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ORIGINAL RESEARCH

SPINAL AND PERIPHERAL DRY NEEDLING VERSUS PERIPHERAL DRY NEEDLING ALONE AMONG INDIVIDUALS WITH A HISTORY OF LATERAL ANKLE SPRAIN: A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT

Background: In addition to established interventions, dry needling may reduce impairments leading to greater functional abilities for individuals following ankle sprain.

Hypothesis/Purpose: The purpose of this study was to compare effects of spinal and peripheral dry needling (DN) with peripheral DN alone on impairments and functional performance among individuals with a history of lateral ankle sprain.

Study Design: Randomized controlled trial.

Methods: Twenty individuals with a history of lateral ankle sprain (18 bilateral, 2 unilateral) participated in this study (4 males, 16 females; mean age 28.9 +/- 9.2 years). During the first of two sessions, participants completed the Foot and Ankle Disability Index (FADI) and the Cumberland Ankle Instability Tool (CAIT) and their strength, unilateral balance, and unilateral hop test performance was assessed. Participants were randomly assigned to a spinal and peripheral DN group (SPDN), or a peripheral only DN group (PDN). Participants in the SPDN site group received DN to bilateral L5 multifidi and fibularis longus and brevis muscles on the involved lower extremity. Participants in the PDN group received DN to the fibularis muscles alone. Participants' strength, balance and hop test performance were reassessed immediately following the intervention, and at follow-up 6-7 days later, all outcome measures were reassessed. Three-way mixed model ANOVAs and Mann-Whitney U tests assessed between group differences for outcome variables with normal distributions and non-normal distributions, respectively.

Results: ANOVAs showed significant group by time interaction ($p < 0.05$) for invertor strength, significant side by group and time by group interactions ($p < 0.05$) for plantarflexor-evertor strength, no significant findings for dorsiflexor-invertor strength, significant side by time interaction ($p < 0.05$) for unilateral balance, significant main effect of time ($p < 0.05$) for triple hop for distance test, and significant main effect of side ($p < 0.05$) for the CAIT. Mann-Whitney U tests showed no significance ($p > 0.05$) for the side hop test or FADI.

Conclusion: The results suggest that DN of the multifidi in addition to fibularis muscles does not result in improvements in strength, unilateral balance or unilateral hop test performance, compared to DN the fibularis muscles alone among individuals with a history of ankle sprain.

Key Words: Dry needling**,** functional performance tests, lateral ankle sprain

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INTRODUCTION

Ankle sprains are one of the most common injuries encountered during sporting and recreational activities.[1] Lateral ankle sprains may lead to functional ankle instability with patients reporting a feeling of the ankle joint "giving way" and experiencing recurrent sprains.[2,3] It has been estimated that 40% of ankle sprain cases will result in chronic ankle instability (CAI).[4] Impaired muscle function is common among individuals with CAI and may explain the joint's vulnerability to recurrent injury. Previous investigators have shown abnormalities of the fibularis muscles in persons with CAI, including reduced reaction time, diminished postural control and corticomotor excitability, and the presence of myofascial trigger points (MTrPs).[5,6,7] MTrPs are areas of increased irritability in palpable taut bands of skeletal muscle tissue that are clinically associated with both local and referred pain, muscle dysfunction, and autonomic phenomena.[8-10]

In addition to other intervention strategies, the use of dry needling as a treatment for MTrPs is gaining attention as investigations on its effectiveness emerge. Dry needling is the insertion of a monofilament needle with the intent of treating a MTrP by disrupting the physiological milieu that causes the abnormal contraction, leading to restoration of proper muscular function.[10,11] While theories regarding the precise etiology and pathophysiology of MTrPs continue to evolve, three main theories have emerged to explain this phenomenon: the integrated hypothesis, expanded trigger point hypothesis, and intra-muscular stimulation (IMS). These theories originate from the research performed by Simons and Travell, Gerwin, Shah, and Dommerholt.[10,12-17] Based on the IMS theory, Gunn[18] proposes that the pain from MTrPs is a result of neuropathic pain from the irritation of the spinal nerve root caused by the shortening of the corresponding segmental paravertebral muscles.[13,18] Hypersensitivity then develops in skeletal muscles innervated with the nerve root, leading to the development of MTrPs.[15,17,18] Treatment approaches utilizing Gunns' IMS theory[19] suggest that performing dry needling to the muscles of the spine normalizes the resting length of paraspinal muscles, reduces spinal nerve compression and muscle dysfunction along the corresponding myotomes to produce long-lasting pain reduction.

While the physiological mechanism of dry needling is still a topic of debate, numerous studies support the efficacy of dry needling as an intervention with reported improvements in range of motion, muscle activation patterns, reduction in both local and referred pain, and decreased end plate dysfunction related to trigger points.[8,11-13,15,16,19,20] Individuals with and without low back pain have demonstrated varied responses in muscle activation following a dry needling intervention to the lumbar multifidi muscles.[21-23] Studies investigating the physiological effects of dry needling of the lumbar multifidi muscles in individuals with[22,23] and without low back pain[21] demonstrate changes in nociceptive sensitivity, segmental mobility and motor function following the interventions. In a study by Koppenhaver et al., individuals with mechanical low back pain received a dry needling intervention to bilateral L4-5 and L5-S1 multifidi.[22] Ultrasonography was used to visualize the thickness of the multifidus muscles pre and post-intervention and one week following the dry needling intervention. The results of the study indicated that the participants with improved scores on the Oswestry Disability Index (ODI) had an improvement in the thickness of the multifidi contraction one week following the intervention. An increase in muscle thickness implies that dry needling may have an effect on selective activation of motor nerve fibers and a facilitory effect within the multifidus muscles. Conversely, participants with continued pain and no improvement in the ODI scores at one week demonstrated a decrease in the lumbar multifidi muscle contraction following the needling intervention suggesting that pain inhibition may continue to produce an inhibitory effect within the multifidi muscles.[22]

To date, a significant portion of dry needling research has focused on treatment of the upper quarter and several studies have shown that dry needling to muscles in the upper quarter has significant effects on pain reduction, increased range of motion, and improved quality of life.[15,20,24] Fewer studies have focused on the effects of dry needling on conditions of the lower extremity in general, or specifically, the foot and ankle. The efficacy of dry needling in the treatment of plantar fasciitis demonstrated a beneficial effect when paired with traditional therapeutic procedures, with two studies authors' reporting

statistically significant reduction in plantar heel pain.[25,26] With regard to chronic ankle instability, a randomized clinical trial compared the effects of combined MTrP dry needling of the fibularis muscle and therapeutic exercises to therapeutic exercises alone for pain and function in subjects with chronic ankle instability.[5] The authors concluded that subjects who received the combined therapy approach demonstrated superior outcomes in pain and function one month after ceasing treatment.

Few studies are available that compare the efficacy of different dry needling treatment sites. Based on the IMS theory, one approach proposed by Gunn,[18] suggests that the clinician dry needle the site of the peripheral trigger point and proximal multifidi of the corresponding segmental level. While Gunn's approach has been adopted by some clinicians the authors are aware of only one study comparing this dual site method to treatment of the distal trigger point alone. Ga et al, 2007[27] investigated the effects of dry needling at the C3-C5 spinal levels and the upper trapezius versus the upper trapezius alone among aging adults with chronic myofascial pain syndrome. At a 4-week follow-up, these authors reported that the subjects who received spinal and peripheral dry needling had decreased pain and depression and increased cervical ROM compared to the patients who received only peripheral needling.

The purpose of this study was to compare the effects of spinal and peripheral dry needling (DN) with peripheral DN alone on impairments and functional performance among individuals with a history of lateral ankle sprain.

METHODS

Study Design

This study was a single-blinded randomized controlled trial. Participants were randomly assigned to one of two intervention groups: 1) a peripheral dry needling (PDN) group receiving dry needling to the fibularis longus and brevis muscles of the involved lower extremity, or 2) a spinal and peripheral dry needling (SPDN) group, receiving needling of the L5 multifidi bilaterally and the fibularis longus and brevis muscles of the involved lower extremity. Investigators assessing outcome measures were blinded to participants' group allocation and the physical therapists administering the dry needling intervention were blinded to results of outcome assessments. Participants were not blinded to group assignment. A sham procedure was not included, as based on previously published work, using a blunt needle (sham) does not successfully blind subjects to dry needling versus sham dry needling groups.[28] The study was approved by the institution's Institutional Review Board and informed consent was obtained from participants prior to data collection.

Participants

Thirty-eight prospective participants were screened for inclusion in this study. Twenty subjects with unilateral or bilateral history of ankle sprain satisfied the eligibility criteria, agreed to participate, and were enrolled in the study (4 males and 16 females; 2 unilateral and 18 bilateral; average age 28.9 years, SD 9.2 years). Among those subjects with bilateral involvement, the side that performed less well on the strength, balance and hop tests was the side that received the DN to the fibularis muscles and the side that performed better on the strength, balance and hop tests did not receive DN to the fibularis muscles. For the purposes of this study, the side that did or did not receive DN of the fibularis muscles will be identified as the "involved side" or "uninvolved side", respectively. The flow of subjects through the study is summarized in Figure 1, and subject characteristics are summarized in Table 1.

Eligibility criteria included: 1) age between 18 and 65 years, 2) sustained at least one self-reported lateral ankle sprain within 12 months prior to enrolling in the study, 3) inflammatory symptoms present at the time of initial injury (pain, swelling, warmth or redness), and 4) the previous ankle sprain(s) interrupted normal physical activity for at least one day. Additionally, participants' were required to have the ability to perform specific functional activities at the time of the study, including walking at a self-selected pace over an even surface without pain and performing single leg hops (with or without pain).

Participants were excluded from the study if they: 1) had a history of a knee or hip injury to either lower extremity within 12 months of enrolling in the study, 2) had a history of fracture of either lower

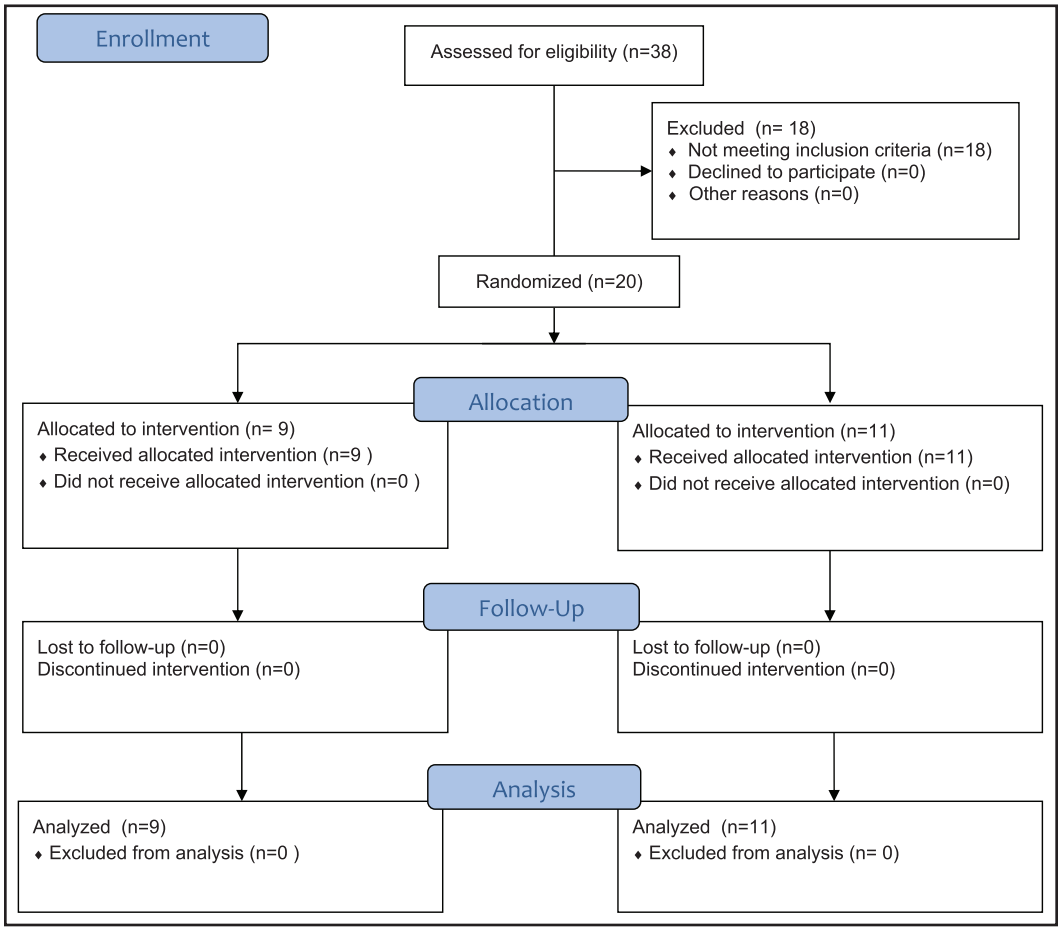

Figure 1. *Participant Allocation.*

Table 1. *Participant Characteristics (n = 20).*

Characteristic	Group		
	SPDN (n=9)	PDN (n=11)	p-value
	Frequency (percentage)		
Sex			0.26
Male	1	3	
Female	8	8	
	Mean (standard deviation)		
Age (years)	29.0 (9.0)	28.8 (9.9)	0.68
Height (centimeters)	152.4 (8.0)	168.2 (11.7)	0.83
Weight (kilograms)	68.5 (7.7)	68.0 (14.4)±	0.91
Baseline FADI	5.3 (5.1)	6.1 (15.8)	0.12
Baseline Cumberland			
Involved side	19.9 (4.8)	20.2 (7.4)	0.91
Uninvolved side	24.7 (6.9)	24.5 (8.4)	0.95

SPDN= Spinal and Peripheral Dry Needling
PDN= Peripheral Dry Needling
±n=10 for this value, as one subject declined to provide weight

extremity requiring surgical reduction, 3) had previous surgery to either lower extremity, 4) exhibited neurological symptoms resulting from a traumatic brain injury, spinal cord injury, stroke, or peripheral nerve injury, 5) received physical therapy interventions or dry needling to the spine and/or the affected lower extremity within six months of enrolling in this study, 6) were taking prescription blood thinners at the time of the study or non-prescription NSAISs within 24 hours of the dry needling intervention, 7) were pregnant at the time of the study, 8) had systemic infection or immunosuppression at

the time of the study, and 9) had been diagnosed with osteoarthritis in the lumbar spine or either lower extremity.

Procedures

Participants were seen during two onsite visits one week apart. During the initial visit, participants' baseline self-reported functional status, strength, balance, and single leg hop tests were assessed in order of right leg followed by left leg and this order was maintained throughout the study. Following obtainment of baseline outcome measures, based on allocation previously determined by use of a random number table with group assignment identified in concealed envelopes, participants were randomly assigned to the PDN or SPDN group. Following randomization into groups, the dry needling intervention was performed by one of three physical therapists, each of whom had completed over 50 hours of supervised training and had a minimum of three years of dry needling experience. Immediately following the intervention, investigators blinded to participants' group, re-assessed participants' strength, balance, and single leg hop tests. Pain was monitored at four separate times: 1) pre-assessment, pre-needling, 2) post-assessment, pre-needling, 3) post-needling, pre-reassessment, and 4) post-needling, post-reassessment. One week after the initial visit, investigators again assessed participants' self -reported functional status, strength, balance, and single leg hop tests. Pain level was monitored again pre-assessment and post-assessment during the second visit. Participants in the study were monitored throughout the study for adverse reactions to the needling procedure such as a sympathetic response (fainting, profuse sweating, dizziness), excessive bruising or bleeding, and signs of infection by investigator observation and verbally cuing the participants to report their current status during the dry needling procedure.

Outcome Measures

Self-Reported Functional Status

Functional status was assessed with the Foot and Ankle Disability Index (FADI) and the Cumberland Ankle Instability Tool (CAIT). The FADI is a self-reported functional questionnaire that includes a 26-item ADL subscale and an 8-item sports specific subscale. There is evidence for reliability and validity with a test-retest intraclass correlation coefficient (ICC) of 0.89 for the ADL subscale and 0.84 for the sports subscale.[29,30] The CAIT is a 9-item questionnaire used to classify severity of functional ankle instability. Test-retest reliability for the CAIT has been reported with an ICC of 0.96. An assessment of the CAIT's validity showed a score of 28 or higher had a sensitivity and specificity of 86% and 83%, respectively, in differentiating between those who had experienced an ankle sprain or not.

Strength

Strength testing was performed bilaterally for three ankle muscle groups: 1) invertors, 2) dorsiflexor/invertors, and 3) plantarflexors/evertors. Examiners measured strength with the MicroFET2 handheld dynamometer (Hoggan Scientific LLC; Salt Lake City, UT). Testing positions for each movement were standardized to maintain consistency throughout the study. Each muscle group was measured three times on each side to assess intra-examiner reliability. Additionally, all strength measurements were repeated by a second examiner for every other participant to assess inter-examiner reliability. The participant was positioned sitting on the edge of a treatment table for all strength tests with the contralateral lower extremity supported on a footstool. To test the invertors and plantarflexors/evertors, the examiner was seated in a chair with the elbow flexed approximately 90 degrees and braced against the knee. When testing the invertors, the examiner placed the dynamometer directly on the medial aspect of the first metatarsal head perpendicular to the foot. When testing the plantarflexors/evertors, the examiner placed the dynamometer on the inferior-lateral aspect of the fifth metatarsal head, about 45 degrees from parallel with the foot. To test dorsiflexors/invertors, the examiner was standing with the elbow locked; the examiner placed the dynamometer on the superior-medial aspect of the first metatarsal head, about 45 degrees from parallel with the foot.

The participant was instructed to push into the dynamometer with maximal force and hold the contraction for five seconds. The average of the three trials for each muscle group was calculated and used for data analysis.

Balance

Balance was assessed using a unilateral version of the Modified Clinical Test of Sensory Integration and Balance (MCTSIB). The MCTSIB has been shown to be a simple and inexpensive measure to assess generalized balance deficits and effectiveness of physical therapy interventions on balance deficits.[31] The MCTSIB assesses duration of standing balance with eyes open and eyes closed on both noncompliant and compliant surfaces. Despite the participants' history of ankle sprain(s), a more challenging, unilateral single limb balance testing method was selected with the expectation that a bilateral lower extremity balance assessment would result in a ceiling effect.

Each participant performed the unilateral single leg balance assessment, testing the right lower extremity first followed by the left lower extremity, without footwear and the components of the test were performed on each limb in the following order: 1) single leg stance on a noncompliant surface with eyes open, 2) single leg stance on a noncompliant surface with eyes closed, 3) single leg stance on a compliant surface (foam cushion) with eyes open, and 4) single leg stance on a compliant surface with eyes closed. Participants were instructed to hold their position during each component for as long as possible up to 30 seconds. A two and a half inch thick AIREX Balance Pad (Power Systems, LLC; Knoxville, TN) was used to provide the compliant surface.

Single Leg Hop Tests

Following the balance test, subjects were given standardized instructions to perform hop tests. Two single leg hop tests, the side hop and triple hop, were utilized because both demonstrate good test-retest properties.[29,32] Participants performed three trials bilaterally for each test and were allotted one minute of rest between each trial.

The side hop test requires participants to laterally hop on one foot over a gap of 30 cm separated by two pieces of tape. One repetition was counted as successful clearance over the tape and back to the starting position. Participants were instructed to perform ten repetitions as quickly as possible. The examiner measured the time taken to perform the 10 repetitions with a stopwatch.

The triple hop test required participants to forward hop three times on a single leg and attain maximum distance.[29] Following a successful landing on the third hop, the examiner marked the location of the posterior heel and recorded the total distance travelled in centimeters. Any errors required the participant to restart the trial. Participants performed the test until three successful trials were completed for both extremities. For both the side hop and triple hop tests, the average of the three trials was calculated and used for data analysis.

Other Measured Variables

Pain

Pain was monitored using the Visual Analogue Scale (VAS). The VAS has been shown to be a valid and reliable pain assessment tool and is more sensitive to small changes in pain than verbal pain scales.[33,34] A standard VAS consisting of a horizontal line 100 mm in length anchored with the descriptors "no pain" on the left and "very severe pain" on the right was utilized, and participants were asked to mark the point on the line between the two anchors that best represented where they perceived their pain. The participant's mark was then measured in millimeters and transformed into a pain rating, with each 10 mm increment assigned the value of 1 point. Participants were blinded to their previous answers to the VAS in order to minimize bias.

Dry Needling Intervention

One of three physical therapists, all with at least ten years of clinical experience and a minimum of three years dry needling experience, performed the dry needling interventions. First, the physical therapist identified trigger points in the fibularis longus and brevis muscles. Trigger points were identified using the approach described in Gerwin et al.,[35] as it has been shown to exhibit good intra-examiner reliability when applied by experienced clinicians. This method defines trigger points as those meeting all the following criteria: 1) hypersensitive spot in a palpable taut band, 2) palpable or visible local twitch on palpation, and 3) reproduction of referred pain elicited by palpation of the sensitive spot. All participants fulfilled the first criteria outlined by Gerwin et al.,[35] a hypersensitive spot within a palpable taut

band, which by the author's description was indicative of a latent trigger point. Participants in this study were self-reporting a history of a lateral ankle sprain and were able to perform strength and balance tests with minimal pain, so it was not anticipated that active trigger points as noted by a local twitch response or reproduction of referred pain would be present in all participants. All subjects meeting the inclusion criteria for the study had a locally tender and palpable taut band within both fibularis longus and brevis, as noted by cross-muscle fiber palpation.

Participants in the SPDN group received dry needling in the following muscles: 1) the ipsilateral L5 multifidus of the involved side, 2) the contralateral L5 multifidus, 3) a trigger point identified in the proximal fibularis longus muscle of the involved side, and 4) a trigger point identified in the distal fibularis brevis muscle of the involved side. The L5 segmental level was chosen for two reasons: 1) the expectation of the most consistent anatomical innervation pattern of the fibularis muscles, and 2) the L5 multifidi are more readily identified through palpation than the multifidi at the S1 level. Participants in the PDN group received dry needling to trigger points in the fibularis longus and brevis muscles only.

Prior to insertion of a needle, the skin over the area to be treated was cleaned with an alcohol wipe. Disposable single use Seirin® brand stainless steel needles (.30 x 60 mm for multifidus muscles, .30 x 40 mm for fibularis muscles) were used in this study. With the participant in the prone position, the physical therapist first administered needling bilaterally to the multifidus at the L5 segment,[36] in the order of more involved side followed by the contralateral side. The needling procedure was performed at the bilateral multifidi with the patient prone to facilitate patient relaxation and accurate location of the L5 multifidus muscle. The therapist utilized a pistoning technique (up and down movement of the needle) for 30 seconds at approximately 1 Hz, then left the needle in each multifidus muscle for an additional five minutes. The patient was then moved to the sidelying position in order to facilitate accurate and reproducible location of palpable taut bands in the fibularis longus and brevis, and to ensure a consistent and safe needling technique using the fibula as a bony backdrop to the procedure. With the participant in the contralateral side-lying position, the physical therapist identified a trigger point in the proximal fibularis longus and a trigger point in the distal fibularis brevis using the method previously described.[36] The physical therapist then administered trigger point dry needling to the proximal trigger point using a pistoning and fanning method[37] (changing the inclination angle of the needle) for at least 30 seconds at approximately 1 Hz. If after 30 seconds the trigger point had not yet cleared, the pistoning and fanning technique was continued until the physical therapist no longer observed any visible or palpable muscle twitches. The authors describe the clearing technique as the continuation of the dry needling technique until local muscle twitches are no longer visible or palpable by the therapist during the dry needling intervention. The same technique was then applied to the distal fibularis brevis muscle, (during the five minute "in situ" time on the fibularis longus). The needle was left in the fibularis longus and the fibularis brevis for an additional five minutes at each site.

Data Analysis

Participants' baseline characteristics were summarized as means and standard deviations for continuous variables and as frequencies for categorical variables. The balance tests are reported and analyzed as composite scores (each of the four tests were summed for the treated and untreated sides). Normality of distribution and homogeneity of variance of baseline characteristics and outcome variable were assessed with Shapiro-Wilk and Levene's test, respectively. Between group differences in baseline characteristics were analyzed using independent t-tests for continuous variables with normal distribution, Mann-Whitney U tests for continuous variables with non-normal distribution, and chi-square analysis for categorical variables. The intra-examiner and inter-examiner reliability of strength tests were assessed using intra-class correlation coefficients (ICC). Three-way mixed model ANOVAs were utilized to assess between group differences for outcome variables measured on an interval or ratio scale and normal distribution (time and side were the repeated measures). When an overall ANOVA was statistically significant, post-hoc analyses were performed to determine pairwise differences.

Mann-Whitney U tests were used to assess between group differences for outcome variables with non-normal distributions.

RESULTS

There were no significant between group differences in baseline characteristics ($p > 0.05$), summarized in Table 1. ICCs (3,3) assessing intra-examiner reliability of strength tests ranged from .84-.98 and ICCs (2,3) assessing inter-examiner reliability of strength tests ranged from .64-.93. Descriptive summaries of all outcome measures are presented in Table 2. Graphs of the strength and balance outcome measures are provided in Figures 2-5. As presented in Table 3, there was: 1) a significant group by time interaction ($p = 0.02$) for invertor strength with the peripheral dry needling group (PDN) improving more at the one-week follow-up than the spinal and peripheral (SPDN) group and post-hoc tests showed greater improvement on the treated side of the PDN group than the untreated side or either side of the SPDN group ($p < 0.05$) (Figure 2), 2) a significant group by time ($p = 0.02$) and group by side ($p = 0.02$) interaction for plantarflexor-evertor strength (Figure 3), with the PDN group showing more of an increase at the one week follow up than the SPDN group and the uninvolved side increasing between baseline and 1 week follow up for the PDN group, but decreasing between baseline and 1 week follow up for the SPDN group, and, 3) no significant findings (Figure 4) for dorsiflexor-invertor strength ($p = 0.75$). There was a significant time by side interaction ($p = 0.04$) for unilateral balance with the involved side of the PDN group showing a larger improvement at the one-week follow up than the uninvolved side of the PDN group or either side of the SPDN group (Figure 5). There was a significant main effect of time ($p < 0.01$) for triple hop for distance test, with both groups improving at follow-up and a significant main effect of side for the CAIT, with the uninvolved side consistently showing a better score than the involved side ($p < 0.01$). There were no significant differences between the groups ($p > 0.05$) for the side hop test and the Foot and Ankle Disability Index.

DISCUSSION

The results of the current study are contradictory to one other published study that compared the effects of spinal and peripheral dry needling to peripheral dry needling alone for muscles in the upper extremity and outcomes measures related to pain, cervical ROM and depression scores in older adults. However, there are substantial differences between the two studies in terms of patient demographics, patient condition and outcome measures. Ga et al, 2007[27] investigated the effects of dry needling at the C3-C5 spinal levels and the upper trapezius versus the upper trapezius alone among aging adults with chronic myofascial pain syndrome and used pain, depression score, and cervical ROM as outcome measures. At the four-week follow-up, these authors reported that patients who received spinal and peripheral dry needling had decreased pain and depression and increased cervical ROM than subjects who received only peripheral needling. Due to differences in patient demographics and recorded pain levels between these studies, a direct comparison of study results is difficult. The outcome variables of range of motion and mental functions reported in Ga et al are also difficult to compare with the recorded outcome measures of strength, balance, hop tests and functional ability in this study.[27] Finally, and perhaps most importantly, the participants in the study performed by Ga et al were much more likely to have spinal pathology; this may explain why their subjects showed more improvements with inclusion of spinal dry needling than participants in this study. Future investigations using combined spinal and peripheral dry needling for individuals with and without spinal involvement may provide insight into ideal dry needling sites for subjects with and without spinal involvement.

Strength

The PDN group demonstrated statistically significant improvements in strength of the invertors on the treated side and of the plantarflexor-evertors on both the treated and untreated sides. Improvement of invertors on the treated side suggests a peripheral mechanism of effect whereas improvement of the plantarflexor-evertors on both sides suggests a central mechanism of effect. Both peripheral and central mechanisms have been proposed as potential mechanisms of effect for dry needling.[38,39] Despite the challenge of reliably identifying active myofascial trigger points, much previous research on the

Table 2. *Outcome Measures, reported as Means and Standard Deviations.*

Outcome Measure	Group	
	SPDN (n=9)	PDN (n=11)
Strength Tests (N)		
Initial Session, Pre-Needling		
Involved side		
Inversion	69.4 (17.2)	67.4 (19.1)
Dorsiflexion/Inversion	87.4 (17.7)	81.7 (28.9)
Plantarflexion/Eversion	65.7 (13.8)	57.1 (13.1)
Uninvolved side		
Inversion	67.7 (12.0)	62.9 (16.1)
Dorsiflexion/Inversion	80.0 (17.9)	79.2 (12.9)
Plantarflexion/Eversion	69.7 (18.8)	62.0 (16.4)
Initial Session, Post-Needling		
Involved side		
Inversion	67.1 (14.7)	66.4 (15.7)
Dorsiflexion/Inversion	86.4 (16.6)	86.3 (24.7)
Plantarflexion/Eversion	62.9 (14.9)	64.4 (11.5)
Uninvolved side		
Inversion	66.3 (9.9)	63.6 (8.4)
Dorsiflexion/Inversion	81.7 (16.0)	85.2 (18.5)
Plantarflexion/Eversion	61.4 (13.6)	63.5 (13.6)
One Week Follow-up		
Involved side		
Inversion	63.5 (12.0)	77.3 (22.9)
Dorsiflexion/Inversion	78.1 (16.1)	85.0 (26.2)
Plantarflexion/Eversion	60.2 (13.2)	66.7 (14.5)
Uninvolved side		
Inversion	62.0 (16.8)	66.0 (17.5)
Dorsiflexion/Inversion	75.2 (11.0)	86.1 (32.4)
Plantarflexion/Eversion	61.7 (20.4)	68.1 (16.2)
Balance Tests (seconds)		
Composite Unilateral MCTSIB[α]		
Initial Session, Pre-Needling		
Involved side	74.35 (17.18)	78.54 (22.56)
Uninvolved side	78.24 (18.06)	82.12 (19.92)
Initial Session, Post-Needling		
Involved side	77.32 (20.72)	80.95 (28.45)
Uninvolved side	80.06 (13.71)	84.15 (18.08)
One Week Follow-up		
Involved side	80.58 (12.35)	96.29 (10.61)
Uninvolved side	83.84 (10.39)	86.67 (11.14)
Side Hop Test (s)		
Initial Session, Pre-Needling		
Involved side	17.37 (7.0)	13.24 (6.3)
Uninvolved side	16.94 (7.3)	12.40 (4.7)
Initial Session, Post-Needling		
Involved side	16.05 (7.8)	11.33 (4.3)
Uninvolved side	15.84 (7.6)	12.40[±] (5.6)
One Week Follow-Up		
Involved side	14.73 (6.6)	10.76 (2.9)
Uninvolved side	14.66 (6.0)	11.54 (4.0)
Triple Hop for Distance (cm)		
Initial Session, Pre-Needling		
Involved side	368.1 (78.8)	401.4 (87.0)
Uninvolved side	380.6 (78.9)	398.8 (91.4)
Initial Session, Post-Needling		
Involved side	378.0 (89.2)	424.7 (86.1)
Uninvolved side	378.2 (84.1)	419.8 (93.8)
One Week Follow-Up		
Involved side	393.1 (85.5)	446.5 (86.6)
Uninvolved side	395.7 (86.9)	436.6 (95.4)

SPDN= Spinal and Peripheral Dry Needling
PDN= Peripheral Dry Needling
[α]Modified Clinical Test of Sensory Integration and Balance

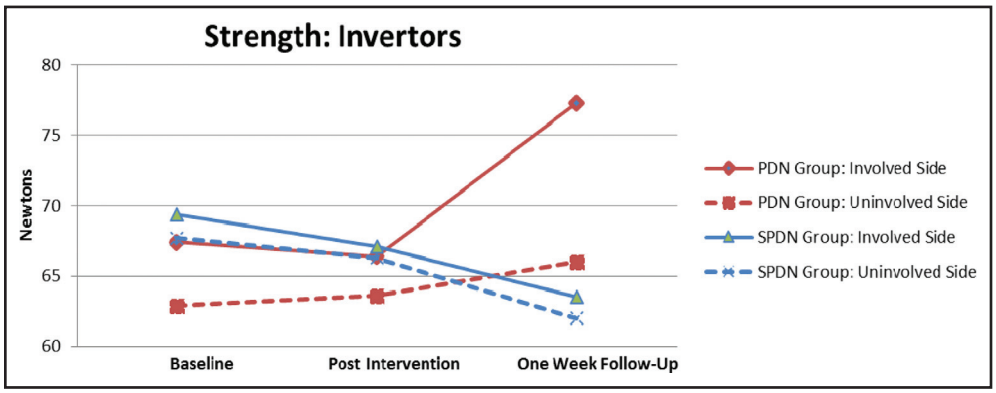

Figure 2. *Strength of invertors, measured in newtons.*
PDN Group = Peripheral Dry Needling Group; SPDN = Spinal and Peripheral Dry Needling Group

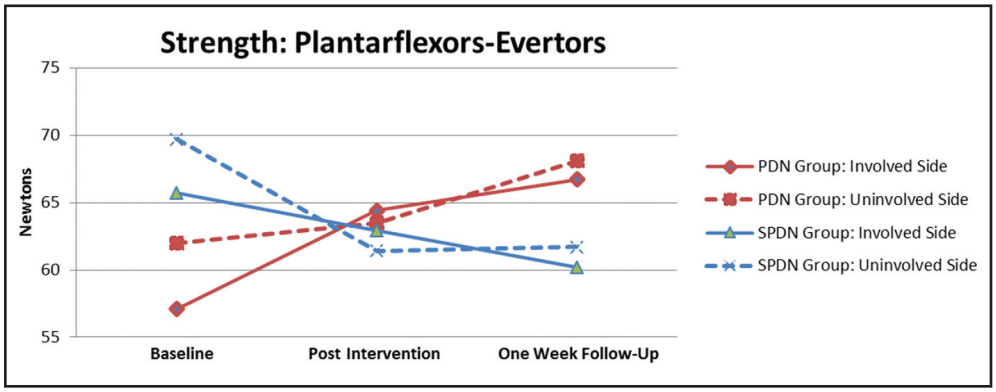

Figure 3. *Strength of plantarflexors-evertors, measured in newtons.*
PDN Group = Peripheral Dry Needling Group; SPDN = Spinal and Peripheral Dry Needling Group

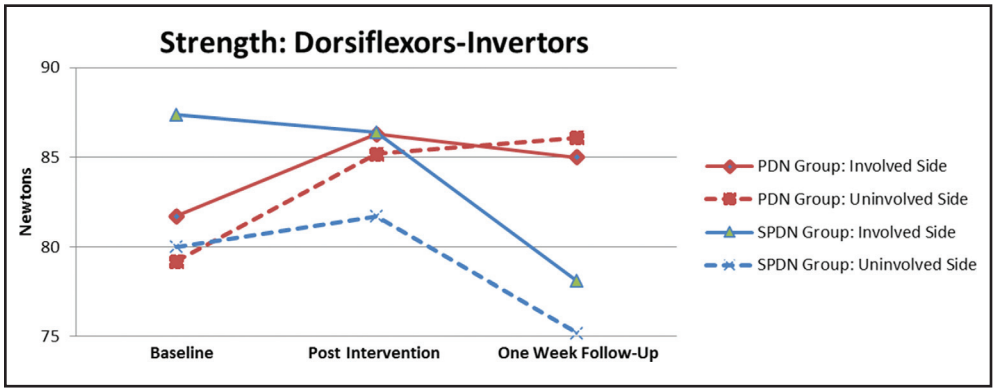

Figure 4. *Strength of dorsiflexors-invertors, measured in newtons.*
DN Group = Peripheral Dry Needling Group; SPDN = Spinal and Peripheral Dry Needling Group

effects of dry needling has focused on individuals with active myofascial trigger points.[20] Because dry needling of active trigger points results in local twitch responses on the contralateral,[40] as well as the treated side (as measured by electromyography), some authors suggest that active trigger points are centrally-maintained tissue states rather than a peripheral phenomenon.[39] Interestingly, dry needling of latent trigger points appears to result in local twitch responses on the treated side only.[40] Participants in

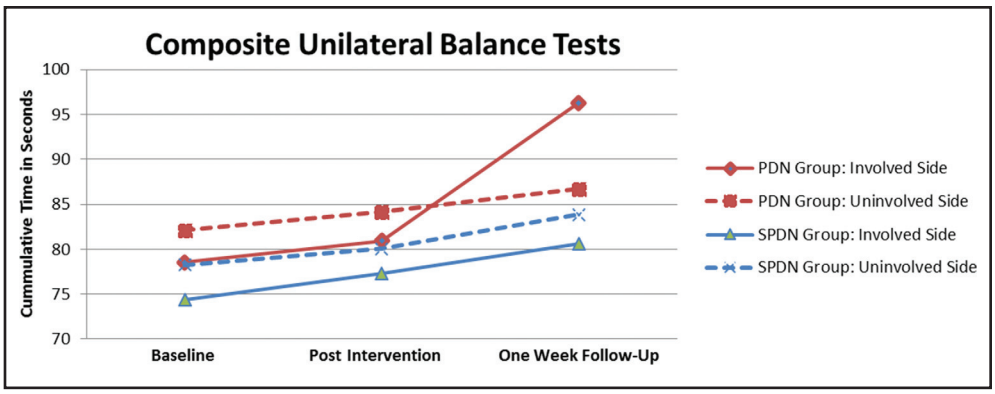

Figure 5. *Composite Unilateral Modified Clinical Tests of Sensory Integration and Balance (MCTSIB) measured in seconds. PDN Group = Peripheral Dry Needling Group; SPDN = Spinal and Peripheral Dry Needling Group*

Table 3. *Results of ANOVA and Mann-Whitney U Tests.*

Outcome Measure	DF	F	Results
Strength Tests (N)			
Inversion	1	6.9	a x b (p= 0.02)
Dorsiflexion/Inversion			N.S.
Plantarflexion/Eversion	1; 1	6.60; 6.75	a x b (p= 0.02); a x c (p= 0.02)
Composite Unilateral MCTSIB[α]	1	4.77	b x c (p= 0.04)
Hop Test (s)			
Side Hop Test			N.S.
Triple Hop for Distance	1	30.50	a (p< 0.01)
Foot and Ankle Disability Index			N.S.
Cumberland Ankle Instability Tool	1	10.28	c (p< 0.01)

a = main effect of group
c = main effect of side
a x b = group by time interaction
b x c = time by side interaction
a x c = group by side interaction
N.S. = Non Significant
[α]Modified Clinical Test of Sensory Integration and Balance

this study were not required to exhibit active trigger points in the fibularis longus and brevis, however, all subjects were required to exhibit tenderness indicative of latent trigger points in these muscles. As the study did not control for type of trigger points, it is possible that participants with active trigger points or latent trigger points responded differently to the needling intervention and this might have affected the study findings. Conversely, though not always statistically significant, strength in the SPDN group decreased between baseline and follow-up. Speculatively, it is possible that dry needling of the multifidi resulted in inhibition of the multifidi and peripheral musculature accounting for these findings among the SPDN group. Additionally, if the multifidi were inhibited after needling, less core stability could also account for some decreases in strength in this group. Study participants were seated on a treatment table during the hand dynamometry and no external trunk support was provided during testing. Therefore, trunk stability could have affected performance on these tests. Participants in both groups had low initial pain scores with low variability across time, so the strength increases and decreases in the PDN and SPDN groups, respectively, may not stem from any central or peripheral pain-related mechanism. Rather, it may be changes within the muscle spindles (facilitory or inhibitory) that explain the differences in strength at the ankle between the two groups.

Balance

Composite scores of the single limb balance tests showed that the treated side of the PDN group demonstrated a statistically significantly improvement in single leg balance compared to the untreated side or either side of the SPDN group. Previous investigators have shown reduced reaction time and postural

control of the fibularis longus muscle during a perturbation task among basketball players with chronic ankle instability as compared with healthy basketball players.[6] Other investigators have reported reduced corticomotor excitability of the fibularis muscles among individuals with unilateral chronic ankle instability compared to healthy individuals.[7] Should dry needling of the fibularis muscles have any effect on their cortiomotor excitability or reaction time, this may explain an increase in performance on unilateral balance tests and are future areas of investigation. If dry needling the multifidi has any inhibitory effect on the fibularis muscles, then the effects of needling spinally may negate the facilitory effects of dry needling the fibularis muscles. Alternatively, inhibition of the multifii may decrease core stability affecting the SPDN participants' performance on these tests.

Other Outcome Measures

Though there were some increases in strength and balance on the treated side of the PDN group at the one week follow-up, there were not similar findings for the single limb hop tests, as performance on the triple hop increased on both sides of both groups and there were no differences in performance of the side hop test. It is likely that the increases on the triple hop test were due to a motor learning effect. Previous research has shown test-retest improvements on unilateral hop tests one to two days following baseline (on both the operative and non-operative sides) among individuals 16 weeks following ACL reconstruction when no expected improvements in impairments would explain the better performance.[41] Nor were the increases in strength and balance on the treated side of the PDN group at the one week follow-up mirrored by improvements on the CAIT or FADI; as would be expected, the CAIT showed the uninvolved side consistently scoring higher than the involved side across groups and time points and there was no between groups difference on the FADI. The changes in strength and balance may not be large enough for any reflection in higher demand activities or overall functional level. A previous investigation of the effects of dry needling of the fibularis longus and brevis muscles in addition to proprioception exercises for individuals with chronic ankle instability and a history of lateral ankle sprain showed improvements in pain level and scores on the Functional Ankle Ability Measure (FAAM) compared to proprioceptive exercises alone.[5] These participants received four needling interventions as compared to the single treatment provided in this study, so it is possible that multiple needling treatments are needed to gain enough improvement to be reflected in a functional assessment tool.

Limitations

There was no control group in this study so no conclusions can be drawn that any changes in outcomes measures for the two dry needling groups are different from a group receiving no treatment. The small sample size limits statistical power and the intervention was limited to a single session with short-term follow-up, whereas typically in clinical care, patients receive needling interventions across multiple visits. Though participants' baseline CAIT scores are indicative of individuals who have experienced an ankle sprain, participants' history of lateral ankle sprains were self-reported, so we cannot be certain their injuries would have been medically diagnosed as lateral ankle sprain at the time they occurred. Finally, participants were unable to be successfully blinded to their intervention group, and this may have introduced bias.

CONCLUSION

The results of this study suggest that in individuals with a history of ankle sprain, DN to the corresponding multifidi segments in addition to MTrPs in the fibularis longus and brevis muscles does not result in short-term improvements in strength, unilateral balance, unilateral hop test performance or self-reported functional ability as compared to DN in the fibularis muscles alone. Based on these findings, it appears that DN of the fibularis muscles in individuals with a history of ankle sprain may provide some short-term improvements in strength and unilateral balance, though additional studies with larger sample sizes are needed to substantiate these findings.

REFERENCES

1. Beynnon BD, Murphy DF, Alosa DM. Predictive factors for lateral ankle sprains: a literature review. *J Athl Train.* 2002;37(4):376.
2. Ferran NA, Maffulli N. Epidemiology of sprains of the lateral ankle ligament complex. *Foot Ankle Clin.* 2006;11(3):659-662.

3. Hertel J. Functional anatomy, pathomechanics, and pathophysiology of lateral ankle instability. *J Athl Train.* 2002;37(4):364.
4. Chan KW, Ding BC, Mroczek KJ. Acute and chronic lateral ankle instability in the athlete. *Bull NYU Hosp Joint Dis.* 2011;69(1):17.
5. Salom-Moreno J, Ayuso-Casado B, Tamaral-Costa B, et al. Trigger point dry needling and proprioceptive exercises for the management of chronic ankle instability: A randomized clinical trial. *Ev Based Compl Alt Med.* 2015;2015:790209.
6. Mendez-Rebolledo G, Guzman-Munoz E, Gatica-Rojas V, et al. Longer reaction time of the fibularis longus muscle and reduced postural control in basketball players with functional ankle instability: A pilot study. *Phys Ther Sport.* Aug 2015;16(3):242-247.
7. Pietrosimone BG, Gribble PA. Chronic ankle instability and corticomotor excitability of the fibularis longus muscle. *J Athl Train.* Nov-Dec 2012;47(6):621-626.
8. Legge D. A history of dry needling. *J Musculoskel Pain.* 2014;22(3):301-307.
9. Moral OMd. Dry needling treatments for myofascial trigger points. *J Musculoskel Pain.* 2010;18(4):411-416.
10. Simons DG, Travell JG, Simons LS. *Travell & Simons' Myofascial Pain and Dysfunction: Upper Half of Body.* Vol 1: Lippincott Williams & Wilkins; 1999.
11. Dunning J, Butts R, Mourad F, et al. Dry needling: a literature review with implications for clinical practice guidelines 1. *Phys Ther Rev.* 2014;19(4):252-265.
12. Cagnie B, Dewitte V, Barbe T, et al. Physiologic effects of dry needling. *Curr Pain Headache Rep.* 2013;17(8):1-8.
13. Dommerholt J. Dry needling—peripheral and central considerations. *J Man Manip Ther.* 2011;19(4):223-227.
14. Dommerholt J, Bron C, Franssen J. Myofascial trigger points: an evidence-informed review. *J Man Manip Ther.* 2006;14(4):203-221.
15. Ga H, Choi J-H, Park C-H, et al. Dry needling of trigger points with and without paraspinal needling in myofascial pain syndromes in elderly patients. *J Alt Compl Med.* 2007;13(6):617-624.
16. Gerwin RD, Dommerholt J, Shah JP. An expansion of Simons' integrated hypothesis of trigger point formation. *Curr Pain Headache Rep.* 2004;8(6):468-475.
17. Kim T-H, Lee C-R, Choi T-Y, et al. Intramuscular stimulation therapy for healthcare: a systematic review of randomised controlled trials. *Acupuncture Med.* 2012;30(4):286-290.
18. Gunn CC. *The gunn approach to the treatment of chronic pain. Intramuscular stimulation for myofascial pain of radiculopathic origin. Second ed.* New York: Churchill Livingstone. 1996.
19. Kalichman L, Vulfsons S. Dry needling in the management of musculoskeletal pain. *J Am Board Fam Med.* 2010;23(5):640-646.
20. Kietrys DM, Palombaro KM, Azzaretto E, et al. Effectiveness of dry needling for upper-quarter myofascial pain: a systematic review and meta-analysis. *J Orthop Sports Phys Ther.* 2013;43(9):620-634.
21. Dar G, Hicks GE. The immediate effect of dry needling on multifidus muscles' function in healthy individuals. *J Back Musculoskel Rehab.* 2016;29(2):273-278.
22. Koppenhaver SL, Walker MJ, Su J, et al. Changes in lumbar multifidus muscle function and nociceptive sensitivity in low back pain patient responders versus non-responders after dry needling treatment. *Man Ther.* 2015;20(6):769-776.
23. Castro-Sanchez AM, Garcia-Lopez H, Mataran-Penarrocha GA, et al. Effects of dry needling on spinal mobility and trigger points in patients with fibromyalgia syndrome. *Pain Physician.* 2017;20(2):37-52.
24. Gemmell H, Allen A. Relative immediate effect of ischaemic compression and activator trigger point therapy on active upper trapezius trigger points: A randomised trial. *Clin Chiro.* 2008;11(4):175-181.
25. Cotchett MP, Landorf KB, Munteanu SE, et al. Effectiveness of trigger point dry needling for plantar heel pain: study protocol for a randomised controlled trial. *J Foot Ankle Res.* 2011;4(5):1-10.
26. Karagounis P, Tsironi M, Prionas G, et al. Treatment of plantar fasciitis in recreational athletes two different therapeutic protocols. *Foot Ank Spec.* 2011;4(4):226-234.
27. Ga H, Choi JH, Park CH, et al. Dry needling of trigger points with and without paraspinal needling in myofascial pain syndromes in elderly patients. *J Alt Compl Med.* 2007;13(6):617-624.
28. Geist K, Bradley C, Hofman A, et al. Clinical effects of dry needling among asymptomatic individuals with hamstring tightness: a randomized controlled trial. *J Sport Rehabil.* 2016:1-31.
29. Martin RL, Davenport TE, Paulseth S, et al. Ankle stability and movement coordination impairments: ankle ligament sprains: clinical practice guidelines linked to the international classification of functioning, disability and health from the orthopaedic section of the American Physical Therapy Association. *J Orthop Sports Phys Ther.* 2013;43(9):A1-A40.

30. Hale SA, Hertel J. Reliability and sensitivity of the foot and ankle disability index in subjects with chronic ankle instability. *J Athl Train.* 2005;40(1):35-40.
31. Cohen H, Blatchly CA, Gombash LL. A study of the clinical test of sensory interaction and balance. *Phys Ther.* 1993;73(6):346-351.
32. Noyes FR, Barber SD, Mangine RE. Abnormal lower limb symmetry determined by function hop tests after anterior cruciate ligament rupture. *Am J Sports Med.* 1991;19(5):513-518.
33. McCormack HM, David JdL, Sheather S. Clinical applications of visual analogue scales: a critical review. *Psychol Med.* 1988;18(04):1007-1019.
34. Paul-Dauphin A, Guillemin F, Virion J-M, et al. Bias and precision in visual analogue scales: a randomized controlled trial. *Am J Epidem.* 1999;150(10):1117-1127.
35. Gerwin RD, Shannon S, Hong C-Z, et al. Interrater reliability in myofascial trigger point examination. *Pain.* 1997;69(1):65-73.
36. Liguori R, Krarup C, Trojaborg W. Determination of the segmental sensory and motor innervation of the lumbosacral spinal nerves. An electrophysiological study. *Brain.* 1992;115 (Pt 3):915-934.
37. Yeganeh Lari A, Okhovatian F, Naimi S, et al. The effect of the combination of dry needling and MET on latent trigger point upper trapezius in females. *Man Ther.* 2016;21:204-209.
38. Dommerholt J. Dry needling - peripheral and central considerations. *The J Man Manip Ther.* 2011;19(4):223-227.
39. Dunning J, Butts R, Mourad F, et al. Dry needling: a literature review with implications for clinical practice guidelines. *Phys Ther Rev.* 2014;19(4):252-265.
40. Audette JF, Wang F, Smith H. Bilateral activation of motor unit potentials with unilateral needle stimulation of active myofascial trigger points. *Am J Phys Med Rehabil.* 2004;83(5):368-374, quiz 375-367, 389.
41. Reid A, Birmingham TB, Stratford PW, et al. Hop testing provides a reliable and valid outcome measure during rehabilitation after anterior cruciate ligament reconstruction. *Phys Ther.* 2007;87(3):337-349.