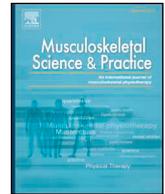




ELSEVIER

Contents lists available at ScienceDirect

Musculoskeletal Science and Practice

journal homepage: www.elsevier.com/locate/musksp

Original article

An international survey of the comprehensiveness of the McKenzie classification system and the proportions of classifications and directional preferences in patients with spinal pain

Stephen May^{a,*}, Richard Rosedale^b^a Sheffield Hallam University, Sheffield, UK^b Department of Physiotherapy, London Health Sciences Centre, London, Ontario, Canada

ARTICLE INFO

Keywords:

Spine
Classification
McKenzie system

ABSTRACT

Background: Classification of spinal pain has been a key goal identified in the research. However it is not clear if existing classification systems are comprehensive.

Objective: To examine the comprehensiveness and distribution of classifications within the McKenzie classification system (MDT), and the directional preference in consecutive patients with spine pain.

Study design: Prospective, observational study.

Methods: Clinicians with a Diploma in MDT provided data on patients that they had assessed, classified, managed, and then confirmed their classification at discharge. They provided data on the spinal area, the MDT classification, and the loading strategy used in management.

Results: Fifty-four clinicians from at least 15 different countries provided data on 750 patients: lumbar 64.8%, cervical 29.6%, thoracic 5.6%. The distribution of classifications was as follows: Derangement 75.4%, OTHER 22.8%, Dysfunction 1.7%, Postural syndrome 0.1%. In Derangements 82.5% had a directional preference for extension, 12.9% for lateral forces, and 4.6% for flexion. Those patients classified as one of the OTHER subgroups were given specific classifications.

Conclusion: Derangement was the most common classification and extension was by far the most common directional preference. A substantial proportion were classified as OTHER subgroups, for whom management is less straightforward.

1. Introduction

A key priority proposed for the management of spinal problems has been the identification of subgroups, with the purpose of appropriately stratifying heterogeneous populations, allowing matched interventions (Borkan et al., 1998; Bouter et al., 2003). In principle, the introduction of various systems of classification over the decades should have helped to address this priority. However, various barriers to implementation have been identified and concerns expressed by clinicians resulting in a less than universal uptake (Tousignant-Laflamme et al., 2017; Davies et al., 2014; Sheeran et al., 2015). Hence, the specific impact of the use of classification systems on the societal burden of spinal pain is difficult to ascertain but is likely to be limited (Tousignant-Laflamme et al., 2017). One of the reasons expressed for a lack of uptake of classification systems has been the perception that none provides a means by which all, or at least the vast majority of patients, can be classified (Sheeran

et al., 2015; Alrwaily et al., 2016). In other words, they do not cover all the possible scenarios of spinal presentation and/or do not adequately address all the multifaceted influences and barriers to recovery. The comprehensiveness of classification systems currently used is a matter of some dispute (Alrwaily et al., 2016; Rosedale et al., 2016). As these systems evolve and are revised it is important to continue to evaluate whether clinicians who are exclusively using these systems can at least adequately classify all their patients. Despite the fact that so far, research has failed to substantiate claims that subgrouping patients will yield more definitive and positive outcomes (Foster et al., 2011; Saragiotto et al., 2016), there is not yet a call for, or a consensus that, these approaches should be abandoned. Hence, the rationale that clinicians and researchers should continue to explore the clinical utility, reliability and validity of these systems appears to be reasonable.

One such classification system commonly used for spinal problems is the McKenzie system of Mechanical Diagnosis and Therapy (MDT),

* Corresponding author.

E-mail addresses: s.may@shu.ac.uk (S. May), richard_dale@hotmail.com (R. Rosedale).

which was first described over 30 years ago in relation to its application in the lumbar spine (McKenzie, 1981), and then over 20 years ago in relation to the cervical and thoracic spines (McKenzie, 1990). During the intervening years, the system has been subject to modifications concerning the number and type of subgroups, as well as classification definitions (McKenzie and May 2000, 2003, 2006). Additional refinements regarding the definitions and criteria for the McKenzie syndromes and the McKenzie OTHER subgroups have been made over the last decade by the McKenzie Institute International (MII) Education Council (Appendix).

The MDT system is based on specific, but non-pathology based syndromes and subgroups: Derangement, Dysfunction, Postural Syndrome and the OTHER McKenzie subgroups. The McKenzie syndromes as well as these OTHER subgroups have established operational definitions and clinical criteria enabling differential diagnosis (McKenzie and May 2000, 2003, 2006). Though the McKenzie syndromes have remained the same over time, the definition of the most prevalent classification, Derangement Syndrome, has changed.

The OTHER diagnostic and management considerations were discussed in a 2003 publication (McKenzie, 1981), when ten distinct categories were listed. An updated list of OTHER categories was published in the MII literature in 2014 (MDT World Press, 2015; 4:1:4–6). Five of the original categories were retained: Spinal Stenosis, Sacro-iliac joint, Post-surgery, Chronic Pain Syndrome, and Mechanically Inconclusive. Three were deleted from the list (hip, spondylolisthesis, zygapophyseal joint); and three were added (Inflammatory, Mechanically Unresponsive Radicular Syndrome, and Structurally Compromised). As well as the change in subgroups included in the OTHER category, the operational definitions have been modified over time and the most recent updated definitions for all syndromes and subgroups are presented in the appendix. The use of the updated classifications has not as yet been surveyed among MDT clinicians.

For any classification system to have clinical utility there are some essential components that are required. Among these, reliability (Buchbinder et al., 1996) and comprehensiveness (Stanton et al., 2013), pertaining to the ability to classify all patients in the population it is designed for, are important. For the McKenzie system of classification reliability has generally been reported as good for the lumbar spine (Razmjou et al., 2000; Kilpikoski et al., 2002; Clare et al., 2005), moderate when identifying the primary McKenzie syndromes in the cervical spine (Clare et al., 2005; Bybee and Dionne, 2007) and mixed for classification in the extremities (Heidar-Abady et al., 2014; Takasaki et al., 2017; Willis et al., 2016).

Surveys investigating the comprehensiveness, along with the proportions of the individual classifications have previously been conducted in the spine (Hefford, 2007; Otero and Bonnet, 2014, 2016), and in the extremities (May and Rosedale, 2012). All previous surveys in the spine reported that clinicians could classify 100% of their consecutive patients. Proportions have been reported consistently in the spine with around 70–80% of patients fitting criteria for one of the McKenzie syndromes with the rest complying with criteria from one of the OTHER subgroups. The majority of these, 70–80%, were recorded as Derangement (Hefford, 2007; Otero and Bonnet, 2014, 2016). For patients with extremity problems the proportion of patients who are classified with the different syndromes is somewhat more evenly spread, with just over one third being classified as Derangement, another third as one of the OTHER subgroups and the remainder as Articular or Contractile Dysfunctions (May and Rosedale, 2012). In the spine, a few also fit the Postural Syndrome operational definition and though this appears to be common in the young student population, it is not commonly seen in the clinical environment (May et al., 2011). Thus, previous research into the reliability and comprehensiveness has appeared to validate the clinical utility of the system in a range of different clinical environments (Hefford, 2007; Otero and Bonnet, 2014, 2016; May and Rosedale, 2012; May et al., 2011).

The aims of this survey were to establish the comprehensiveness of

the McKenzie classification system. Secondly, to determine the proportions of classifications and directional preferences for spinal pain with the updated definitions.

2. Methods

Observational data were reported prospectively. Participants were holders of a Diploma in Mechanical Diagnosis and Therapy, for whom email addresses were available, and who consented to collect the data. The Diploma is the highest educational award in the McKenzie Institute's educational programme; it involves a clinical placement and since 2001 involves a distance learning theoretical component. There is a final viva and practical examination. This follows attendance at all four parts of the three to four days program of training; the four parts of which offer initial and more advanced training in the evaluation and management of all spinal and extremity patients.

Participating clinicians were asked to provide limited demographic data about themselves, such as age, gender, years since qualified, years since gaining the Diploma, type of practice setting, and country of residence. The clinicians contacted were from numerous countries around the world and work in a variety of healthcare settings, ensuring a broad and representative clinical population. Data collection occurred over six months from July 2016. Patients were asked if they consented to have their data collected, and were assured that all data was anonymous and confidential; no patient personal details, only clinical details were collected.

Clinicians were asked to collect data on at least 15 consecutive discharged patients with spinal pain. Data was recorded at discharge to ensure that classification was confirmed from initial assessment through to that point. Data related to spinal area, syndrome classification, the stability of this classification and the number of treatment sessions. If classified as Derangement or Dysfunction, then the loading strategies were used to reduce Derangements or remodel Dysfunctions was also recorded.

The data was entered into SPSS/PASW (version 23, IBM, SPSS Inc, Chicago, Illinois) under the following variables: spinal area (lumbar, thoracic, cervical), syndrome classification (Derangement, Dysfunction, Postural, OTHER subgroups), stability of classification from initial assessment to discharge (yes/no), number of treatment sessions (dichotomized between ≤ 4 and ≥ 5), and loading strategy if appropriate (extension, flexion, lateral). Treatment sessions were dichotomized at this number of sessions as previous research had suggested that Derangements require significantly fewer treatment sessions, and thus 4 or less number of sessions is an optimum treatment outlay (May and Rosedale, 2012). Data analysis was predominantly descriptive in nature relating to proportions of the different classifications, with 95% confidence intervals (CIs) where appropriate. The 95% CI were calculated to the following formula: $SDp \pm \sqrt{p(1-p)/N}$, where SD is the standard deviation, p is the prevalence estimate as a decimal and N is the sample size (Altman, 1991). The data were nonparametric. Chi-square tests were used to investigate correlations between spinal areas, classifications, directional preference in Derangements, and number of treatment sessions.

Ethical approval was gained from the Faculty of Health and Wellbeing Sheffield Hallam University Ethics Committee, Sheffield Hallam University, UK. Clinicians were approached only twice for consent to participate. Patients provided oral consent for their anonymous data to be used. Data was not collected from any patient refusing consent. There are over 400 clinicians worldwide who have completed the Diploma, and email addresses held by McKenzie Institute International were available for 271 of these clinicians. For data protection reasons the McKenzie Institute International was unable to share these email addresses, but was prepared to email the invitation letter to potential participants. Clinicians then opted in by contacting one of the authors (SM), who then sent out the questionnaires. The McKenzie Institute International sent out a reminder email after five months.

Table 1
Demographic criteria of the clinicians who submitted data (N = 54).

Variables	N	%
Age - mean (SD)	47.1 (10.2)	44
Gender	Female	19 43%
	Male	25 57%
Years as clinician - mean (SD)	23.3 (10.4)	
Years with MDT Diploma (mean (SD))	11.1 (8.8)	
Setting (%)	Hospital	12 27%
	Private practice	28 64%
	Other	4 9%
Total		44
Country (%)	Australia	2 4.5%
	Belgium	2 4.5%
	Brazil	4 9.1%
	Cyprus	2 4.5%
	Czech	1 2.3%
	Denmark	2 4.5%
	Finland	2 4.5%
	France	2 4.5%
	Germany	2 4.5%
	India	1 2.3%
	Italy	2 4.5%
	Netherlands	2 4.5%
	New Zealand	4 9.1%
	Sweden	2 4.5%
	USA	14 32.0%
Total		44 100.0%
Demographic data not provided		10
Clinician total		54

SD = standard deviation; MDT = Mechanical Diagnosis and Therapy; USA = United States of America.

Given the nature of the recruitment process it was not possible to know in more detail the size of the sample frame from which participants came.

3. Results

Fifty-four Diploma holding clinicians provided data, which was 20% of the 271 who were emailed for data collection. These clinicians had a range of years of experience in different clinical settings and were from at least 15 different countries; although not all provided demographic data (Table 1). Of those that did, 12 Diploma holders (27%) took their Diploma prior to 2001 with an on-site, rather than distance learning, theoretical component. The clinicians provided data on 750 patients, who presented with a variety of spinal problems. The majority of patients were lumbar (64.7%) and were classified predominantly as having a Derangement (75.3%). Directional Preference was predominantly (82.5%) extension with the lateral principle being utilized 12.9% of the time (Table 2). There was no correlation between spinal area and classification ($p = 0.66$) (Table 3).

In terms of the stability of the classification between initial and discharge sessions, in 85% of patients' classification remained stable between these visits. In the 15% who altered their classification, details were not gathered on how the classifications changed. Those who were classified as one of the McKenzie OTHER subgroups (22.8%) were most commonly classified as Mechanically Inconclusive (6.7%) or Mechanically Unresponsive Radicular Syndrome (6.0%), with the rest representing seven OTHER subgroups.

Fifty-five percent of patients were seen in four sessions or less; with a mean number of sessions of 4.9 (SD 3.5). The number of treatment sessions was not significantly different in relation to the classification of the spinal problem ($p = 0.54$).

4. Discussion

In this largest survey to date of clinicians representing all continents in the world, the McKenzie system of Mechanical Diagnosis and

Table 2
Patients' data - Classifications (N = 750).

Variables	N	% (95% CI)
Spinal area	Lumbar	486 64.8%
	Cervical	222 29.6%
	Thoracic	42 5.6%
Total		750 100%
Classifications	Derangement	565 75.4 (71.9, 78.1)
	Dysfunction	13 1.7 (1.4, 1.9)
	Postural syndrome	1 0.1 (0.07, 1.2)
	OTHER (see below)	171 22.8 (19.8, 25.8)
Total		750 100%
Directional preference ^a	Extension	466 82.5 (79.8, 85.2)
	Flexion	26 4.6 (4.2, 4.9)
	Lateral	73 12.9 (10.6, 16.2)
Total		565 75.3%
No directional preference ^b		185 24.7%
Total		750 100%
Dysfunction loading	Extension	4
	Flexion	8
	Lateral	1
Total		13 1.7%
OTHER	Serious Pathology	3 0.4%
	Chronic Pain Syndrome	16 2.1%
	Inflammatory	0 0.0%
	Mechanically Inconclusive	50 6.7%
	Mechanically Unresponsive Radicular Syndrome	45 6.0%
	Post-Surgery	12 1.6%
	SLJ/Pregnancy- related Pelvic Girdle Pain	8 1.1%
	Spinal Stenosis	21 2.8%
	Structurally Compromised	7 0.9%
	Trauma/Recovering Trauma	9 1.2%
Total		171 22.8%
Overall total		750 100%

^a Derangement only.

^b Dysfunction, Postural syndrome and OTHER.

Table 3
Patients' data - by spine area - N (%).

Classification	Lumbar	Cervical	Thoracic	Total
Derangement	353 (73%)	181 (82%)	31 (74%)	565
Extension treatment principle	276	164	26	466
Flexion treatment principle	21	4	1	26
Lateral treatment principle	56	13	4	73
Dysfunction	9 (1.8%)	3 (1%)	1 (2%)	13
Postural	1 (0.2%)	0	0	1
OTHER	123 (25%)	38 (17%)	10 (24%)	171
Serious Pathology	2	1		3
Inflammatory				0
Chronic Pain Syndrome	8	6	1	15
Mechanically Inconclusive	39	7	4	50
Mechanically Unresponsive Radicular Syndrome	32	11	1	44
Post-Surgery	9	3		12
SLJ/Pregnancy- related Pelvic Girdle Pain	8			8
Spinal Stenosis	12	8		21
Structurally Compromised	5		2	7
Trauma/Recovering Trauma	5	2	2	9
Overall total	486 (100%)	222 (100%)	42 (100%)	750

Therapy (MDT) enabled the classification and hence the management strategy for all participating patients. Hence, comprehensiveness of the most recent McKenzie classification system for spinal patients has been

established in this survey. This is a particularly important finding as the lack of comprehensiveness has been reported as one of the shortcomings of current low back pain classification systems (Alrwaily et al., 2016; Fritz, 2010). For example, Treatment-Based Classification has a reported rate of 34% with an ‘unclear classification’ (Stanton et al., 2013).

The other principle findings of the study related to distributions of the McKenzie classifications. One aspect of this was the large majority of patients designated as having a directional preference and being classified as Derangement (75%, 95% CI 71.9%, 78.1%). The positive response in outcomes for this classification in regard to both pain and/or function has been reported in numerous trials and cohorts (Long et al., 2004; Werneke et al., 2011; Albert et al., 2012; Surkitt et al., 2012). Centralization only occurs in Derangement syndrome and this phenomenon has been reported to be a strong predictor of various functional (Edmond et al., 2014; Skytte et al., 2005; May and Aina, 2012), pain (Skytte et al., 2005; May and Aina, 2012), psychosocial (May and Aina, 2012; Edmond et al., 2010; Werneke et al., 2012; Al-Obaidi et al., 2013) and return to work outcomes (Long, 1995; Werneke and Hart, 2001). Though in this survey we did not investigate the proportion of Derangements that centralized, one previous report found that 65% of Derangements exhibited centralization (Werneke et al., 2011). However, the present study did not evaluate outcomes, but only the breakdown of classifications, so extrapolation to such an end must be treated with some caution.

There are several studies with which comparisons can be made. In a multi-centered randomized controlled trial, 11 physical therapy clinics in five countries recruited 312 subjects. Two hundred and thirty (74%) of these patients demonstrated a directional preference at the initial screening prior to randomization and would be classified as Derangements (Long et al., 2004). In another study 34 credentialed physical therapists in New Zealand recruited 321 patients with lumbar, cervical and thoracic problems; of who 78% were classified as Derangement (Hefford, 2007). In France, 35 therapists evaluated 349 lumbar patients and 297 cervical patients. For both the lumbar and cervical patients 92% were classified as Derangement (Otero and Bonnet, 2014, 2016).

Thus, in regard to the classification of Derangement the findings from the present study are remarkably consistent with previous studies, with over 75% having this classification, despite the updated definition and criteria. This is supported by the 95% CI (71.9%, 78.1%). The changes in definitions of the McKenzie syndromes do not appear to have impacted the proportions of classifications. The most common directional preference was again consistent, with this survey reporting 82% (95% CI, 79.8%, 85.2%) responding to extension and previous studies reporting between 72% and 84% (Hefford, 2007; Otero and Bonnet, 2014, 2016). In this study 12.9% (95% CI, 10.6%, 16.2%) responded to lateral exercises which is between the lower (10%) (Long et al., 2004) and upper (22%) (Hefford, 2007) of previously reported prevalence. Flexion directional preference was 4.6% (95% CI, 4.2%, 4.9%), again, between the lower (3%) (Hefford, 2007) and upper (7%) (Long et al., 2004) of previously reported prevalence.

It has been proposed that the predominance of one classification in a system undermines its value in regards to discrimination and hence diminishes the system's efficiency (Fritz, 2010). However, if discrimination was lacking, there would likely be markedly more variability in prevalence rates across studies. With the consistency demonstrated between studies and across the world, in different settings, it is clear that clinicians do not have this issue and the current definition and criteria therefore appear to be sufficient for effective discrimination.

The next most prevalent classifications were from the OTHER subgroups, in which, as discussed in the introduction, changes have been made, and operational definitions clearly specified. In this survey about 23% were classified in one of the OTHER subgroups; compared to 5–8% (Otero and Bonnet, 2014), 10% (Hefford, 2007), 17% (May 2006) and 28% (Werneke et al., 2010) in previous studies. Hefford (Clare et al.,

2005) also presented data on five earlier studies with a total population of 538 patients with a mean OTHER classification of 12%. None of these other studies used the updated classification and operational definitions that were in this survey.

In the present survey the largest proportions of the OTHER subgroups were Mechanically Inconclusive and Mechanically Unresponsive Radicular Syndrome with a rate of 6.7% and 6.0% respectively. This compares to the similar rate of 8.5% reported for Mechanically Inconclusive in a 2016 retrospective cohort (Werneke et al., 2016). The classification of Mechanically Unresponsive Radicular Syndrome is a recent addition to the OTHER subgroups and so its proportion cannot be directly compared to any previous studies. None of the other subgroups of OTHER had a proportion of greater than 3%, between 1% and 3% each, which is very similar to the earlier surveys (May 2006).

Though the individual percentage for these OTHERs is low, together they make up 22.8% (95% CI, 19.8%, 25.7%) of patients, which would mean that once classified, clinicians would need to be competent at managing these patients. The specific subgroup dictates the management strategy. So, for example, whereas those with Serious Pathology less than 1% in this and a previous survey (May 2006) would be referred onto the appropriate medical provider, those who are Mechanically Inconclusive would be managed by creating the ideal environment for recovery. This would include modifying aggravating movements/positions and potentially addressing functional deficits, physical impairments and psychosocial barriers to recovery using concepts of self-management, MDT symptom interpretation and education, and reassurance.

Previous reports have misinterpreted those patients classified as McKenzie OTHER subgroups as if they could not be categorized within the MDT system (Fritz, 2010). If this was the case this would indeed make the McKenzie system deficient and lacking comprehensiveness. However, these subgroups are established options within the McKenzie system each with their own definition and criteria (appendix), and as can be seen in this study, they are well utilized by clinicians.

However, it could be argued that the reliability of this most recent classification system has not been corroborated, and that clinicians may simply be inappropriately allocating patients into the categories that are available. Without additional reliability testing this cannot be known. Furthermore, the subgroup of Mechanically Inconclusive could be considered as a group that is essentially unclassifiable, with the presentation not meeting the criteria for any other syndrome or subgroup. However, this subgroup accounted for only 6.7% of this population and there are specific guidelines for managing this subgroup as outlined above, hence it can be considered as a specific subgroup with a specific management strategy.

The McKenzie Syndromes of Dysfunction and Postural Syndrome together accounted for less than 2% of this population and with the definitions and criteria unchanged over recent years we would expect this to be consistent with previous reports. This is in fact the case, for Postural Syndrome with previously reports ranging from 0.9% (Otero and Bonnet, 2014) to 1.3% (Hefford, 2007) and for Dysfunction, with rates between 2 and 5% (Bybee and Dionne, 2007; May 2006; Werneke et al., 2010) with one exception reporting a somewhat higher rate of 7% (Hefford, 2007). With this low rate of these two syndromes, it is worth noting that for spinal patients the McKenzie system of classification is essentially split with three quarters Derangements and nearly all the rest one of the OTHER subgroups with very few Dysfunctions and Postural Syndrome classifications.

The strengths of the present study were the large numbers of patient data collected along with the large number of clinicians involved from over 15 different countries. However, not all countries were represented, and the practice setting were predominantly private, hence a limitation to the study is that generalizability to all countries and to the public health care system cannot be made. Another limitation is the relatively low participation rate of 20% of emailed Diploma clinicians, the sample is therefore a highly selective proportion of Diploma

holders. It cannot be known why the response rate was so low. A further limitation is that the clinicians involved in this survey made classifications independently and without confirmation by another clinician. However, they were all very experienced MDT clinicians and the classification was reported at the initial and final evaluation. It should be noted that not all clinicians provided data on 15 patients in the time-frame allocated, with an average of 13.3 each. Some reported at data submission that they had run out of time in the follow-up period to include all 15 patients, or that clinic circumstances had changed. Another limitation is that it is unknown if the exclusive use of MDT classification for the purposes of this survey reflected the normal practice of the clinicians involved in the study, or if their normal practice involved the use of other approaches and systems. A final limitation is that no patient demographic information was collected as part of this survey making generalization difficult. The purpose of the survey was to document the clinical utility of the classification system, not to evaluate clinical outcomes. It should be noted that randomized trials of the MDT for low back pain have produced mixed results and this is reflected in two previous systematic reviews (Clare et al., 2004; Machado et al., 2006).

5. Conclusions

This study establishes that the updated McKenzie system can be used by clinicians across the world to comprehensively classify all their spinal patients. It provides support for the clinical utility of the system, and further evidence that Derangement is a very common clinical presentation among patients with spinal problems. It also verifies that for Derangement the overwhelming majority of patients are extension responders. However, a small but significant number were found to respond to flexion or lateral exercises which highlights the importance of a mechanical evaluation to ensure that patients with Derangement are matched to their specific directional preference. OTHER subgroups, rather than Dysfunction and Postural Syndrome, account for the majority of the remaining classifications, reinforcing why the McKenzie system should be considered as more than just the three McKenzie Syndromes.

Conflicts of interest

Richard Rosedale is a tutor on McKenzie courses. Richard Rosedale is contracted to the McKenzie Institute International as the Director of Education and as an International Instructor.

Ethics approval

Ethical approval to conduct this study was granted by the Faculty of Health and Wellbeing Research Ethics Committee of Sheffield Hallam University. Clinicians' consent to participate was inferred from their voluntary participation.

Funding

None declared.

Acknowledgements

The authors would like to thank the participating clinicians for their time and effort in collecting the data.

References

Al-Obaidi, S.M., Al-Sayegh, N.A., Nakhi, H.B., et al., 2013. Effectiveness of McKenzie intervention in chronic low back pain: a comparison based on the centralization phenomenon utilizing selected bio-behavioral and physical measures. *Int. J. Phys. Med. Rehab* 1, 4.

Albert, H.B., Hauge, E., Manniche, C., 2012. Centralization in patients with sciatica: are pain responses to repeated movement and positioning associated with outcome or types of disc lesions? *Eur. Spine J.* 21, 630–636.

Alrwaily, M., Timko, M., Schneider, M., et al., 2016. Treatment-based classification system for low back pain: revision and update. *Phys. Ther.* 96, 1057–1066.

Altman DG. *Practical Statistics for Medical Research*. London, Chapman & Hall, 1991 (page 230).

Borkan, J.M., Koes, B., Reis, S., Cherkin, D.C., 1998. A report from the second international forum for primary care research on low back pain. Reexamining priorities. *Spine* 23 (18), 1992–1996.

Bouter, L., Penick, V., Bombardier, C., 2003. Cochrane back review group. *Spine* 28, 1215–1218.

Buchbinder, R., Goel, V., Bombardier, C., et al., 1996. Classification systems of soft tissue disorders of the neck and upper limb: do they satisfy methodological guidelines? *J. Clin. Epidemiol.* 49, 141–149.

Bybee, R.F., Dionne, C.P., 2007. Interrater agreement on assessment, diagnosis, and treatment for neck pain by trained physical therapist students. *J. Phys. Ther. Edu.* 21, 39–47.

Clare, H., Adams, R., Maher, C., 2004. A systematic review of efficacy of McKenzie therapy for spinal pain. *Aust. J. Physiother.* 50, 209–216.

Clare, H.A., Adams, R., Maher, C.G., 2005. Reliability of McKenzie classifications of patients with cervical or lumbar pain. *J. Manip. Physiol. Ther.* 28, 122–127.

Davies, C., Nitz, A., Mattacola, C., et al., 2014. Practice patterns when treating patients with low back pain: a survey of physical therapists. *Physiother. Theory Pract.* 30 (6), 399–408.

Edmond, S.L., Werneke, M.W., Hart, D.L., 2010. Association between centralization, depression, somatization, and disability among patients with nonspecific low back pain. *J. Orthop. Sports Phys. Ther.* 40, 801–810.

Edmond, S.L., Cutrone, G., Werneke, M., et al., 2014. Association between centralization and directional preference; and functional and pain outcomes in patients with neck pain. *J. Orthop. Sports Phys. Ther.* 44, 68–75.

Foster, N.E., Hill, J.C., Hay, E.M., 2011. Subgrouping patients with low back pain in primary care: are we getting any better at it? *Man. Ther.* 16, 3–8.

Fritz, J., 2010. Disentangling classification systems from their individual categories and the category-specific criteria: an essential consideration to evaluate clinical utility. *J. Man. Manip. Ther.* 18, 205–208.

Hefford, C., 2007. McKenzie classification of mechanical spinal pain: profile of syndromes and directions of preference. *Man. Ther.* 13, 75–81.

Heidar-Abady, A., Rosedale, R., Overend, T.J., et al., 2014. Inter-examiner reliability of diplomats in the mechanical diagnosis and therapy system in assessing patients with shoulder pain. *J. Man. Manip. Ther.* 22, 199–205.

Kilpikowski, S., Airaksinen, O., Kankaanpää, M., et al., 2002. Interexaminer reliability of low back pain assessment using McKenzie method. *Spine* 27, E207–E214.

Long, A., 1995. The centralization phenomenon: its usefulness as a predictor of outcome in conservative treatment of chronic low back pain (a pilot study). *Spine* 20, 2513–2521.

Long, A., Donelson, R., Fung, T., 2004. Does it matter which exercise? A randomized controlled trial of exercises for low back pain. *Spine* 29, 2593–2602.

Machado, L., De Souza, M., Ferreira, P., et al., 2006. The McKenzie method for low back pain: a systematic review of the literature with a meta-analysis approach. *Spine* 31, E254–E262.

May, S., 2006. Classification by McKenzie mechanical syndromes: a survey of McKenzie-trained faculty. *J. Manip. Physiol. Ther.* 29, 637–642.

May, S., Aina, A., 2012. Centralization and directional preference: a systematic review. *Man. Ther.* 17, 497–506.

May, S., Rosedale, R., 2012. A survey of the McKenzie classification system in the extremities: prevalence of mechanical syndromes and preferred loading strategies. *Phys. Ther.* 92, 1175–1186.

May, S., Nanche, G., Pingle, S., 2011. High frequency of McKenzie's postural syndrome in young population of non-care seeking individuals. *J. Man. Manip. Ther.* 19, 48–54.

McKenzie RA. *Lumbar Spine Mechanical Diagnosis and Therapy*. New Zealand, Spinal Publications, 1981.

McKenzie RA. *Cervical and Thoracic Spine Mechanical Diagnosis and Therapy*. New Zealand, Spinal Publications, 1990.

McKenzie RA, May S. *The Human Extremities: Mechanical Diagnosis and Therapy*. Wellington, New Zealand: Spinal Publications New Zealand Ltd; 2000.

McKenzie RA, May S. *Lumbar Spine Mechanical Diagnosis and Therapy*. New Zealand, Spinal Publications, 2003.

McKenzie RA, May S. *Cervical and Thoracic Spine Mechanical Diagnosis and Therapy*. New Zealand, Spinal Publications, 2006.

Otero, J., Bonnet, F., 2014. Low back pain: prevalence of McKenzie's syndrome and directional preferences. *Kinesither Rev.* 14, 36–44.

Otero, J., Bonnet, F., 2016. Neck pain: prevalence of McKenzie's syndrome and directional preferences. *Kinesither Rev.* 16, 2–10.

Razmjou, H., Kramer, J.F., Yamada, R., 2000. Interrater reliability of the McKenzie evaluation in assessing patients with mechanical low-back pain. *J. Orthop. Sports Phys. Ther.* 30, 368–389.

Rosedale, R., Hoyt, K., Clare, H., Schenk, R., 2016. On "Treatment-Based classification system for low back pain: revision and update" Alrwaily, M Timko M, Schneider M, et al. *Phys. Ther.* 96, 1057–1066 *Phys Ther.* 2016; 96: 1669-1670.

Saragiotto, B.T., Maher, C.G., Moseley, A.M., et al., 2016. A Systematic review reveals that the credibility of subgroup claims in low back pain trials was low. *J. Clin. Epidemiol.* 79, 3–9.

Sheeran, L., Coales, P., Sparkes, V., 2015. Clinical challenges of classification based targeted therapies for non-specific low back pain: what do physiotherapy practitioners and managers think? *Man. Ther.* 20, 456–462.

- Skytte, L., May, S., Petersen, P., 2005. Centralization: its prognostic value in patients with referred symptoms and sciatica. *Spine* 30, E293–E299.
- Stanton, T.R., Hancock, M.J., Apeldoorn, A.T., et al., 2013. What characterizes people who have an unclear classification using treatment-based classification algorithm for low back pain? A cross-sectional study. *Phys. Ther.* 93, 345–355.
- Surkitt, L.D., Ford, J.J., Hahne, A.J., et al., 2012. Efficacy of directional preference management for low back pain: a systematic review. *Phys. Ther.* 92, 652–665.
- Takasaki, H., Okuyama, K., Rosedale, R., 2017. Inter-examiner classification reliability of Mechanical Diagnosis and Therapy for extremity problems - systematic review. *Musculo Sci. Pract.* 27, 78–84.
- Tousignant-Laflamme, Y., Martel, M., Joshi, A., Cook, C., 2017. Rehabilitation management of low back pain – it's time to pull it all together!. *J. Pain Res.* 10, 2373–2385.
- Werneke, M., Hart, D.L., 2001. Centralization phenomenon as a prognostic factor for chronic low back pain and disability. *Spine* 26, 758–765.
- Werneke, M.W., Hart, D., Oliver, D., McGill, T., Grigsby, D., Ward, J., Weinberg, J., Oswald, W., Cutrone, G., 2010. Prevalence of classification methods for patients with lumbar impairments using the McKenzie syndromes, pain pattern, manipulation, and stabilization clinical prediction rules. *J. Man. Manip. Ther.* 18, 197–210.
- Werneke, M.W., Hart, D.L., Cutrone, G., et al., 2011. Association between directional preference and centralization in patients with low back pain. *J. Orthop. Sports Phys. Ther.* 41, 22–31.
- Werneke, M.W., Hart, D.L., George, S.Z., et al., 2012. Change in psychosocial distress associated with pain and functional status outcomes in patients with lumbar impairments referred to physical therapy services. *J. Orthop. Sports Phys. Ther.* 41, 969–980.
- Werneke, M., Edmond, S., Deutscher, D., et al., 2016. Effect of adding McKenzie Syndrome, centralization, directional preference, and psychosocial classification variables to a risk adjusted model predicting functional status outcomes for patients with lumbar impairments. *J. Orthop. Sports Phys. Ther.* 46, 726–741.
- Willis, S., Rosedale, R., Rastogi, R., et al., 2016. Inter-rater reliability of the McKenzie system of mechanical diagnosis and therapy in the examination of the knee. *J. Man. Manip. Ther.* 25, 83–90.