



## Mechanical diagnosis and therapy and Morton's neuroma: a case-series

Michael David Post <sup>a</sup> and Joseph R. Maccio<sup>b</sup>

<sup>a</sup>Integrated Musculoskeletal Care, Inc, Tallahassee, FL, USA; <sup>b</sup>Maccio Physical Therapy, Troy, NY, USA

### ABSTRACT

**Objectives:** Morton's neuroma (MN) is a neuralgia involving the common plantar digital nerves of the metatarsal region. Evidence-based treatment options for MN are sparse, and utility of physical therapy (PT) is unknown. Mechanical Diagnosis and Therapy (MDT) is a classification system utilizing direction-specific treatment for orthopedic conditions based on mechanical and symptomatic response to repeated end range movements. The purpose of this case series is to describe the management of three patients with a medical diagnosis of MN using the MDT classification system.

**Methods:** Three female patients aged 54–75 years with unilateral plantar forefoot pain for 6 weeks to 8 years were referred by a podiatrist following positive clinically accepted diagnostic criteria for MN including radiological imaging and provocation testing. Patients were evaluated and treated utilizing MDT assessment and treatment principles. The intervention consisted of repeated movements matched to the patient's directional preference at either the lumbar spine (1 patient) or distal extremity (2 patients).

**Results:** Immediate and one-year outcomes were excellent, demonstrating rapid and lasting improvement. Following discharge, the patients have been asymptomatic or able to self-manage without seeking additional medical intervention for this condition. Total visit frequency per patient averaged 2–3 visits total across 8–16 days.

**Discussion:** Responses to repeated end range movements testing allowed for classification and prescription of exercise to rapidly improve symptoms and function in three patients referred to PT services with medically diagnosed MN. This series provides preliminary evidence that MDT may be effective in classifying and treating patients with MN.

### KEYWORDS

McKenzie; mechanical diagnosis and therapy; metatarsalgia; Morton's neuroma; extremities; MDT; directional preference; repeated end-range movements

## Background

Morton's neuroma (MN) is an intermetatarsal neuralgia of the foot that accounts for a significant proportion of patients seen by foot and ankle surgeons, as well as those presenting to orthopedic clinics [1,2]. It is the second most common compressive neuropathy, behind carpal tunnel syndrome [3]. In the UK, the incidence of Morton's neuroma has been reported as 87 and 50 out of 100,000 females and males, respectively [1]. Literature supporting conservative and non-conservative management is limited and is often of low quality because of methodological issues, and small sample sizes [2]. A Cochrane review concluded that results of conservative care are so poor that initial treatment should be surgery [1]. Although surgery is generally accepted as a gold-standard first line of treatment, podiatrists contend that there is no convincing evidence that surgery results in better patient outcomes than conservative care [4]. Surgery has resulted in variable success (62–83%) and is dependent upon accurate diagnosis as there is a potential for excision of asymptomatic interdigital nerves [1,2]. Current podiatrist clinical practice guidelines do not include manual therapy or physical therapy (PT) as

a treatment option prior to surgical intervention in the management of MN [5].

Mechanical diagnosis and therapy (MDT) is a classification system that utilizes repeated end range movements to evaluate and treat musculoskeletal conditions [6,7]. Classification in the extremities is determined based on the patient's response to repeated end range movement testing into one of 4 main syndromes; Derangement, Dysfunction, Postural, or Other, which includes referral of symptoms from the spine [7] (see Table 1). Prevalence of the Derangement syndrome in peripheral joints has been reported from 40–79% in the literature [8–11]. A systematic review reported acceptable inter-rater reliability of MDT assessment in the peripheral joints [12]. Examination of a suspected Derangement seeks to identify a direction of preference, a physiological movement that results in rapidly improved pain and movement. The directional preference movement is then used as an intervention for the patient's condition, leading to favorable patient outcomes [7–9,11].

Providers of manual therapy (MT) who are not physical therapists, have reported literature supportive of MT intervention for MN [4,13]. A recent case report has demonstrated efficacy of a PT intervention

**Table 1.** MDT syndromes.

Classification	Response to repeated movements
<ul style="list-style-type: none"> <li>• Derangement Syndrome</li> </ul>	<ul style="list-style-type: none"> <li>• Increasing Symptoms in one direction, decreasing symptoms in the other</li> </ul>
<ul style="list-style-type: none"> <li>• Dysfunction Syndrome (peri-articular)</li> </ul>	<ul style="list-style-type: none"> <li>• Temporary pain produced only at limited end range</li> </ul>
<ul style="list-style-type: none"> <li>• Dysfunction Syndrome (contractile tissues)</li> </ul>	<ul style="list-style-type: none"> <li>• Temporary pain produced only by resisted tests or end range in opposite direction to resistance</li> </ul>
<ul style="list-style-type: none"> <li>• Postural Syndrome</li> </ul>	<ul style="list-style-type: none"> <li>• No pain during repeated movements</li> </ul>
<ul style="list-style-type: none"> <li>• Other – Chemical pain</li> </ul>	<ul style="list-style-type: none"> <li>• All directions cause lasting pain in the subacute condition</li> </ul>
<ul style="list-style-type: none"> <li>• Other – Chronic pain state</li> </ul>	<ul style="list-style-type: none"> <li>• Persistent pain in which initial active therapy causes temporary increase of symptoms</li> </ul>

with the use of repeated end range movements in a patient with medically-diagnosed MN [14]. The author reported using repeated and loaded end range metatarsophalangeal joint (MPJ) flexion to create a rapid improvement in the patient's pain and functional level, sustained at 6 months. The current series is, to the author's knowledge, the only report of multiple patients treated by a PT. The current case-series details three patients with MN and their successful outcomes one-year post-discharge following treatment with direction-specific exercise, often referred to as directional preference (DP) [7–9,11].

## Methods

For this report, three non-consecutive patients out of thirteen consecutive referrals were selected to represent potential loading strategies, or reductive exercises. Overall, five of thirteen (38%) were classified as a Derangement from this cohort (unpublished data). The remaining ten patients were excluded from presentation in this study as the purpose of this report is to highlight the various loading strategies available to the MDT clinician in examination and treatment of this condition. Those not classified as Derangement were treated through functional retraining and is not described further as it is not considered relevant to this goal of this manuscript. The same podiatrist diagnosed MN following clinical testing and, magnetic resonance imaging (MRI) or ultrasonography and referred the patient for physical therapy. A standard MDT examination will be described with each case, which included repeated end range movements to the lumbar spine and painful extremity while monitoring symptomatic and mechanical response. A non-specific classification, into one of the four main syndromes described above, was made for each case to guide exercise prescription. No other intervention was applied other than those reported in the case descriptions.

The primary outcomes for this study were the numeric pain rating scale (NPRS), 10-meter walk test to assess gait speed, global perceived effect, and global rating of change (GROC). These are previously

validated measures for assessing pain and function with established values for minimal detectable change and minimal clinically important difference [15–19]. Significant change is qualified as a  $\pm 5$  point change on the GROC, and 0.10 m/s or 0.13 m/s for substantial and significant change with gait speed testing [15–19]. Clinical tests with established utility in detection of MN were utilized; Mulder's click, squeeze test, plantar percussion, and web space tenderness test [2,20,21]. Mulder's click has been reported with a 95% sensitivity, 100% specificity, and a 5% false-negative rate in a study of 22 subjects [2]. Additionally, a positive test combining more than one of the squeeze test, plantar percussion, and web space tenderness test has been shown to be significantly associated with a symptomatic lesion when utilizing MRI to confirm diagnosis [20].

Range of motion (ROM) measurements were categorized using nil, minimal, moderate, and major loss as proposed by McKenzie and May [7]. Lumbar ROM was assessed actively in standing and extremity ROM was assessed passively by the treating clinician. Sitting posture is rated as good, fair, or poor as directed by the standard McKenzie examination template. A concordant sign is referred to throughout the text as any functional activity or test to be reassessed for change based on repeated end range movements.

The patients consented for the submission of this case series in a medical journal with de-identified details. This study protocol was exempt from Institutional Review Board appraisal, approved by the New York University School of Medicine Institutional Review Board, New York, USA. A clinician with a doctorate in PT and credential in MDT completed all interventions and outcomes tracking.

## Case description

### Case 1

#### History and function

A 75-year-old female presented with intermittent right plantar foot pain and toe discomfort, approximating the intermetatarsal space and digit II, of insidious onset 4–6 weeks prior to PT examination. The patient reported symptoms worsen with weight-bearing activity while wearing tight-fitting shoes, and improve with non-weight-bearing activity and use of loose-fitting shoes. She reported walking tolerance of less than 5 blocks, inability to wear tight-fitting shoes, and occasional resting pain after increased activity. Average NPRS was 4–5/10 and described as aching, dull, and tingling. The patient reported Advil or Tylenol provided only slight relief and was not utilized with any consistency. Ultrasonography by the podiatrist was (+) for intermetatarsal neuroma of the second web space, measuring 3.5 mm. Past medical history was significant

for osteoporosis, anxiety and depression. The patient's goal was to be able to wear tight-fitting shoes.

### **Examination and observation findings**

The patient described 4/10 pain on the NPRS, at rest. MPJ II demonstrated; flexion ROM with moderate loss and end range pain, extension ROM with moderate loss and no pain. Gait speed measured as 0.76 m/sec, single and double leg heel raise were performed with partial range; each were painful and used as concordant signs. Positive clinical tests specific to Morton's neuroma included squeeze test and tenderness to palpation at MPJ II. Sitting posture was marked as fair and lumbar extension ROM demonstrated minimal loss; other lumbar ROM demonstrated nil loss.

### **Repeated end range movements testing**

Posture correction to upright sitting and repeated end range movements of the lumbar spine, 10 repetitions of flexion and extension in standing, revealed no effect to the concordant signs which suggested no spinal involvement. Repeated end range movements were commenced at the MPJ joints. Unloaded extension of MPJ II provided no effect to symptoms during or after 10 repetitions. Unloaded flexion of the same increased pain during performance but symptoms returned to baseline within 1 min of rest. Upon progression of force of the activity, 10 repetitions of unloaded flexion with clinician overpressure of MPJ II increased and worsened her pain with single and double heel raise, and gait. Based on worsening of symptoms during reassessment of concordant signs, a joint Derangement or Other classification was suspected at this time. The direction of intervention was changed to extension of the toes and progressed to 2 × 10 repetitions of semi loaded MPJ extension with self overpressure (see [Figure 1\(a\)](#)); this decreased symptoms and remained better afterwards with the

above concordant signs. Therefore, the examination was ended and a provisional classification was made; joint Derangement, with directional preference of extension. The patient was prescribed the exercise to be performed 10 repetitions every 2–3 h until the following session.

### **Intervention, follow up, and outcome**

Visit 2 was completed 5 days following examination. The patient reported daily home exercise compliance, approximately 4 times per day. She denied medication use throughout the remainder of her care. The patient reported 50% improvement on the global perceived effect scale. Average NPRS was 2–3/10. She was able to walk 8 blocks prior to onset of pain. Right single leg heel raise continued to produce end range pain but the patient demonstrated symmetrical ROM compared to the left. Gait speed was unchanged. No additional progress was observed within the session with repeated end range unloaded MPJ extension with self overpressure for 2 × 10 repetitions. A force progression, repeated end range loaded MPJ extension with self overpressure (see [Figure 1\(b\)](#)) for 2 × 10 repetitions, was found to decrease pain with single leg heel raise and the patient was provided the exercise to be performed at home for 10 repetitions every 2–3 h. The previous exercise was discharged.

Visit 3, discharge, was completed 2 days later. The patient reported home exercise compliance, approximately 6 times per day. The patient noted some mild pain with the exercise in the AM but notes it improved with repetition. She reported wearing shoes she had not worn since the initial onset of the pain and reported walking faster. Gait speed was improved, 0.87 m/sec (0.11 m/sec improvement from examination), GROC +7, double and single leg heel raise were tolerated for 20 repetitions each. The



**Figure 1.** (a): Semi-loaded MPJ extension with self overpressure. (b): Loaded MPJ extension with self overpressure.

patient was recommended to continue with the repeated end range movement, loaded MPJ extension with self overpressure, for the next two weeks with additional sets and repetitions as needed.

At 6 months and 1 year, a phone interview follow up was completed. The patient reported no reoccurrence of symptoms and denies seeking additional care related to management of the condition.

## Case 2

### History and function

A 67-year-old female presented with intermittent right plantar foot pain, approximating the intermetatarsal space III, of insidious onset 6 weeks prior to PT examination. The patient reported symptoms worsen with weight bearing activity, and improve with non-weight bearing activity and rest. She reported painful walking unlimited distances while using a plantar pad insert. Average NPRS was 2–4/10 and described as shooting, and pressure. The patient denied the use of pain medication for pain-relief of this condition. Recent X-Ray was (-), MRI was (+) for intermetatarsal neuroma of the third web space, measuring 4 × 4 mm. Past medical history was significant for irritable bowel syndrome and colon cancer. The patient's goal was to avoid invasive procedures for further treatment.

### Examination and observation findings

The patient was painless, 0/10 NPRS, at rest. MPJ digit III demonstrated flexion ROM with moderate loss and pain during movement, extension ROM with nil loss and no pain. Gait speed was measured as 1.12 m/sec, the patient was unable to perform single leg heel raise; each were painful and used as concordant signs. Positive clinical tests specific to Morton's neuroma included Mulder's click and percussion test in the third web space. Sitting posture was marked as fair and lumbar ROM was marked with nil loss and no symptom reproduction.

### Repeated end range movements testing

Posture correction to upright in sitting and repeated end range movements of the lumbar spine, 10 repetitions of flexion and extension in standing, revealed no effect to the concordant signs which suggested no spinal involvement. Repeated end range movements were commenced at the MPJ. An unloaded force progression, flexion of digit III with clinician overpressure (see Figure 2(a)), was found to produce pain and remain worse afterwards with walking. Based on symptoms remaining worse following testing, a joint Derangement or Other classification was suspect at this time. Intervention was modified to extension of the toes and progressed to unloaded extension of MPJ III with clinician overpressure (see Figure 2(b)). Symptoms returned to baseline after 2 × 10 repetitions but concordant signs remained painful and



**Figure 2.** (a): Unloaded MPJ digit II toe flexion with clinician overpressure. (b): Unloaded MPJ digit II toe extension with clinician overpressure. (c,d,e): Semi-loaded extension with self overpressure and oscillations.

plateaued with additional repetitions. A force progression, semi loaded extension with self overpressure and oscillations (see Figure 2(c,d,e)) for  $2 \times 10$  repetitions, was found to decrease pain afterwards with single leg heel raise. Based on pain decreasing and remaining better with the above concordant signs, the examination was ended at the time and a provisional classification was made: joint Derangement, with directional preference of extension. The patient was prescribed the exercise to be performed 10 repetitions every 2–3 h until the following session.

### **Intervention, follow up, and outcome**

Visit 2 was completed 8 days following examination. The patient reported variable home exercise compliance, approximately 6 times per day which reduced to 2 to 3 times per day when symptoms were improved approaching follow up. The patient reported 95% improvement on the global perceived effect scale. Average NPRS was 0/10. Gait speed was significantly improved (1.39 m/sec current or 0.27 m/sec increase from examination) [12], GROCC +6, and single-leg heel raise was tolerated for 20 repetitions. The patient self-discharged the use of plantar pad inserts. The patient was recommended to continue with the repeated end range movement, semi loaded MPJ extension with self overpressure and oscillations, for the next two weeks with additional as needed.

At 6 months and 1 year, a phone interview follow up was completed. The patient reported no recurrence of symptoms and denies seeking additional care related to management of the relevant condition.

## **Case 3**

### **History and function**

A 54-year-old female presented with intermittent left plantar foot pain, approximating the intermetatarsal space II, of insidious onset 8 years prior to PT

examination. The patient reported symptoms worsened with walking, wearing heels, prolonged sitting, and improve with self-massage, toe stretches, and wearing shoes with a round-toe box. She reported modifying her walking commute to work to shorten the walking distance, inability to wear tight shoes, and limited sitting tolerance at work due to a reported singular incident of shooting leg pain from her left foot to posterior thigh. Average NPRS was 8/10 and described as burning, sharp, and cramping. The patient denied use of medication for the management of this condition. Recent X-Ray was (–), ultrasonography was (+) for an unspecified intermetatarsal neuroma of the second web space. Past medical history was significant for melanoma excision on right foot and Graves' disease. The patient's goal was to be able to wear boots for the upcoming Winter without increased pain.

### **Examination and observation findings**

The patient was painless, 0/10 NPRS, at rest. MPJ II and III demonstrated flexion and extension ROM with minimal loss and no pain. Gait speed was normal (1.45 m/sec) and asymptomatic, and single leg heel raise was pain-free through full range [18]. Positive clinical tests specific to Morton's neuroma included Mulder's click at intermetatarsal space II, tenderness to palpation at inter-MPJ space III, and squeeze test; both were painful and were used as concordant signs. Sitting posture was marked as poor and lumbar ROM was marked with nil loss and no symptom reproduction.

### **Repeated end range movements testing**

Posture correction to upright in sitting had no effect as the patient was asymptomatic at this point of the examination. Repeated end range movements of the lumbar spine, repeated end range extension in lying with self overpressure (see Figure 3)  $\times 20$  repetitions,



**Figure 3.** Repeated extension in lying with self overpressure.

was tested based reporting of symptoms when sitting and the prior incident of shooting pain distal to proximal through her left leg. The repeated end range lumbar extension in lying with self overpressure was found to abolish pain with retesting Mulder's click, squeeze test and tenderness to palpation at inter-MPJ space III. Based on the abolished symptoms response, a lumbar Derangement was suspected at this time. An attempt was made to provoke symptoms for further clarity in the patient's symptoms presentation, repeated end range flexion in standing with self overpressure for 2 × 20 repetitions had no effect on concordant signs. Based on the patient response the examination was ended at the time and a provisional classification was made: lumbar Derangement, with directional preference of extension. The patient was prescribed the exercise, repeated end range lumbar extension in lying with self overpressure, to be performed 10 repetitions every 2–3 h. Additional relevant instructions to the patient included posture correction and limiting excessive lumbar flexion activity until the following session.

#### **Intervention, follow up, and outcome**

Visit 2 was completed 16 days following examination. Follow up was encouraged at a larger interval due to inability to provoke the patient's symptoms after the repeated end range extension in lying exercise. The therapist and patient agreed that 2 weeks would be a sufficient time period to assess efficacy of the prescribed exercise. The patient reported home exercise compliance, approximately 4 times per day. The patient reported 100% improvement on the global perceived effect scale. Average NPRS was 0/10. Mulder's click, tenderness to palpation, and plantar percussion were pain-free. She reported one incident where she sensed the pain was returning and, upon performance of the exercise, her discomfort resolved. She was able to wear any shoes without pain since examination. The patient was recommended to continue with the repeated end range movement, repeated end range extension in lying with self overpressure, for the next two weeks with additional sets and repetitions as needed.

At 6 months and 1 year, a phone interview follow up was completed. The patient reported no reoccurrence of symptoms and denies seeking additional care related to management of the condition.

#### **Discussion**

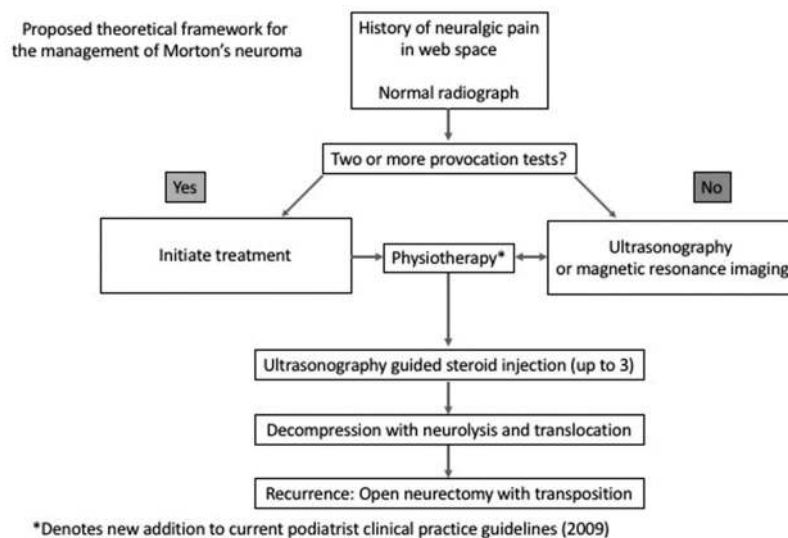
The previous cases, referred to PT with a medical diagnosis of MN, demonstrated successful outcomes utilizing the MDT system to classify and treat symptoms based on a non-pathoanatomical model. Contrary to

the clinical practice guidelines [5], which advocate therapeutic injections and surgery as the first-line treatment approach for management of this condition, this series applied clinician-assisted and self-treatment options for patients with medically diagnosed MN following clinical and imaging testing. Combined with a recently published report [14], these patients further the potential long-term benefits following examination and treatment utilizing the MDT system for MN.

Chiropractic and podiatric literature have reported success within this population in application of passive manual interventions, such as manipulation, to provide short-term relief of patient's symptomatic complaints [4,13]. A PT reported a single-case following a similar approach to describe short-term reductions in pain-pressure threshold testing [22]. Waldecker [23] displayed similar results over the short term when working with a more nonspecific population diagnosed with metatarsalgia symptomatology. Given the difficult differential diagnosis of patients with metatarsalgia, it is likely that a number of patients responsive to manual therapy within that study would have met diagnostic criteria of symptomatic MN according to current diagnostic standard [2,5]. The current series, and a prior report [14], demonstrates use of manual therapy and repeated end range movements as an effective treatment option that provides long-term relief of symptoms for those with MN.

A limitation of this study is its small sample size. To date, there are limited cases in the literature which are suggestive of the utility of physical therapy in the presence of medically diagnosed Morton's neuroma. The overall prevalence rates when classifying this condition utilizing the MDT classification system is unknown [14,22].

With the application of a dynamic mechanical evaluation and treatment approach, classification can guide not only treatment but also triage those that respond poorly to conservative management. The current series of patients represents a small, non-consecutive sample of 13 patients (unpublished data). Derangement syndrome has been classified in a limited number of cases (5 of 13) in this population and more rigorous research should be conducted to determine the rates of MDT classification in this population. Those not classified as a fast-responding Derangement may be unresponsive to this approach and may progress to more invasive measures such as injection therapy or surgery as current guidelines primarily recommend [5]. Prior literature supported how MDT may improve the selection process for surgical patients with lumbar spine diagnoses [24]. With larger studies of higher quality, perhaps PT might be included as part of the clinical practice guidelines for management of MN (see Figure 4) [5].



**Figure 4.** Proposed theoretical framework for managing Morton's neuroma, modified from the current podiatrist clinical practice guidelines [5].

## Conclusion

A thorough mechanical assessment that evaluates the patient response to repeated end range movements testing should be considered as part of the treatment algorithm in the presence of medically diagnosed MN. The current case series of patients classified as Derangement syndrome utilizing MDT principles demonstrated rapid improvements in a short intervention period and a low number of treatment sessions. Moreover, the patients demonstrated year-long benefits following provision of self-treatment exercises, which promoted self-management. Clinically, rapid responses such as in the described cases are typical and further investigation is warranted on a larger sample size to evaluate the treatment effect of MDT examination and treatment in symptomatic patients with identified MN.

## Disclosure statement

No potential conflict of interest was reported by the authors.

## Funding

The authors have no funding details to disclose.

## Notes on contributors

**Michael David Post** is a doctor of physical therapy and holds a diploma in Mechanical Diagnosis and Therapy (MDT). He is currently a Fellow in Training for the American Academy of Orthopedic Manual Physical Therapy. He is published in the application of MDT in the presence of the medical diagnosis Morton's neuroma. He has presented a poster at an International MDT conference detailing the same case.

**Joseph R. Maccio** is a doctor of physical therapy and holds a diploma in Mechanical Diagnosis and Therapy (MDT). He is published in the application of MDT in the wrist, hip osteoarthritis, ankle, after failed anterior cervical fusion and discectomy, and lateral epicondylagia, and further investigation of classification of MDT syndromes in the extremities. He has given a platform presentation at the McKenzie Americas Conference detailing the prevalence of directional preference at the wrist. He has also presented numerous posters at national and international MDT conferences regarding ankle, lumbar, cervical, elbow, and hip pain. He has also presented a clinical mentoring webinar for the McKenzie Institute USA on the identification of derangement and directional preference. He is the Clinical Instructor (CI) for a MDT-specific clinical rotation for doctoral physical therapy students.

## ORCID

Michael David Post  <http://orcid.org/0000-0002-1376-6430>

## References

- [1] Thomson CE, Gibson JNA, Martin D. Interventions for the treatment of Morton's neuroma. *Cochrane Database Syst Rev.* 2004;(3). Art. No.: CD003118
- [2] Jain S, Mannan K. The diagnosis and management of Morton's neuroma. *Foot Ankle Spec.* 2013;6(4):307–317.
- [3] Latinovic R, Gulliford MC, Hughes RA. Incidence of common compressive neuropathies in primary care. *J Neurol Neurosurg Psychiatry.* 2006 Feb;77(2):263–265.
- [4] Cashley DG, Cochrane L. Manipulation in the treatment of plantar digital neuralgia: a retrospective study of 38 cases. *J Chiropr Med.* 2015;14(2):90–98.
- [5] Clinical Practice Guideline Forefoot Disorders Panel, Thomas JL, Blitch EL 4th, Chaney DM, et al. Diagnosis and treatment of forefoot disorders. Section 3. Morton's intermetatarsal neuroma. *J Foot Ankle Surg.* 2009 March – April;48(2):251–256.

- [6] McKenzie R, May S. The lumbar spine. Waikanae New Zealand: Spinal Publications; 2003.
- [7] McKenzie R, May S. The human extremities. Wellington: Spinal Publications New Zealand; 2009.
- [8] Rosedale R, Rastogi R, May S, et al. Efficacy of exercise intervention as determined by the McKenzie system of mechanical diagnosis and therapy for knee osteoarthritis: a randomized controlled trial. *J Orthop Sports Phys Ther.* 2014;44(3):173–181.
- [9] Maccio JR, Carlton L, Fink S, et al. Directional preference of the wrist: a preliminary investigation. *J Man Manip Ther.* 2017;25(5):244–250.
- [10] May SJ, Rosedale R. A survey of the McKenzie classification system in the extremities: prevalence of preferred loading strategies. *JOSPT.* 2012;92(9):1175–1186.
- [11] Abady AH, Rosedale R, Chesworth BM, et al. Application of the McKenzie system of mechanical diagnosis and therapy (MDT) in patients with shoulder pain; a prospective longitudinal study. *J Man Manip Ther.* 2017;25(5):235–243.
- [12] Takasaki H, Okuyama K, Rosedale R. Inter-examiner classification reliability of mechanical diagnosis and therapy for extremity problems – systematic review. *Musculoskelet Sci Pract.* 2017;27:78–84.
- [13] Govender N, Kretzmann H, Price JL, et al. A single-blinded randomized placebo-controlled clinical trial of manipulation and mobilization in the treatment of Morton's neuroma. *J Am Chiropr Assoc.* 2007;44(3):8–18.
- [14] Post M. Mechanical diagnosis and therapy and Morton's neuroma: a case report. *Phys Can Physiother Canada.* 2019;71(2):130–133.
- [15] Farrar JT, Young JP, LaMoreaux L, et al. Clinical importance of changes in chronic pain intensity measured on an 11-point numerical pain rating scale. *Pain.* 2001;94(2):149–158.
- [16] Kamper SJ, Ostelo RWJG, Knol DL, et al. Global perceived effect scales provided reliable assessments of health transition in people with musculoskeletal disorders, but ratings are strongly influenced by current status. *J Clin Epidemiol.* 2010;63(7):760–766.
- [17] Perera S, Mody SH, Woodman RC, et al. Meaningful change and responsiveness in common physical performance measures in older adults. *J Am Geriatr Soc.* 2006;54(5):743–749.
- [18] Bohannon RW. Comfortable and maximum walking speed of adults aged 20–79 years: reference values and determinants. *Age Ageing.* 1997;26(1):15–19.
- [19] Kamper SJ, Maher CG, Mackay G. Global rating of change scales: a review of strengths and weaknesses and considerations for design. *J Man Manip Ther.* 2009;17(3):163–170.
- [20] Owens R, Gougoulias N, Guthrie H, et al. Morton's neuroma: clinical testing and imaging in 76 feet, compared to a control group. *Foot Ankle Surg.* 2011;17(3):197–200.
- [21] Mahadevan D, Venkatesan M, Bhatt R, et al. Diagnostic accuracy of clinical tests for Morton's neuroma compared with ultrasonography. *J Foot Ankle Surg.* 2015;54(4):549–553.
- [22] Sault JD, Morris MV, Jayaseelan DJ, et al. Manual therapy in the management of a patient with a symptomatic Morton's neuroma: a case report. *Man Ther.* 2016;21:307–310.
- [23] Waldecker U. Limited range of motion of the lesser MTP joints - a cause of metatarsalgia. *Foot Ankle Surg.* 2004;10(3):149–154.
- [24] Wetzel FT, Donelson R. The role of repeated end-range/pain response assessment in the management of symptomatic lumbar discs. *Spine J.* 2003;3(2):146–154.