics.

	N = 84
Sex – n (%)	
Male	22 (26.19)
Female	62 (73.81)
Age group – n (%)	
18–29	15 (17.86)
30–49	27 (32.14)
50–69	31 (36.9)
70+	11 (13.10)
Language – n (%)	
English	40 (47.62)
French	44 (52.38)
Work – n (%)	
Active	24 (28.57)
Sedentary	60 (71.43)
Mechanism of injury – n (%)	
No apparent reason	58 (69.05)
Excessive mechanical load	8 (9.52)
Fall	7 (8.33)
Car accident	11 (13.10)
Duration of symptoms (months) – mean (SD)	
6–11	16 (19.05)
12–23	17 (20.24)
24–59	23 (27.38)
60 and more	17 (20.24)
Missing data	11 (13.10)
Highest level of education – n (%)	
No diploma	3 (3.57)
Secondary	26 (30.95)
College	13 (15.48)
University	34 (40.48)
Missing data	8 (9.52)
Pain intensity (0–10 scale) reported during initial assessment (mean ± SD)	5.42 ± 2.05
Pain intensity (Section 1 of NDI)	n (%)
	Total n = 69
I have no neck pain at the moment	2 (2.90)
The pain is very mild at the moment	11 (15.94)
The pain is moderate at the moment	27 (39.13)
The pain is fairly severe at the moment	21 (30.43)
The pain is very severe at the moment	8 (11.59)
The pain is the worst imaginable at the moment	0 (0)

Table 2. Central sensitization inventory (CSI) mean score and severity levels.

CSI score ± SD	4,566 ± 1,463
Presence of CS (CSI ≥ 40) n (%)	44 (62%)
Subclinical (0–29)	11 (15.5%)
Mild (30–39)	16 (22.5%)
Moderate (40–49)	13 (18.3%)
Severe (50–59)	18 (25.4%)
Extreme (60+)	13 (18.3%)

previously,[20] [subclinical (0–29), mild (30–39), moderate (40–49), severe (50–59), and extreme (60+)] are shown in Table 2, where most patients (46.6%) in our sample were categorized as ‘severe’ or ‘extreme’ signs and symptoms of CS.

The presence of cognitive-emotional drivers of pain were gathered through the TSK and PCS questionnaires. The average scores were: 42.2 ± 7.6 on the TSK (/68) for kinesiophobia and 21.8 ± 12.5 on the PCS (/52) for pain catastrophization. When using the proposed cut-offs, the proportion of patients presenting with significant level of kinesiophobia (TSK ≥ 37) and pain catastrophization (PCS ≥ 30) was 79.1 and 30.7%, respectively.

3.4. Association between derangement syndrome and biopsychosocial influences

3.4.1. Co-occurrence of nociceptive biomechanical, nervous system hypersensitivity, and cognitive-emotional drivers of pain

When assessing the co-occurrence of MDT classification (derangement) and CS, sixty-nine patients provided data for this descriptive analysis. We observed the co-occurrence of CS and DER for 33 patients, implicating that 64.71% of patients presenting with a DER had CS (47.8% of our sample) (Figure 4(a)).

Moreover, in our sample, we had complete data for a total of 63 patients regarding the MDT classification, the

*Body diagram adapted from Werneke et al. [17]

Figure 2. Distribution of the location of the most distal painful symptoms. Source: Body diagram adapted from Werneke et al. [17].

Figure 3. MDT characteristics (A) Distribution of MDT classification; (B) Distribution of directional preference.

Table 3. Associations between central sensitization, derangement and psychosocial factors.

	OR	95% CI	p-value
Association with CS			
Pain (NPRS ≥ 5)	3.180	1.080–9.363	$p = 0.032^*$
Distal pain (arm and below)	2.159	0.775–6.013	$p = 0.137$
Classified in derangement	1.813	0.599–5.485	$p = 0.272$
Presence of catastrophizing (PCS ≥ 30)	3.500	1.010–12.123	$p = 0.041^*$
Presence of fear of movement (TSK ≥ 37)	1.944	0.590–6.404	$p = 0.270$
Presence of disability (NDI ≥ 20)	3.797	1.346–10.713	$p = 0.010^*$
Association with derangement			
Presence of catastrophizing (PCS ≥ 30)	1.174	0.350–3.935	$p = 0.795$
Presence of fear of movement (TSK ≥ 37)	0.1823	0.022–1.525	$p = 0.084$
High neck pain-related disability (NDI ≥ 20)	0.375	0.121–1.116	$p = 0.084$

*Statistically significant ($p < 0.05$).

presence of CS and cognitive-emotional factors. Figure 4(b) shows the overlap between the presence of DER, central sensitization and fear of movement. Twenty-four (24) patients of our sample (38.1%) presented with (1) a mechanical component (presence of DER), (2) signs of nervous system hypersensitivity (CSI score > 40) and (3) a significantly high score on fear of movement (a cognitive-emotional driver of pain).

Figure 4. Distribution of the number of patients presenting with each characteristic (A) Overlap between derangement and central sensitization; (B) Overlap between derangement, central sensitization and fear of movement.

3.4.2. Association between derangement, central sensitization, and cognitive-emotional drivers of pain

Statistically significant associations were found between the presence of CS (CSI ≥ 40) and (a) pain catastrophizing (PCS ≥ 30) (OR = 3.5, [1.0–12.1]) and (b) high perception of disability due to neck pain (NDI ≥ 40) (OR = 3.8, [1.3–10.7]). There was no statistically significant association between CS and the presence of fear of movement (TSK ≥ 37) (OR = 1.9, [1.3–10.7]) (Table 3).

The estimate of the relative risks with their confidence intervals are shown in Table 3. We observed that the proportion of patients with high pain catastrophizing is 3.5 times higher (95% CI = 1.010–12.123) in patients with CS compared to patients without CS. Likewise, patients with high ratings of neck-pain-related disability have 3.8 time more chance to show CS than patients with low neck pain-related disability (OR = 3.8; 95% CI = 1.346–10.713).

When CS is categorized into severity levels, the mean scores for the PCS, TSK, and NDI were progressively higher as the severity of CS augments (R^2 of the linear regression lines for the mean TSK scores, mean PCS scores and mean NDI scores in relation to the CS severity were 0.871, 0.934, 0.981, respectively).

4. Discussion

4.1. MDT characteristics

Around 80% of our sample was classified into one of the MDT mechanical subgroups. Thus, the majority of our chronic neck pain population had a specific mechanical presentation. Mechanical pattern of pain (according to the symptomatic response) is therefore important to identify as it guides the treatment approach.[14]

These findings are similar to previously reported prevalence of DER and centralization, which were found to be lower in chronic neck pain (64, 39%, respectively) compared to acute cases (82–92, 56%, respectively). [4,6,26,27] Two reasons could explain this discrepancy between acute and chronic cases. First, the presence of centralization and DER are associated with a better prognosis [28] while persistent symptoms are often associated with poorer prognosis.[9,22,25,29] Thus, DER and centralization could be characteristics associated with duration of symptoms. Secondly, the definition of DER usually refers to a mechanical problem that is ‘rapidly’ reversible.[14,30] However, mechanical patterns in chronic and acute pain behave differently, as psychosocial factors or CS are more predominant in persistent pain—thus, mechanical origin of pain can be less frequent [9,31] or harder to solicit in a single assessment. Therefore, our findings are in accordance with the higher prevalence of DER and centralization in acute cases compared to chronic cases found in previous research. Lastly, since DER was the predominant classification with retraction being the most frequently observed directional preference, our findings suggest very little variability for MDT in chronic neck pain population. This lack of variability should be investigated further in future studies.

4.2. Presence and severity of CS

In our sample, the percentage of patients presenting signs of CS ($CSI \geq 40$) was 62%. This adds to the literature as a previous systematic review concluded lack of evidence regarding CS in chronic idiopathic neck pain. [32] Several points can explain their conclusion. First, only six articles were reviewed. Secondly, none of the previous studies used the CSI to measure the presence of CS, a recently developed and validated tool to measure CS.[20] This leads to a high heterogeneity between the six included studies, which prevents definite conclusion.[32] Lastly, in one of the included studies, the level of pain and disability was lower in the chronic idiopathic neck pain group compared to the chronic whiplash associated neck pain.[33] Since there is some evidence for a correlation between central pain processing mechanisms and pain levels,[34] this could alter the results. Since the presence of CS modulates treatment responses,[35] and our study supports its presence in this population, its identification is crucial. The added benefits of specific approaches to treat CS have been documented in previous research and include but are not limited to biopsychosocially driven

rehabilitation,[36] progressive goal attainment programs [37] and pain education.[38]

Moreover, although not statistically significant ($p = 0.379$), the mean CSI score is lower than 40 ($CSI: 38.3 \pm 2.1$) when the neck pain is central, as opposed to when the neck pain is asymmetrical or referred distally ($CSI: 46.0 \pm 14.9$) suggesting that a more widespread pain location may be clinically useful to identify patients with CS in chronic neck pain. In the chronic low back pain population, widespread pain drawn on a body diagram is a screening tool used to identify patients with CS and psychosocial issues.[39,40]

4.3. CS and MDT: a non-mutually exclusive way to classify in a chronic neck pain population?

Co-occurrence of DER and CS was present in 64.7% of our sample. Since complementary treatment approaches which target CS directly have been shown to be effective at improving outcomes in chronic neck pain patients [36–38] and the use of MDT principles yield similar results in chronic low back pain,[41,42] our findings suggest potential benefits from a combined treatment approach.

The ‘chronic pain’ subgroup of MDT seems associated with CS.[43] However, this subgroup is mutually exclusive from the three main mechanical subgroups. This unidimensional way of classifying may fail to identify many patients with a mechanical syndrome and CS.

4.4. Psychosocial factors in relation to CS and MDT

An association was found between the presence of CS and fear of movement ($OR = 1.9$, [1.3–10.7]), catastrophizing ($OR = 3.5$, [1.0–12.1]) and disability ($OR = 3.8$, [1.3–10.7]). This supports the findings of previous research that found close associations between maladaptive psychosocial factors and CS.[44] It is theorized that these factors contribute to the presence of CS. Since the literature supports that the activity of descending pathways of the brain can be modulated by cognitive-emotional drivers of pain,[10,11] identifying these drivers to better target treatment is clinically relevant. Potential treatment options include, but are not limited to cognitive-behavioral approaches [45] and therapeutic neuroscience education,[38] which aim to decrease the influence of cognitive-emotional drivers of pain.

We observed a significant overlap between MDT mechanical subgroups and psychosocial factors, but without any significant statistical association. This coexistence of different drivers of pain supports the hypothesis that the different subgroups of the MDT classification system might co-exist since patients can present with characteristics which are specific to two different subgroups (i.e.: directional preference for the DER subgroup and CS for the MDT’s ‘chronic pain’ category of the ‘other’ subgroup), particularly in chronic cervical pain. Identifying the complete clinical profile of an

individual patient is important as these factors modulate treatment recommendations and effectiveness.[10,11] Therefore, while the MDT classification might be useful for diagnosing and treating a subgroup of chronic neck pain patients, the addition of CS and psychosocial concepts could help to better characterize these patients. Ultimately, this could help therapists give a more individualized treatment.

4.5. Relation to the biopsychosocial model of pain

Our findings were expected. Chronic neck pain is often multifactorial,[46] which can include mechanical [46,47] and non-mechanical influences.[48] It is well documented that a biopsychosocial approach is recommended to assess and treat persistent and painful conditions.[49] Chronic pain is better understood by the biopsychosocial model of pain, where the perception of experience of pain is modulated by biological components (i.e. nociceptive and nervous system hypersensitivity factors), psychological components (i.e. attitudes, beliefs, psychosocial disorders) as well as contextual or environmental factors (i.e. support).[46,50] Our findings reinforce the importance and theoretical basis of this model; since overlap between the three domains' drivers of pain was frequently observed.

Hence, the frequent co-occurrence of MDT mechanical syndrome with CS was not surprising. In fact, these findings correlate with current understanding of the physiology of pain mechanisms, which are that pain is a dynamic phenomenon influenced by both peripheral and central processing.[51] As such, nociceptive/peripheral inputs can be modulated by the central nervous system. In these cases, central sensitization is the term used when nociceptive inputs are augmented or facilitated, leading to increased perceived pain. In other words, nociception and central sensitization can co-occur. According to MDT, mechanical subgroups are mutually exclusive from other non-mechanical subgroups classified in the 'other' subgroup. In these non-mechanical subgroups, it is likely that the origin of pain is predominantly centrally driven. Since the mechanical subgroups of MDT present with specific mechanical patterns, the type of pain of the patients classified in these are most likely nociceptive dominant, but other influences cannot be excluded. Thus, our findings support previously described mechanisms of pain.[51] Since mechanisms of pain are viewed as a continuum, MDT's 'strict' classification might miss important patients' characteristics which can influence intervention. However, the added benefit of identifying central sensitization and cognitive-emotional drivers of pain and addressing these in chronic neck pain patients while using the MDT approach needs to be confirmed, as previous research in the lumbar spine showed that a lack of directional preference could help therapists screen for patients who needed additional psychologically informed-PT.[52] Furthermore, in the lumbar spine, the exclusive use of the MDT approach yielded significant

improvements in pain, disability, and psychosocial factors.[42,53] Thus, future research should evaluate the added benefit of a combined approach, which explicitly address the concepts of CS, cognitive-emotional drivers and MDT to the exclusive use of MDT.

4.6. Limitations

There are several limitations to the current study. The use of a convenience sampling method and of a cross-sectional design does not allow for generalizability; nor for any definite conclusion on the prevalence of each MDT subgroups and the presence of CS. An attempt to minimize this bias was to gather data from consecutive patients which were evaluated by many different trained therapists. The researchers tried to reach trained Canadian therapists by contacting the McKenzie institute and e-mailing all certified therapists figuring on the McKenzie Institute Canada website. Furthermore, the sample size of 84 is relatively small which can hinder the precision of our prevalence estimates. Another limitation of the current study is that a definite MDT classification can sometimes take up to three sessions to identify.[16,27] Hence, we may have underestimated the occurrence of some mechanical clinical characteristics (i.e.: centralization). Furthermore, since the exclusion from the other three mechanical subgroups is a criterion for the 'chronic pain' subgroup when using MDT, the classification of 'chronic pain' might take even more time to be identified. Nonetheless, a previous prevalence study showed that the prevalence of DER seemed to be stable over the subsequent visits.[27] However, this previous study merged acute and chronic pain, making it challenging to draw definitive conclusion on the temporal stability of MDT for chronic neck pain.

4.7. Clinical implications

Considering that the majority of our patients were classified as DER, and that they also present with either CS and/or cognitive-emotional factors, our results suggest that MDT classification and biopsychosocial influences are not mutually exclusive. Without assessing CS and psychological distress in addition to MDT classification, physical therapists may miss crucial prognostic/diagnostic information.

5. Conclusion

To our knowledge, this is the first study to characterize MDT classification in conjunction with biopsychosocial influences for a cohort of individuals with chronic neck pain. Since more than half patients classified into one of the MDT mechanical syndrome presented with signs of CS, our findings suggest that these clinical characteristics are not mutually exclusive. Thus, without assessing CS and psychological distress in addition to MDT classification, physical therapists may miss crucial prognostic/diagnostic information.

Disclosure statement

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Appendix 1

THE MCKENZIE INSTITUTE
CERVICAL SPINE ASSESSMENT

Date _____

Name _____ Sex M / F

Address _____

Telephone _____

Date of Birth _____ Age _____

Referral: GP / Orth / Self / Other _____

Work: Mechanical stresses _____

Leisure: Mechanical stresses _____

Functional Disability from present episode _____

Functional Disability score _____

VAS Score (0-10) _____

HISTORY

Present Symptoms _____

Present since _____ improving / unchanging / worsening

Commenced as a result of _____ or no apparent reason

Symptoms at onset: neck / arm / forearm / headache _____

Constant symptoms: neck / arm / forearm / headache _____

Intermittent symptoms: neck / arm / forearm / headache _____

Worse bending sitting turning lying / rising
am / as the day progresses / pm when still / on the move
other _____

Better bending sitting turning lying
am / as the day progresses / pm when still / on the move
other _____

Disturbed Sleep Yes / No Pillows _____

Sleeping postures prone / sup / side R / L Surface firm / soft / sag

Previous Episodes 0 1-5 6-10 11+ Year of first episode _____

Previous History _____

Previous Treatments _____

SPECIFIC QUESTIONS

Dizziness / tinnitus / nausea / swallowing / +ve / -ve Gait / Upper Limbs: normal / abnormal

Medications: Nil / NSAIDS / Analg / Steroids / Anticoag / Other _____

General health: Good / Fair / Poor _____

Imaging: Yes / No _____

Recent or major surgery: Yes / No _____ Night pain: Yes / No _____

Accidents: Yes / No _____ Unexplained weight loss: Yes / No _____

Other _____

EXAMINATION**POSTURAL OBSERVATION**

Sitting: *Good / Fair / Poor* Standing: *Good / Fair / Poor* Protruded Head: *Yes / No* Wry neck: *Right / Left / Nil*
 Correction of Posture: *Better / Worse / No effect* _____ Relevant: *Yes / No*
 Other Observations _____

NEUROLOGICAL

Motor Deficit _____
 Sensory Deficit _____

Reflexes _____
 Dural Signs _____

MOVEMENT LOSS	Maj	Mod	Min	Nil	Pain
Protrusion					
Flexion					
Retraction					
Extension					

	Maj	Mod	Min	Nil	Pain
Lateral flexion R					
Lateral flexion L					
Rotation R					
Rotation L					

TEST MOVEMENTS Describe effect on present pain – During: produces, abolishes, increases, decreases, no effect, centralising, peripheralising. After: better, worse, no better, no worse, no effect, centralised, peripheralised.

	Symptoms During Testing	Symptoms After Testing	Mechanical Response		
			↑Rom	↓Rom	No effect
Pretest symptoms sitting _____					
PRO _____					
Rep PRO _____					
RET _____					
Rep RET _____					
RET EXT _____					
Rep RET EXT _____					
Pretest symptoms lying _____					
RET _____					
Rep RET _____					
RET EXT _____					
Rep RET EXT _____					
If required pretest pain sitting _____					
LF - R _____					
Rep LF - R _____					
LF - L _____					
Rep LF - L _____					
ROT - R _____					
Rep ROT - R _____					
ROT - L _____					
Rep ROT - L _____					
FLEX _____					
Rep FLEX _____					

STATIC TESTS

Protrusion _____ Flexion _____
 Retraction _____ Extension: *sitting / prone / supine* _____

OTHER TESTS**PROVISIONAL CLASSIFICATION**

Derangement Dysfunction Postural OTHER
 Central or Symmetrical Unilateral or Asymmetrical above elbow Unilateral or Asymmetrical below elbow

PRINCIPLE OF MANAGEMENT

Education _____ Equipment Provided _____
 Extension Principle _____ Lateral Principle _____
 Flexion Principle _____ Other _____
 Barriers to Recovery _____
 Treatment goals _____