Randomized Trial

Effects of Dry Needling on Spinal Mobility and Trigger Points in Patients with Fibromyalgia Syndrome

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Background: The etiology of fibromyalgia syndrome (FMS) is inconclusive, but central mechanisms are well accepted for this pain condition. Myofascial pain syndrome (MPS) is one of the most common musculoskeletal pain diseases and is characterized by myofascial trigger points (MTrPs). It has been suggest that MTrPs have an important factor in the genesis of FMS.

Objective: The purpose of the current randomized clinical trial was to compare the effectiveness of dry needling versus cross tape on spinal mobility and MTrPs in spinal muscles in patients with FMS.

Study Design: A single-blind randomized controlled trial was conducted on patients with FMS.

Setting: Clinical setting.

Methods: Sixty-four patients with FMS were randomly assigned to an experimental group receiving dry needling therapy or to a control group for cross tape therapy in the MTrPs in the latissimus dorsi, iliocostalis, multifidus, and quadratus lumbourum muscles. Spinal mobility measures and MTrPs algometry were recorded at baseline and after 5 weeks of treatment.

Results: The repeated measures analysis of variance (ANOVA) demonstrated that significant differences between groups were achieved for the MTrPs in latissimus dorsi muscle (right axillary portion: F = 9.80, $P = 0.003$); multifidus muscle (right L2 level: F = 11.80, $P = 0.001$); quadratus lumborum (right lateral superficial upper: F = 6.67, $P = 0.012$; and right lateral superficial lower: F = 5.38, $P = 0.024$). In addition, the ANOVA repeated measures test showed significant differences between groups for the segmental amplitude thoracic spine in the standing erect position (F = 7.33, $P = 0.009$), and segmental amplitude of lumbar spine (F = 11.60, $P = 0.001$) in the sitting erect position.

Limitations: The outcomes were not collected from a long-term follow-up period. Dry needling therapy or cross tape were used alone when in reality physical therapists usually treat patients with FMS using a multi-modal approach. A non-treatment control group was not included.

Conclusions: This study has demonstrated that dry needling therapy reduces myofacial trigger points algometry on thoracic and lumbar muscles. Dry needling and cross tape approaches reported a similar effect size for spinal mobility measures in patients with FMS.

Key words: Fibromyalgia, trigger points, physical therapy modalities, musculoskeletal equilibrium, myofascial pain syndromes

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Fibromyalgia syndrome (FMS) is a chronic musculoskeletal pain condition with a prevalence ranging from 0.5% to 5% (1). The etiology of FMS is inconclusive, but central mechanisms are well accepted for this pain condition. It has been suggested that FMS pain is partially maintained by peripheral impulse input from deep tissues (2). Nociceptive stimuli from muscle tissues are recognized as being relevant to the development of FMS (3,4).

Myofascial pain syndrome (MPS) is one of the most common musculoskeletal pain diseases and is characterized by myofascial trigger points (MTrPs) (5). Simons et al (6) suggested that MTrPs are an important factor in the genesis of FMS. Myofascial trigger point pain is defined as pain arising from one or more MTrPs, which are hyperirritable spots in skeletal muscle that are associated with hypersensitive palpable nodules in taut bands. MTrPs can be painful on compression and may give rise to referred pain and/or tenderness, as well as autonomic responses (sweating, vasoconstriction, and vasodilation) (7). These are caused by an excessive release of acetylcholine from motor endplates, which results in the chronic shortening and contracture of sarcomeres, coupled with decreased circulation, leading to ischemia and hypoxia. As a result, the sensory afferent nerve fibers of the muscle are sensitized by bradykinins, cytokines, prostaglandins, and histamine, which often leads to central sensitization of the dorsal horn neurons (8).

Dry needling is a therapeutic procedure that involves inserting a dry needle into an MTrP with the aim of inactivating the trigger point and mitigating pain (9). The therapeutic mechanism of dry needling in the management of myofascial pain is supported by accumulative evidence from basic science research (10). Local administration of lidocaine injections to tender points in FMS management increases the plasma concentrations of met-enkephalin. A similar response has been reported for dry needling in the treatment of myofascial trigger point symptoms (11). One study also concluded that patients severely affected by FMS may obtain short-term improvement following dry needle stimulation of tender points in fibromyalgia. The efficacy of dry needling has been confirmed in several studies on acute and chronic low back pain (12,13), lumbar myofascial pain (14), chronic lumbar myofascial trigger points (15), whiplash (16), and in a systematic review on the management of myofascial trigger points (17).

In accordance with the literature review, the purpose of the current randomized clinical trial was to compare the effectiveness of dry needling versus cross tape on spinal mobility, pain intensity, and MTrPs in spinal muscles in FMS patients.

Methods

Patients

Patients with FMS were recruited from among members of the Murcia Fibromyalgia Association (Spain) who had clinical records at the Virgen de la Arrixaca University Hospital. A single-blind randomized controlled trial was conducted. The diagnosis of fibromyalgia was based on criteria formulated by the American College of Rheumatology (ACR). Chronic widespread musculoskeletal pain symptoms were assessed using scores on the widespread pain index and symptom severity scale (18).

Selection Criteria

The inclusion criteria were 1) diagnosed FMS; 2) between 18 and 65 years of age; 3) limitation of usual activities due to pain on at least one day in the previous 30 days; 4) agreement to attend evening therapy sessions; and 5) non-practice of regular physical activity. The exclusion criteria were 1) a history of surgery; 2) the presence of comorbid conditions (e.g., morbid obesity, inflammatory diseases, irritable bowel syndrome, and interstitial cystitis); 3) a history of whiplash injury; 4) severe physical disability; 5) uncontrolled endocrine disorders (e.g., hyperthyroidism, diabetes); 6) illness (e.g., schizophrenia or substance abuse); 7) the use of medication other than as-needed analgesics (excluding long-term narcotics); 8) malignancy; 9) psychiatric disorders; and 10) a score of ≥ 9 points in the Beck depression inventory. The selection was conducted in accordance with the declaration of Helsinki and all patients signed an informed consent form prior to their inclusion in the study.

Outcome Measures

Patients provided clinical and demographic information about their age, height, weight, gender, and level of education. MTrPs were explored in the following pairs of muscles: latissimus dorsi, iliocostalis, quadratus lumborum, and multifidus. Evaluation was performed with a 2-minute rest period between muscles. The diagnosis of MTrPs was carried out according to the criteria described by Gerwin et al (19) and Simons et al (6): 1) the presence of a palpable taut band within a skeletal muscle; 2) the presence of a hyperirritable spot in the taut band; 3) a local twitch response

elicited by snapping palpation of the taut band; and 4) the presence of referred pain in response to MTrP compression. MTrPs were classified as not present, latent, or active. MTrPs were considered active when local and referred pain reproduced clinical pain symptoms with manual compression, and latent when local and referred pain did not reproduce symptoms with a mechanical pain algometer (Kg/cm^2) (Pain Diagnosis and Treatment Inc., Great Neck, NY, USA). The mean of the 3 trials (intra-examiner reliability) was calculated and used for the main analysis. A 30-second resting period was allowed between each trial. Pain intensity was also assessed with the 10-point visual analog scale (VAS) (0: no pain, 10: maximum pain).

In addition, spinal mobility was measured using the Spinal Mouse system, a hand-held computer-assisted electromechanical device used to measure spinal curvature in an upright standing position, a flexed standing position, flexed transfer movement to upright standing, an upright sitting position, a flexed sitting position, and flexed transfer movement to upright sitting. Firstly, the C7 and S3 landmarks were determined by palpation and marked on the skin surface with a dermographic pencil. The device was then guided along the midline of the spine starting at the C7 spinous process and finishing at the top of the anal crease (S3). Two rolling wheels followed the contour of the spine, and distance and angle measurements were communicated from the device to a base station positioned approximately 1 to 2 meters away and interfaced with a personal computer. Data were sampled every 1.3 mm, giving a sampling frequency of 150 Hz. This information was used to calculate the following relative positions of the sacrum and vertebral bodies of the underlying bony spinal column by means of a recursive algorithm (20): 1) all the individual motion segment angles (from T1-T2 through to L5-S1); 2) the sacral slope (angle subtended between S1 and the transversal plane); 3) thoracic curvature (from T1-T2 through to T11-T12); 4) lumbar curvature (from T12-L1 to the sacrum); and 5) the angle of trunk inclination (angle subtended between the vertical and a line joining C7 to the sacrum). The range of flexion (ROF) and range of erect position to flexion (ROEF) were determined for each vertebral motion segment (from T1-T2 to L5-S1). Positive values indicated a kyphotic position or flexion, and negative values indicated a lordotic position or extension.

Interventions

Dry Needling Therapy

Active and latent MTrPs were marked in black and red, respectively. Active and latent MTrPs were needled in the same position used by the blinded examiner for diagnosis. All dry needling procedures were performed by the same researcher, and the technique used was similar to the Hong method (21), using sterile Ener-Qi needles (EQ 1661) for the punction of MTrPs in the following pairs of muscles: latissimus dorsi (MTrPs in axillary and mid portion), back iliocostoalis (MTrPs in T6, T11, and L1 levels), multifidus (MTrPs in T4, L2, S1, and S4 levels), and quadratus lumborum (lateral superficial upper, middle deep upper, middle deep lower, and lateral superficial lower triggers points). After cleansing the skin with chlorhexidine (2%), the needle (0.25 x 25: diameter x length) was inserted to a depth of 5 – 15 mm, depending on the latent or active deep trigger point. The needle was inserted in each MTrP using Hong's fast-in, fast-out technique until there was a local twitch response. Hypoxia by compression (15 seconds) was applied to each active or latent MTrP needled. All patients received 4 once-weekly sessions (21).

Cross Tape Therapy

Cross tape therapy was applied to active or latent trigger points (active and latent MTrPs were marked in black and red, respectively) in the same pairs of muscles detailed for dry needling therapy. The skin was cleaned with 2% chlorhexidine before application. All patients received 4 once-weekly sessions.

Randomization

Following the baseline examination, patients were randomly assigned to receive either dry needling therapy or cross tape therapy. Both groups were treated by a physical therapist with more than 10 years' experience in the management of individuals with chronic pain. Concealed allocation (ratio 1:1) was performed using a computer-generated randomized table of numbers created before the start of data collection by a researcher not involved in the recruitment or treatment of patients. Individual sequentially numbered index cards with the random assignment were prepared. The index cards were folded and placed in sealed opaque envelopes. Another therapist, blinded to the baseline examination, opened the envelope

and proceeded with treatment according to the group assignment.

Outcome measures were assessed at baseline (before the first treatment session), and 48 hours after the 4-week intervention period by an assessor blinded to the patients' treatment allocation.

Statistical Analysis

Statistical analysis was performed using SPSS statistical software version 22.0. A *P*-value of < 0.05 was considered statistically significant. After a descriptive analysis, the normal distribution of variables was verified by means of the Kolgomorov-Smirnov test. Baseline demographic and clinical variables were compared between both groups using χ^2 tests for categorical data and Student t-tests for continuous data. Repeated measures analysis of variance (ANOVA) was used to analyze the time effects between both groups (dry needling versus cross tape) and the effects of group interaction for all outcome measurements (VAS, MTrPs algometry, and spinal mobility) between baseline and post-treatment. Changes in variable scores within and between groups were measured by means of a 95% confidential interval of t-tests for paired or independent samples, as appropriate. Effect sizes were calculated using Cohen's d coefficient. An effect size of < 0.2 reflected a negligible difference, between ≥ 0.2 and < 0.5 a small difference, between ≥ 0.5 and < 0.8 a moderate difference, and ≥ 0.8 a large difference.

Table 1. *Patient characteristics at baseline.*

	Dry needling Group N = 32	Cross Tape Group N = 32	*P*-value
Mean age	46.65 ± 6.26	44.97 ± 7.11	0.680
Age range	43 – 56	41 – 57	-
Weight (kg)	70.34 ± 16.61	67.56 ± 14.85	0.483
Height (cm)	161.25 ± 6.31	160.63 ± 7.57	0.721
Male/Females	3/29	2/30	0.648
Educational level (N)	-	-	0.298
No studies	5	1	-
School level	14	17	
Bachelor level	10	9	-
University level	3	5	-

Values are expressed as absolute and relative frequencies (n = 64) for categorical variables and as means ± standard deviations for continuous variables. No differences between groups ($P > 0.050$).

Results

Participant Flow

Out of the 64 patients recruited for the study, 5 men and 59 women aged from 27 to 58 years (mean: 45.72 ± 7.14 years) and diagnosed with fibromyalgia met the inclusion criteria and were randomly assigned to either the dry needling group (n = 32) or the cross tape group (n = 32) (Table 1). A flow chart of the participants' recruitment and follow-up is shown in Fig. 1.

Changes in Algometry for the MTrPs.

After 4 weeks' treatment the number of active MTrPs decreased significantly in the dry needling group [dry needling group (baseline: active n = 163, latent n = 3, not present n = 672; post-treatment: active n = 72, latent n = 13, not present n = 807); cross tape group (baseline: active n = 182, latent n = 4, not present n = 663; post-treatment: active n = 169, latent n = 4, not present n = 695)]. The repeated measures ANOVA showed that significant differences between groups were achieved for the following MTrPs: latissimus dorsi muscle (right axillary portion: F = 9.80, *P* = 0.003); multifidus muscle (right L2 level: 11.80, *P* = 0.001); quadratus lumborum (right lateral superficial upper: F = 6.67, *P* = 0.012); quadratus lumborum (right lateral superficial lower: F = 5.38, *P* = 0.024). Within-group analysis showed a significant pre-post-treatment improvement for most MTrPs in both groups. Table 2 shows pre-post-intervention values and scores for within- and between-group changes with associated 95% CI for the algometry of myofascial trigger points. The effect sizes ranged from negligible to moderate for the dry needling group (minimum d = 0.06, maximum d = 0.67) and from negligible to small for the cross tape group (minimum d = 0.04 maximum d = 0.37).

Changes in VAS

The repeated measures ANOVA showed significant differences between groups for VAS scores (F = 36.285, *P* = 0.001). Within-group analysis showed a significant pre-post-treatment improvement for pain intensity in both groups [dry needling: *P* < 0.01; CI 95% 3.31 (2.50, 4.13); cross tape: *P* < 0.016; CI 95% 0.56 (1.11, 1.01)].

Changes in Spinal Mobility Measures

The repeated measures ANOVA showed significant differences between groups for thoracic spine segmental amplitude in the erect standing position (F = 7.33, *P* = 0.009), lumbar spine segmental amplitude in the

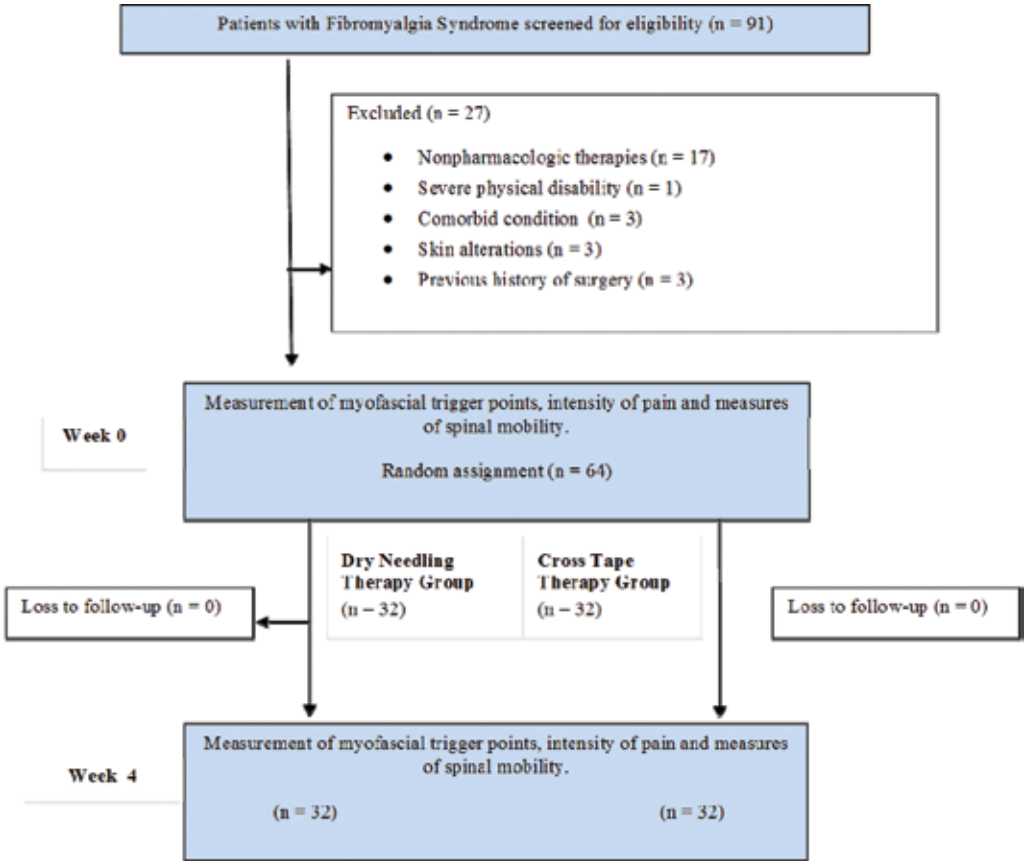

Fig. 1. *Design and flow of participants through the trial.*

erect sitting position (F = 11.60, *P* = 0.001), sacral slope in the flexed sitting position (F = 5.54, *P* = 0.022), the range of flexion for thoracic-lumbar spine segmental amplitude in the sitting position (F = 9.11, *P* = 0.004), the range of erect to flexion for the sacral slope (F = 4.48, *P* = 0.039), thoracic spine segmental amplitude (F = 6.45, *P* = 0.014), and thoracic-lumbar spine segmental amplitude in the sitting position (F = 13.11, *P* = 0.001). Significant within-group pre-post-treatment improvement is detailed in Table 3 (pre-post-intervention values and scores for within- and between-group changes with associated 95% CI for standing spinal mobility) and Table 4 (pre-post-intervention values and scores for within- and between-group changes with associated 95% CI for seated spinal mobility). The effect sizes ranged from negligible to small for the dry needling group (minimum d = 0.02, maximum d = 0.44) and the cross tape group (minimum d = 0.005 maximum d = 0.42) in the standing position. In the sitting position the effect sizes ranged from negligible to moderate for the dry needling group (minimum d = 0, maximum d = 0.63) and from negligible to small for the cross tape group (minimum = 0.02 maximum d = 0.37).

Discussion

In this study, a 4-week dry-needling therapy significantly decreased the number of MTrPs in comparison to the cross tape group, mainly in MTrPs of the latissimus dorsi, multifidus, and quadratus lumbourum muscles. Dry needling also showed a major improvement in pain intensity. However, both therapies reported an effect size ranging from negligible to small for spinal mobility measures in both groups, except in the dry needling group in the sitting position, where the effect sizes

Table 2. *Baseline, post-treatment, pre-post-treatment differences and change scores in each group (95% confidence interval) for MTrPs algometry.*

Outcome/ Group	Side	Baseline	One Month Post-treatment	Paired t-test *P*	Within-Group Score Changes	Between-Group Score Changes
Latissimus dorsi (Axillary Portion) (kg/cm²)						
Dry needling	Right	3.36 ± 0.73	3.88 ± 0.82	0.001*	-0.60 (-0.87, -0.34)	0.003 (0.19,0.91)
	Left	4.02 ± 0.49	4.05 ± 0.55	0.034*	-0.06 (-0.25, 0.12)	
Cross-tape	Right	3.26 ± 0.70	3.29 ± 0.71	0.001*	0.01 (-0.15, 0.17)	0.55 (0.24, 0.69)
	Left	3.50 ± 0.63	3.53 ± 0.61	0.016*	0.01 (-0.12, 0.13)	
Latissimus dorsi (Mid Portion) (kg/cm²)						
Dry needling	Right	4.08 ± 0.67	4.17 ± 0.63	0.161	-0.91 (-0.25, 0.07)	0.40 (0.09, 0.70)
	Left	3.72 ± 0.61	3.78 ± 0.59	0.007*	-0.14 (-0.28, -0.004)	
Cross-tape	Right	4.35 ± 0.51	4.50 ± 0.25	0.034*	-0.06 (-0.21, 0.10)	0.47 (0.24, 0.69)
	Left	3.87 ± 0.69	4.01 ± 0.61	0.001*	-0.14 (-0.24, -0.03)	
Back ilicostalis (T6 Level) (kg/cm²)						
Dry needling	Right	3.09 ± 1.04	3.66 ± 0.67	0.001*	-0.57 (-0.89, -0.26)	0.20 (-0.22, 0.62)
	Left	3.49 ± 0.85	3.72 ± 0.69	0.031*	-0.22 (-0.45, 0.003)	
Cross-tape	Right	3.23 ± 0.99	3.42 ± 0.94	0.001*	-0.18 (-0.43, 0.07)	0.19 (-0.20, 0.58)
	Left	3.45 ± 0.86	3.50 ± 0.91	0.001*	-0.06 (-0.18, 0.07)	
Back ilicostalis (T11 Level) (kg/cm²)						
Dry needling	Right	3.59 ± 0.98	3.84 ± 0.74	0.006*	-0.26 (-0.49, -0.03)	0.30 (-0.15, 0.76)
	Left	3.93 ± 0.62	4.18 ± 0.40	0.001*	-0.25 (-0.44, -0.06)	
Cross-tape	Right	3.34 ± 1.06	3.45 ± 1.08	0.001*	-0.10 (-0.33, 0.12)	0.27 (-0.03, 0.57)
	Left	3.64 ± 0.93	3.88 ± 0.79	0.001*	-0.21 (-0.40, -0.02)	
Back ilicostalis (L1 Level) (kg/cm²)						
Dry needling	Right	3.66 ± 0.99	4.13 ± 0.78	0.001*	-0.46 (-0.80, -0.12)	0.92 (0.43, 1.41)
	Left	3.78 ± 0.98	4.18 ± 0.65	0.013*	-0.43 (-0.73, -0.12)	
Cross-tape	Right	3.17 ± 1.16	3.23 ± 1.20	0.001*	-0.06 (-0.34, 0.22)	0.30 (-0.12, 0.72)
	Left	3.64 ± 1.06	3.88 ± 1.06	0.001*	-0.21 (-0.37, -0.05)	
Multifidus (T4 level) (kg/cm²)						
Dry needling	Right	4.03 ± 0.96	4.40 ± 0.77	0.004*	-0.37 (-0.71, -0.04)	0.66 (0.20, 1.13)
	Left	4.32 ± 0.88	4.65 ± 0.52	0.002*	-0.39 (-0.68, -0.10)	
Cross-tape	Right	3.74 ± 1.05	3.83 ± 1.11	0.015*	-0.09 (-0.34, 0.17)	0.57 (0.20, 0.93)
	Left	3.98 ± 0.92	4.13 ± 0.88	0.001*	-0.13 (-0.27, 0.01)	
Multifidus (L2 level) (kg/cm²)						
Dry needling	Right	3.69 ± 1.07	4.45 ± 0.84	0.001*	-0.82 (-1.20, -0.45)	0.90 (0.40, 1.39)
	Left	3.92 ± 1.07	4.38 ± 0.94	0.001*	-0.46 (-0.78, -0.14)	
Cross-tape	Right	3.48 ± 1.10	4.11 ± 1.03	0.001*	-0.003 (-0.26, 0.26)	0.15 (-0.34, 0.64)
	Left	3.47± 1.11	4.25 ± 0.96	0.001*	-0.13 (-0.27, 0.01)	

Table 2 (cont). *Baseline, post-treatment, pre-post-treatment differences and change scores in each group (95% confidence interval) for MTrPs algometry.*

Outcome/ Group	Side	Baseline	One Month Post-treatment	Paired t-test *P*	Within-Group Score Changes	Between-Group Score Changes
Multifidus (S1 level) (kg/cm²)						
Dry needling	Right	4.79 ± 0.63	4.86 ± 0.58	0.008*	-0.06 (-0.10, -0.02)	-0.07 (-0.35, 0.21)
	Left	4.81 ± 0.61	4.92 ± 0.46	0.011*	-0.11 (-0.25, 0.04)	
Cross-tape	Right	4.82 ± 0.41	4.87 ± 0.46	0.002*	-0.06 (-0.12, 0.001)	0.33 (-0.04, 0.69)
	Left	4.49 ± 1.02	4.57 ± 0.99	0.001*	-0.08 (-0.28, 0.13)	
Multifidus (S4 level) (kg/cm²)						
Dry needling	Right	5.03 ± 0.47	5.13 ± 0.23	0.039*	-0.10 (-0.26, 0.06)	0.06 (-0.10, 0.23)
	Left	5.11 ± 0.16	5.08 ± 0.23	0.056	-0.05 (-0.11, 0.003)	
Cross-tape	Right	4.96 ± 0.57	5.06 ± 0.44	0.001*	-0.10 (-0.16, -0.05)	-0.01 (-0.11, 0.08)
	Left	5.16 ± 0.18	5.17 ± 0.21	0.001*	-0.09 (-0.13, -0.06)	
Quadratus Lumborum (Lateral Superficial Upper) (Kg/cm²)						
Dry needling	Right	4.59 ± 0.54	4.70 ± 0.44	0.001*	-0.98 (-1.37, -0.58)	0.23 (-0.03, 0.50)
	Left	4.74 ± 0.12	4.76 ± 0.15	0.004*	-0.38 (-0.67, -0.09)	
Cross-tape	Right	4.42 ± 0.66	4.47 ± 0.64	0.001*	-0.16 (-0.53, 0.21)	0.08 (-0.01, 0.17)
	Left	4.64 ± 1.17	4.66 ± 0.21	0.002*	0.02 (-0.24, 0.27)	
Quadratus Lumborum (Middle Deep Upper) (Kg/cm²)						
Dry needling	Right	4.59 ± 0.54	4.70 ± 0.44	0.013*	-0.11 (-0.24, 0.02)	0.23 (-0.08, 0.54)
	Left	4.74 ± 0.12	4.76 ± 0.15	0.304	-0.03 (-0.06, 0.01)	
Cross-tape	Right	4.42 ± 0.66	4.47 ± 0.64	0.001*	-0.05 (-0.10, -0.01)	-0.16 (-0.41,0.09)
	Left	4.64 ± 0.17	4.67 ± 0.21	0.220	-0.01 (-0.06, -0.03)	
Quadratus Lumborum (Middle Deep Lower) (Kg/cm²)						
Dry needling	Right	4.71 ± 0.54	4.75 ± 0.52	0.038*	-0.05 (-0.09, 0.001)	0.56 (0.05, 1.08)
	Left	4.68 ± 0.54	4.70 ± 0.68	0.002*	-0.003 (-0.15, 0.14)	
Cross-tape	Right	4.45 ± 0.81	4.51 ± 0.74	0.065	-0.06 (-0.19, 0.06)	0.07 (-0.37, 0.52)
	Left	4.76 ± 0.16	4.85 ± 0.20	0.001*	-0.09 (-0.12, -0.06)	
Quadratus Lumborum (Lateral Superficial Lower) (Kg/cm²)						
Dry needling	Right	4.34 ± 1.02	4.71 ± 0.79	0.003*	-0.38 (-0.66, -0.94)	0.04 (-0.39, 0.46)
	Left	4.91 ± 0.49	4.90 ± 0.69	0.048*	0.003 (-0.15, 0.15)	
Cross-tape	Right	4.68 ± 0.83	4.39 ± 1.11	0.001*	0.001 (-0.14, 0.14)	0.38 (-0.05, 0.81)
	Left	4.67 ± 0.95	4.49 ± 1.06	0.003*	-0.08 (-0.15, -0.01)	

*$P < 0.05$

Values are expressed as means ± standard deviation for baseline and one month post-treatment and as mean score change (95% confidence interval) for within- and between-group values.

ranged from negligible to moderate. These results are explained in a study which reported that AΔ fibers are stimulated 72 hours after dry needling is applied to the trigger point, and that prolonged stimulation of these fibers causes enkephalin to function in the inhibitory interneurons in the posterior horn of the spinal cord, thus reducing pain (21,22). Dry needling also increases local tissue blood circulation and generates a local stretch

Table 3. *Baseline, post-treatment, pre-post-treatment differences and change scores in each group (95% confidence interval) for spinal mobility standing.*

Outcome/ Group	Side	Baseline	One Month Post-treatment	Paired t-test *P*	Within-Group Score Changes	Between-Group Score Changes
T1/T2 (°)						
Dry needling	Standing	-5.72 ± 10.15	-8.06 ± 9.68	0.105	2.34 (-0.52, 5.20)	-13.16 (-16.69, -9.62)
	ROF	-1.88 ± 9.01	-3.66 ± 9.21	0.183	1.78 (-0.89, 4.45)	-11.22 (-14.98, -7.45)
	ROEF	3.94 ± 6.56	4.34 ± 6.98	0.765	-0.41 (-3.16, 2.34)	1.84 (-1.33, 5.01)
Cross-tape	Standing	4.25 ± 4.69	5.09 ± 2.51	0.395	-0.84 (-2.84, 1.15)	
	ROF	6.03 ± 5.65	7.56 ± 5.36	0.251	-1.53 (-4.20, 1.14)	
	ROEF	1.78 ± 6.81	2.50 ± 5.63	0.661	-0.72 (-4.02, 2.59)	
T2/T3 (°)						
Dry needling	Standing	-1.59 ± 11.00	-3.69 ± 10.98	0.193	2.09 (-1.12, 5.30)	-10.41 (-14.38, -6.43)
	ROF	3.97 ± 7.04	3.84 ± 7.81	0.887	0.13 (-1.66, 1.91)	-2.91 (-5.92, 0.11)
	ROEF	5.38 ± 9.24	7.66 ± 9.42	0.245	-2.28 (-6.21, 1.65)	7.56 (4.00, 11.13)
Cross-tape	Standing	7.03 ± 3.32	6.72 ± 2.43	0.579	0.31 (-0.83, 1.45)	
	ROF	7.56 ± 3.57	6.75 ± 3.45	0.393	0.81 (-1.10, 2.72)	
	ROEF	0.41 ± 4.89	0.09 ± 3.60	0.772	0.31 (-1.87, 2.50)	
T3/T4 (°)						
Dry needling	Standing	4.34 ± 7.01	1.34 ± 10.61	0.069	3.00 (-0.25, 6.25)	-5.53 (-9.34, -1.72)
	ROF	7.50 ± 5.56	7.88 ± 7.25	0.757	-0.38 (-2.83, 2.08)	1.88 (-0.96, 4.71)
	ROEF	3.03 ± 8.18	6.50 ± 12.09	0.070	-3.47 (-7.24, 0.31)	7.41 (2.97, 11.84)
Cross-tape	Standing	7.41 ± 2.24	6.88 ± 1.98	0.117	0.53 (-0.14, 1.20)	
	ROF	4.81 ± 2.52	6.00 ± 3.45	0.044*	-1.19 (-2.34, -0.03)	
	ROEF	-2.63 ± 2.92	-0.91 ± 3.40	0.019*	-1.72 (-3.13, -0.31)	
T4/T5 (°)						
Dry needling	Standing	5.69 ± 3.11	5.53 ± 5.91	0.896	0.16 (-2.26, 2.57)	-0.97 (-3.14, 1.20)
	ROF	5.69 ± 3.31	6.94 ± 4.20	0.068	-1.25 (-2.60, 0.10)	1.13 (-0.58, 2.83)
	ROEF	0.06 ± 3.79	1.28 ± 6.81	0.364	-1.22 (-3.91, 1.48)	1.88 (-0.73, 4.48)
Cross-tape	Standing	7.13 ± 2.15	6.50 ± 1.65	0.062	0.63 (-0.03, 1.28)	
	ROF	5.03 ± 3.26	5.81 ± 2.35	0.170	-0.78 (-1.92, 0.35)	
	ROEF	-2.03 ± 3.29	-0. 59 ± 2.83	0.019*	-1.44 (-2.62, -0.25)	
T5/T6 (°)						
Dry needling	Standing	6.16 ± 2.90	5.97 ± 3.21	0.651	0.19 (-0.65, 1.02)	0.25 (-1.13, 1.63)
	ROF	6.16 ± 2.85	6.41 ± 3.60	0.609	-0.25 (-1.24, 0.74)	1.50 (-0.05, 3.05)
	ROEF	0.25 ± 2.82	0.59 ± 3.51	0.508	-0.34 (-1.39, 0.70)	1.50 (0.07, 2.93)
Cross-tape	Standing	5.97 ± 2.55	5.72 ± 2.23	0.478	0.25 (-0.46, 0.96)	
	ROF	4.97 ± 2.40	4.91 ± 2.51	0.892	0.06 (-0.87, 0.99)	
	ROEF	-1.13 ± 2.98	-0.91 ± 2.02	0.679	-0.22 (-1.29, 0.85)	
T6/T7 (°)						
Dry needling	Standing	7.41 ± 2.76	6.59 ± 2.80	0.136	0.81 (-0.27, 1.89)	0.001 (-1.35, 1.35)
	ROF	5.88 ± 2.79	7.25 ± 3.47	0.003*	-1.38 (-2.25,-0.50)	1.56 (-0.09, 3.22)
	ROEF	-1.56 ± 2.71	0.53 ± 3.06	0.009*	-2.09 (-3.61, -0.57)	1.41 (0.005, 2.81)
Cross-tape	Standing	6.19 ± 3.18	6.59 ± 2.60	0.255	-0.41 (-1.12, 0.31)	
	ROF	5.47 ± 3.35	5.69 ± 3.15	0.709	-0.22 (-1.40, 0.96)	
	ROEF	-0.69 ± 3.52	-0.88 ± 2.52	0.796	0.19 (-1.28, 1.65)	
T7/T8 (°)						
Dry needling	Standing	6.38 ± 2.01	6.56 ± 2.53	0.678	-0.19 (-1.10, 0.73)	0.47 (-0.76, 1.69)
	ROF	6.22 ± 2.68	6.34 ± 2.81	0.764	-0.13 (-0.97, 0.72)	-2.03 (-3.56, -0.50)
	ROEF	0.28 ± 2.22	-0.31 ± 3.03	0.334	0.59 (-0.64, 1.83)	-2.66 (-4.10, -1.21)
Cross-tape	Standing	6.09 ± 2.66	6.09 ± 2.37	-	0.001 (-0.65, 0.65)	
	ROF	6.59 ± 3.47	8.38 ± 3.28	0.017*	-1.78 (-3.22, -0.34)	
	ROEF	0.53 ± 3.75	2.34 ± 2.73	0.024*	-1.81 (-3.37,-0.25)	

Table 3 (cont). *Baseline, post-treatment, pre-post-treatment differences and change scores in each group (95% confidence interval) for spinal mobility standing.*

Outcome/ Group	Side	Baseline	One Month Post-treatment	Paired t-test *P*	Within-Group Score Changes	Between-Group Score Changes
T8/T9 (°)						
Dry needling	Standing	6.28 ± 2.63	6.59 ± 2.43	0.403	-0.31 (-1.06, 0.44)	1.81 (0.55, 3.08)
	ROF	8.16 ± 3.06	8.09 ± 3.11	0.893	0.06 (-0.88, 1.01)	0.06 (-1.41, 1.53)
	ROEF	1.91 ± 2.89	1.50 ± 3.64	0.493	0.41 (-0.79, 1.60)	-1.75 (-3.45, -0.05)
Cross-tape	Standing	4.47 ± 2.48	4.78 ± 2.62	0.339	-0.31 (-0.97, 0.34)	
	ROF	8.91 ± 3.63	8.03 ± 2.76	0.102	0.88 (-0.18, 1.93)	
	ROEF	4.50 ± 3.77	3.25 ± 3.13	0.071	1.25 (-0.11, 2.61)	
T9/T10 (°)						
Dry needling	Standing	5.91 ± 3.18	6.59 ± 3.44	0.135	-0.69 (- 1.60, 0.23)	3.47 (1.88, 5.06)
	ROF	7.66 ± 2.56	8.19 ± 3.28	0.284	-0.53 (-1.53, 0.46)	1.25 (-0.68, 3.18)
	ROEF	1.91 ± 2.35	1.81 ± 3.46	0.881	0.09 (-1.17, 1.36)	-2.09 (-4.32, 0.13)
Cross-tape	Standing	3.00 ± 2.78	3.13 ± 2.88	0.771	-0.13 (-0.99, 0.74)	
	ROF	7.16 ± 3.65	6.94 ± 4.37	0.768	0.22 (-1.28, 1.72)	
	ROEF	4.16 ± 4.27	3.91 ± 5.26	0.763	0.25 (-1.42, 1.92)	
T10/T11 (°)						
Dry needling	Standing	4.06 ± 2.63	3.53 ± 3.88	0.300	0.53 (-0.50, 1.56)	3.28 (1.53, 5.03)
	ROF	7.81 ± 2.73	7.19 ± 3.53	0.269	0.63 (-0.51, 1.76)	0.75 (-1.42, 2.92)
	ROEF	3.91 ± 2.63	3.88 ± 3.81	0.960	0.03 (-1.24, 1.30)	-2.25 (-4.36, -0.14)
Cross-tape	Standing	0.81 ± 3.04	0.25 ± 3.07	0.239	0.56 (-0.39, 1.52)	
	ROF	5.81 ± 2.60	6.44 ± 5.01	0.388	-0.63 (-2.08, 0.83)	
	ROEF	5.00 ± 3.11	6.13 ± 4.61	0.183	-1.13 (-2.81, 0.56)	
T11/T12 (°)						
Dry needling	Standing	1.59 ± 3.00	1.41 ± 3.15	0.712	0.19 (-0.84, 1.21)	3.25 (1.80, 4.70)
	ROF	4.72 ± 3.62	4.78 ± 3.81	0.888	-0.06 (-0.96, 0.83)	0.41 (-1.32, 2.14)
	ROEF	3.13 ± 2.92	3.53 ± 2.79	0.494	-0.41(-1.60, 0.79)	-2.66 (-4.27, -1.04)
Cross-tape	Standing	-1.59 ± 3.30	-1.84 ± 2.64	0.508	0.25 (-0.51, 1.01)	
	ROF	5.16 ± 3.43	4.38 ± 3.08	0.160	0.78 (-0.32, 1.89)	
	ROEF	6.81 ± 3.52	6.19 ± 3.60	0.250	0.63 (-0.46, 1.71)	
T12/L1 (°)						
Dry needling	Standing	-2.69 ± 3.07	-2.88 ± 3.56	0.725	0.19 (-0.89, 1.26)	1.22 (-0.23, 2.67)
	ROF	3.59 ± 2.98	4.06 ± 4.12	0.381	-0.47 (-1.54, 0.61)	0.69 (-1.14, 2.52)
	ROEF	6.25 ± 3.23	6.84 ± 3.99	0.357	-0.59 (-1.89, 0.70)	-0.47 (-2.31, 1.37)
Cross-tape	Standing	-4.34 ± 2.77	-4.09 ± 2.05	0.533	-0.25 (-1.06, 0.56)	
	ROF	2.47 ± 2.88	3.38 ± 3.13	0.137	-0.91 (-2.12, 0.30)	
	ROEF	6.75 ± 3.06	7.31 ± 3.35	0.365	-0.56 (-1.81, 0.69)	
L1/L2 (°)						
Dry needling	Standing	-5.53 ± 3.78	-6.19 ± 4.15	0.247	0.66 (-0.48, 1.79)	2.03 (-0.01, 4.07)
	ROF	2.78 ± 3.70	1.63 ± 4.81	0.534	0.38 (-0.84, 1.59)	-0.25 (-2.36, 1.86)
	ROEF	8.59 ± 5.05	9.03 ± 4.66	0.653	-0.44 (-2.40, 1.53)	-2.13 (-4.42, 0.17)
Cross-tape	Standing	-8.06 ± 4.04	-8.22 ± 4.03	0.776	0.16 (-0.95, 1.27)	
	ROF	3.03 ± 4.69	3.88 ± 5.01	0.579	0.44 (-1.15, 2.03)	
	ROEF	11.34 ± 4.65	11.16 ± 4.52	0.819	0.19 (-1.47, 1.84)	
L2/L3 (°)						
Dry needling	Standing	-7.97 ± 3.30	-8.22 ± 4.97	0.682	0.25 (-0.98, 1.48)	2.50 (0.16, 4.84)
	ROF	1.63 ± 4.81	2.19 ± 4.03	0.440	-0.56 (-2.03, 0.91)	-1.34 (-3.36, 0.67)
	ROEF	9.59 ± 5.84	10.44 ± 6.11	0.375	-0.84 (-2.76, 1.07)	-3.84 (-6.66, -1.03)
Cross-tape	Standing	-10.72 ± 4.23	-10.72 ± 4.39	-	0.001 (-0.99, 0.99)	
	ROF	3.88 ± 5.01	3.53 ± 4.05	0.695	0.34 (-1.43, 2.12)	
	ROEF	14.53 ± 5.88	14.28 ± 5.13	0.798	0.25 (-1.72, 2.22)	

Table 3 (cont). *Baseline, post-treatment, pre-post-treatment differences and change scores in each group (95% confidence interval) for spinal mobility standing.*

Outcome/ Group	Side	Baseline	One Month Post-treatment	Paired t-test *P*	Within-Group Score Changes	Between-Group Score Changes
L3/L4 (°)						
Dry needling	Standing	-9.84 ± 4.66	-9.53 ± 5.19	0.725	-0.31 (-2.11, 1.49)	-2.16 (-4.94, 0.63)
	ROF	3.06 ± 3.23	2.22 ± 3.79	0.307	0.84 (-0.81, 2.50)	0.81 (-1.49, 3.11)
	ROEF	12.81 ± 5.48	11.88 ± 6.06	0.350	0.94 (-1.08, 2.95)	3.22 (0.06, 6.37)
Cross-tape	Standing	-7.56 ± 5.78	-7.38 ± 5.92	0.786	-0.19 (-1.58, 1.21)	
	ROF	1.47 ± 4.82	1.41 ± 5.29	0.938	0.06 (-1.55, 1.68)	
	ROEF	9.03 ± 6.08	8.66 ± 6.56	0.676	0.38 (-1.44, 2.19)	
L4/L5 (°)						
Dry needling	Standing	-6.97 ± 3.78	-5.81 ± 4.69	0.034*	-1.16 (-2.22, -0.09)	-2.00 (-4.26, 0.26)
	ROF	0.13 ± 4.11	1.25 ± 4.93	0.187	-1.13 (-2.83, 0.58)	0.84 (-1.42, 3.11)
	ROEF	7.09 ± 5.00	6.97 ± 5.26	0.899	0.13 (-1.86, 2.11)	2.78 (0.36, 5.20)
Cross-tape	Standing	-3.69 ± 4.80	-3.81 ± 4.34	0.849	0.13 (-1.20, 1.45)	
	ROF	1.19 ± 5.08	0.41 ± 4.11	0.349	0.78 (-0.89, 2,46)	
	ROEF	4.94 ± 5.78	4.19 ± 4.37	0.507	0.75 (-1.53, 3.03)	
L5/S1 (°)						
Dry needling	Standing	-3.56 ± 4.01	-4.38 ± 5.12	0.290	0.81 (-0.73, 2.35)	-4.25 (-7.13, -1.37)
	ROF	0.03 ± 2.92	0.66 ± 3.52	0.430	-0.63 (-2.22, 0.97)	-3.66 (-5.86, -1.45)
	ROEF	3.63 ± 4.43	5.03 ± 4.66	0.245	-1.41 (-3.83, 1.01)	0.63 (-2.09, 3.34)
Cross-tape	Standing	0.50 ± 5.01	-0.13 ± 6.34	0.498	0.63 (-1.23, 2.48)	
	ROF	3.28 ± 5.06	4.31 ± 5.16	0.352	-1.03 (-3.26, 1.20)	
	ROEF	2.69 ± 4.86	4.41 ± 6.11	0.217	-1.72 (-4.50, 1.06)	
Sacral Slope (°)						
Dry needling	Standing	21.31 ± 9.68	22.09 ± 8.46	0.465	-0.78 (-2.94, 1.37)	0.75 (-2.96, 4.46)
	ROF	48.69 ± 13.62	53.56 ± 13.82	0.009*	-4.88 (-8.47, -1.28)	-1.03 (-8.62, 6.56)
	ROEF	27.41 ± 15.42	31.53 ± 13.08	0.034*	-4.13 (-7.91, -0.34)	-1.84 (-8.99, 5.30)
Cross-tape	Standing	20.63 ± 5.84	21.34 ± 6.24	0.222	-0.72 (-1.90, 0.46)	
	ROF	54.31 ± 19.25	54.59 ± 16.43	0.906	-0.28 (-5.10, 4.53)	
	ROEF	33.81 ± 19.89	33.38 ± 15.42	0.865	0.44 (-4.75, 5.63)	
Segmental Amplitude Thoracic Spine (°)						
Dry needling	Standing	39.81 ± 18.36	31.88 ± 19.38	0.004*	7.94 (2.70, 13.18)	-17.84 (-25.60,-10.09)
	ROF	61.88 ± 13.80	62.94 ± 14.12	0.591	-1.06 (-5.06, 2.93)	-7.53 (-14.22,-0.84)
	ROEF	22.03 ± 19.96	31.16 ± 19.56	0.008*	-9.13 (-15.68,-2.57)	10.41 (2.77, 18.05)
Cross-tape	Standing	50.25 ± 9.31	49.72 ± 10.31	0.577	0.53 (-1.39, 2.45)	
	ROF	67.19 ± 14.67	70.47 ± 12.61	0.177	-3.28 (-8.13, 1.57)	
	ROEF	16.78 ± 13.43	20.75 ± 9.22	0.080	-3.97 (-8.44, 0.50)	
Segmental Amplitude Lumbar Spine (°)						
Dry needling	Standing	-36.41 ± 10.28	-36.84 ± 8.77	0.698	0.44 (-1.84, 2.71)	-2.66 (-6.75, 1.43)
	ROF	11.53 ± 14.24	13.25 ± 14.24	0.395	-1.72 (-5.79, 2.35)	-2.44 (-8.77, 3.90)
	ROEF	47.81 ± 13.48	49.84 ± 12.25	0.376	-2.03 (-6.64, 2.58)	-0.03 (-5.73, 5.66)
Cross-tape	Standing	-33.66 ± 6.61	-34.19 ± 7.56	0.472	0.53 (-0.96, 2.02)	
	ROF	15.63 ± 14.04	15.69 ± 10.89	0.974	-0.06 (-3.93, 3.80)	
	ROEF	49.00 ± 12.91	49.88 ± 10.48	0.692	-0.88 (-5.33, 3.58)	
Segmental Amplitude Thoracic-Lumbar Spine(°)						
Dry needling	Standing	6.00 ± 3.74	5.81 ± 3.37	0.670	0.19 (-0.70, 1.08)	1.00 (-0.60, 2.60)
	ROF	76.25 ± 18.15	83.13 ± 14.39	0.009*	- 6.88 (-11.92,-1.83)	-2.59 (-10.73, 5.54)
	ROEF	70.31 ± 19.29	77.34 ± 15.15	0.010*	-7.03 (-12.23, -1.83)	-3.63 (-11.94, 4.69)
Cross-tape	Standing	4.91 ± 3.57	4.81 ± 3.01	0.813	0.09 (0.71, 0.89)	
	ROF	85.09 ± 20.46	85.72 ± 17.96	0.781	-0.63 (-5.18, 3.93)	
	ROEF	80.31 ± 21.00	80.97 ± 18.01	0.781	-0.66 (-5.44, 4.13)	

*$P < 0.05$. Values are expressed as means ± standard deviation for baseline and one month post-treatment and as mean score change (95% confidence interval) for within- and between-group values. Abbreviations: ROF (range of flexion), and ROEF (range of erect to flexion).

Table 4. *Baseline, post-treatment, pre-post-treatment differences and change scores in each group (95% confidence interval) for spinal mobility sitting.*

Outcome/ Group	Side	Baseline	One Month Post-treatment	Paired t-test *P*	Within-Group Score Changes	Between-Group Score Changes
T1/T2 (°)						
Dry needling	Sitting	-5.81 ± 9.29	-10.47 ± 10.44	0.007*	4.66 (1.35, 7.96)	-15.50 (-19.49, -11.51)
	ROF	-2.19 ± 10.83	-3.16 ± 10.77	0.425	0.97 (-1.48, 3.41)	-11.81 (-16.07, -7.56)
	ROEF	3.69 ± 7.20	7.28 ± 7.03	0.052	-3.59 (-7.22, 0.03)	3.56 (0.28, 6.84)
Cross-tape	Sitting	2.88 ± 3.63	5.03 ± 4.29	0.021*	-2.16 (-3.96, -0.35)	
	ROF	7.81 ± 6.54	8.66 ± 5.39	0.602	-0.84 (-4.11, 2.42)	
	ROEF	4.91 ± 6.43	3.72 ± 6.05	0.405	1.19 (-1.68, 4.05)	
T2/T3 (°)						
Dry needling	Sitting	-0.09 ± 9.17	-5.16 ± 9.87	0.001*	5.06 (2.43, 7.70)	-10.56 (-14.21, -6.92)
	ROF	4.31 ± 6.68	4.97 ± 7.15	0.627	-0.66 (-3.38, 2.07)	-4.09 (-7.08, -1.10)
	ROEF	4.31 ± 9.02	9.97 ± 8.94	0.006*	-5.66 (-9.56, -1.75)	6.34 (2.79, 9.90)
Cross-tape	Sitting	6.97 ± 3.14	5.41 ± 2.98	0.001*	1.56 (0.72, 2.40)	
	ROF	10.00 ± 5.27	9.06 ± 4.52	0.358	0.94 (-1.11, 2.99)	
	ROEF	2.97 ± 5.26	3.63 ± 4.60	0.475	-0.66 (-2.51, 1.19)	
T3/T4 (°)						
Dry needling	Sitting	0.81 ± 9.22	0.56 ± 9.46	0.886	0.25 (-3.29, 3.79)	-5.56 (-9.03, -2.10)
	ROF	9.97 ± 5.52	8.72 ± 7.62	0.338	1.25 (-1.37, 3.87)	2.66 (-0.36, 5.67)
	ROEF	9.22 ± 11.63	8.03 ± 10.44	0.568	1.19 (-3.01, 5.39)	8.06 (4.18, 11.95)
Cross-tape	Sitting	6.44 ± 3.07	6.13 ± 2.57	0.507	0.31 (-0.64, 1.26)	
	ROF	7.16 ± 3.30	6.06 ± 3.83	0.237	1.09 (-0.76, 2.94)	
	ROEF	0.69 ± 4.12	-0.03 ± 3.44	0.436	0.72 (-1.14, 2.58)	
T4/T5 (°)						
Dry needling	Sitting	3.13 ± 4.38	3.16 ± 7.39	0.982	-0.03 (-2.85, 2.79)	-1.97 (-4.65, 0.72)
	ROF	8.44 ± 4.38	7.84 ± 4.79	0.429	0.59 (-0.92, 2.11)	1.38 (-0.91, 3.66)
	ROEF	5.28 ± 5.37	4.88 ± 8.87	0.741	0.41 (-2.08, 2.90)	3.56 (0.08, 7.05)
Cross-tape	Sitting	5.16 ± 1.67	5.13 ± 1.76	0.918	0.03 (-0.59, 0.65)	
	ROF	6.84 ± 3.24	6.47 ± 4.36	0.705	0.38 (-1.63, 2.38)	
	ROEF	1.63 ± 2.42	1.31 ± 4.32	0.748	0.31 (-1.66, 2.28)	
T5/T6 (°)						
Dry needling	Sitting	3.69 ± 6.40	5.00 ± 3.68	0.236	-1.31 (-3.53, 0.90)	0.47 (-1.03, 1.97)
	ROF	5.22 ± 3.30	6.38 ± 3.87	0.060	-1.16 (-2.36, 0.05)	0.25 (-1.65, 2.15)
	ROEF	1.59 ± 7.56	1.41 ± 4.31	0.887	0.19 (-2.48, 2.85)	-0.31 (-2.45, 1.82)
Cross-tape	Sitting	4.25 ± 2.08	4.53 ± 2.11	0.397	-0.28 (-0.95, 0.39)	
	ROF	4.91 ± 2.72	6.13 ± 3.73	0.046*	-1.22 (-2.41, -0.03)	
	ROEF	0.47 ± 3.09	1.72 ± 4.24	0.067	-1.25 (-2.59, 0.09)	
T6/T7 (°)						
Dry needling	Sitting	4.69 ± 3.41	5.31 ± 3.02	0.311	-0.63 (-1.86, 0.61)	0.84 (-0.64, 2.33)
	ROF	5.88 ± 3.24	6.03 ± 4.01	0.775	-0.16 (-1.26, 0.95)	-1.47 (-3.49, 0.55)
	ROEF	1.28 ± 3.63	0.78 ± 3.11	0.456	0.50 (-0.85, 1.85)	-2.25 (-3.89, -0.61)
Cross-tape	Sitting	4.66 ± 2.67	4.47 ± 2.92	0.620	0.19 (-0.58, 0.95)	
	ROF	6.41 ± 3.46	7.50 ± 4.06	0.138	-1.09 (-2.56, 0.37)	
	ROEF	1.81 ± 3.56	3.03 ± 3.45	0.163	-1.22 (-2.96, 0.52)	
T7/T8 (°)						
Dry needling	Sitting	5.34 ± 2.65	5.34 ± 2.31	-	0.001 (-0.85, 0.85)	0.84 (-0.30, 1.99)
	ROF	5.75 ± 2.78	6.22 ± 3.31	0.323	-0.47 (-1.42, 0.48)	-1.28 (-2.99, 0.43)
	ROEF	0.81 ± 2.72	1.53 ± 3.26	0.218	-0.72 (-1.89, 0.45)	-1.41 (-2.86, 0.04)
Cross-tape	Sitting	5.16 ± 2.22	4.50 ± 2.29	0.085	0.66 (-0.10, 1.41)	
	ROF	7.56 ± 3.29	7.50 ± 3.54	0.907	0.06 (-1.02, 1.15)	
	ROEF	2.22 ± 3.54	2.94 ± 2.49	0.305	-0.72 (-2.12, 0.69)	

Table 4 (cont). *Baseline, post-treatment, pre-post-treatment differences and change scores in each group (95% confidence interval) for spinal mobility sitting.*

Outcome/ Group	Side	Baseline	One Month Post-treatment	Paired t-test *P*	Within-Group Score Changes	Between-Group Score Changes
T8/T9 (°)						
Dry needling	Sitting	5.41 ± 2.88	5.47 ± 2.91	0.839	-0.06 (-0.68, 0.56)	1.38 (0.12, 2.63)
	ROF	8.00 ± 2.78	8.22 ± 3.37	0.700	-0.22 (-1.37, 0.93)	0.38 (-1.35, 2.10)
	ROEF	2.69 ± 3.30	2.81 ± 3.21	0.837	-0.13 (-1.35, 1.10)	-1.00 (-2.64, 0.64)
Cross-tape	Sitting	4.50 ± 3.10	4.09 ± 2.02	0.273	0.41 (-0.34, 1.15)	
	ROF	9.50 ± 3.67	7.84 ± 3.55	0.011*	1.66 (0.42, 2.90)	
	ROEF	5.13 ± 4.18	3.81 ± 3.34	0.091	1.31 (-0.22, 2.85)	
T9/T10 (°)						
Dry needling	Sitting	5.84 ± 2.19	6.06 ± 2.27	0.526	-0.22 (-0.91, 0.48)	2.28 (1.06, 3.50)
	ROF	8.03 ± 2.79	7.63 ± 2.61	0.270	0.41 (-0.33, 1.14)	0.38 (-1.19, 1.94)
	ROEF	2.19 ± 2.47	1.66 ± 2.12	0.315	0.53 (-0.53, 1.59)	-1.78 (-3.29, -0.27)
Cross-tape	Sitting	3.13 ± 2.97	3.78 ± 2.60	0.265	-0.66 (-1.83, 0.52)	
	ROF	6.47 ± 3.46	7.25 ± 3.58	0.309	-0.78 (-2.32, 0.76)	
	ROEF	3.22 ± 4.05	3.44 ± 3.72	0.816	-0.22 (-2.12, 1.68)	
T10/T11 (°)						
Dry needling	Sitting	5.25 ± 2.76	4.22 ± 3.35	0.048*	1.03 (0.01, 2.05)	1.72 (0.18, 3.26)
	ROF	7.44 ± 3.29	7.66 ± 2.46	0.598	-0.22 (-1.06, 0.62)	2.03 (0.57, 3.50)
	ROEF	2.19 ± 2.78	3.38 ± 3.79	0.066	-1.19 (-2.46, 0.08)	0.16 (-1.72, 2.03)
Cross-tape	Sitting	2.72 ± 3.32	2.50 ± 2.78	0.587	0.22 (-0.59, 1.03)	
	ROF	6.47 ± 4.04	5.63 ± 3.34	0.263	0.84 (-0.67, 2.35)	
	ROEF	4.00 ± 4.07	3.22 ± 3.72	0.358	0.78 (-0.93, 2.49)	
T11/T12 (°)						
Dry needling	Sitting	2.97 ± 3.40	2.75 ± 3.44	0.672	0.22 (-0.82, 1.26)	1.28 (-0.53, 3.10)
	ROF	5.34 ± 3.01	4.78 ± 2.80	0.213	0.56 (-0.34, 1.46)	0.84 (-0.56, 2.24)
	ROEF	2.44 ± 3.72	2.09 ± 3.86	0.631	0.34 (-1.10, 1.79)	-0.38 (-2.33, 1.58)
Cross-tape	Sitting	0.75 ± 2.87	1.47 ± 3.82	0.154	-0.72 (-1.72, 0.29)	
	ROF	4.34 ± 2.85	3.94 ± 2.80	0.467	0.41 (-0.72, 1.53)	
	ROEF	3.47 ± 3.27	2.47 ± 3.98	0.186	1.00 (-0.51, 2.51)	
T12/L1 (°)						
Dry needling	Sitting	1.09 ± 3.81	0.94 ± 3.24	0.737	0.16 (-0.78, 1.10)	1.75 (-0.003, 3.50)
	ROF	4.06 ± 2.37	4.06 ± 3.27	-	0.001 (-0.93, 0.93)	1.00 (-0.60, 2.60)
	ROEF	2.88 ± 3.40	3.31 ± 3.60	0.557	-0.44 (-1.94, 1.07)	-0.44 (-2.42, 1.54)
Cross-tape	Sitting	-1.19 ± 2.91	-0.81 ± 3.75	0.351	-0.38 (-1.18, 0.43)	
	ROF	3.34 ± 3.75	3.06 ± 3.11	0.705	0.28 (-1.22, 1.78)	
	ROEF	4.53 ± 3.96	3.75 ± 4.30	0.346	0.78 (-0.88, 2.45)	
L1/L2 (°)						
Dry needling	Sitting	-0.13 ± 3.61	-0.47 ± 3.71	0.617	0.34 (-1.04, 1.73)	1.50 (-0.31, 3.31)
	ROF	3.88 ± 3.10	3.38 ± 3.77	0.445	0.50 (-0.82, 1.82)	0.41 (-1.70, 2.51)
	ROEF	4.09 ± 2.67	3.84 ± 4.26	0.739	0.25 (-1.27, 1.77)	-1.22 (-3.16, 0.73)
Cross-tape	Sitting	-2.97 ± 3.83	-1.97 ± 3.51	0.097	-1.00 (-2.19, 0.19)	
	ROF	3.28 ± 4.16	2.97 ± 4.61	0.615	0.31 (-0.94, 1.57)	
	ROEF	6.13 ± 4.44	5.06 ± 3.48	0.224	1.06 (-0.68, 2.81)	
L2/L3 (°)						
Dry needling	Sitting	-0.88 ± 3.19	-1.31 ± 3.42	0.269	0.44 (-0.36, 1.23)	0.94 (-1.06, 2.94)
	ROF	2.69 ± 3.30	3.47 ± 3.39	0.154	-0.78 (-1.87, 0.31)	0.13 (-1.85, 2.10)
	ROEF	3.56 ± 3.50	4.75 ± 4.39	0.092	-1.19 (-2.58, 0.21)	-0.78 (-3.14, 1.58)
Cross-tape	Sitting	-2.66 ± 4.00	-2.25 ± 4.50	0.461	-0.41 (-1.52, 0.70)	
	ROF	3.72 ± 4.24	3.34 ± 4.46	0.494	0.38 (-0.73, 1.48)	
	ROEF	6.22 ± 4.29	5.53 ± 5.04	0.421	0.69 (-1.03, 2.41)	

Table 4 (cont). *Baseline, post-treatment, pre-post-treatment differences and change scores in each group (95% confidence interval) for spinal mobility sitting.*

Outcome/ Group	Side	Baseline	One Month Post-treatment	Paired t-test *P*	Within-Group Score Changes	Between-Group Score Changes
L3/L4 (°)						
Dry needling	Sitting	-0.56 ± 3.42	-1.00 ± 3.11	0.441	0.44 (-0.71, 1.58)	0.94 (-0.94, 2.82)
	ROF	4.00 ± 2.46	3.72 ± 3.21	0.627	0.28 (-0.89, 1.45)	2.50 (0.66, 4.34)
	ROEF	4.50 ± 3.17	4.56 ± 3.44	0.933	-0.06 (-1.56, 1.44)	1.41 (-0.60, 3.42)
Cross-tape	Sitting	-2.84 ± 4.47	-1.94 ± 4.31	0.218	-0.91 (-2.38, 0.56)	
	ROF	2.22 ± 5.19	1.22 ± 4.09	0.054	1.00 (-0.02, 2.02)	
	ROEF	5.00 ± 5.47	3.16 ± 4.53	0.045*	1.84 (0.04, 3.65)	
L4/L5 (°)						
Dry needling	Sitting	-0.97 ± 3.32	-1.16 ± 3.91	0.741	0.19 (-0.96, 1.33)	2.00 (-0.06, 4.06)
	ROF	0.88 ± 3.50	0.94 ± 4.70	0.933	-0.06 (-1.56, 1.44)	-0.13 (-2.40, 2.15)
	ROEF	1.84 ± 3.59	2.13 ± 4.24	0.729	-0.28 (-1.92, 1.36)	-2.09 (-4.42, 0.23)
Cross-tape	Sitting	-2.16 ± 3.61	-3.16 ± 4.33	0.126	1.00 (-0.30, 2.30)	
	ROF	1.72 ± 4.95	1.06 ± 4.38	0.454	0.66 (-1.11, 2.42)	
	ROEF	4.00 ± 4.58	4.22 ± 5.02	0.818	-0.22 (-2.14, 1.71)	
L5/S1 (°)						
Dry needling	Sitting	-2.03 ± 3.72	-1.97 ± 4.04	0.904	-0.06 (-1.11, 0.99)	-1.28 (-3.38, 0.82)
	ROF	0.53 ± 3.04	0.94 ± 4.51	0.609	-0.41 (-2.01, 1.20)	-4.03 (-6.45, -1.62)
	ROEF	2.41 ± 3.66	3.00 ± 4.83	0.471	-0.59 (-2.25, 1.07)	-2.78 (-5.66, 0.10)
Cross-tape	Sitting	0.31 ± 5.06	-0.69 ± 4.35	0.440	1.00 (-1.61, 3.61)	
	ROF	3.69 ± 5.28	4.97 ± 5.13	0.110	-1.28 (-2.87, 0.31)	
	ROEF	3.44 ± 7.18	5.78 ± 6.56	0.159	-2.34 (-5.66, 0.97)	
Sacral Slope (°)						
Dry needling	Sitting	20.03 ± 8.62	30.47 ± 8.92	0.320	-10.44 (-4.34,1.46)	-5.03 (-9.59, -0.47)
	ROF	28.84 ± 14.38	37.34 ± 16.00	0.002*	-8.50 (-13.49,-3.51)	5.72 (-1.73, 13.17)
	ROEF	27.41 ± 15.42	31.53 ± 13.08	0.002*	-6.97 (-11.20,-2.74)	10.53 (3.20, 17.87)
Cross-tape	Sitting	27.53 ± 8.14	28.50 ± 9.32	0.427	-0.97 (-3.43, 1.49)	
	ROF	30.03 ± 15.61	31.63 ± 13.74	0.332	-1.59 (-4.89, 1.70)	
	ROEF	33.81 ± 19.89	33.38 ± 15.42	0.668	-0.88 (-5.00, 3.25)	
Segmental Amplitude Thoracic Spine (°)						
Dry needling	Sitting	31.19 ± 20.23	21.72 ± 18.42	0.001*	9.47 (4.44, 14.50)	-24.63 (-32.66,-16.59)
	ROF	66.34 ± 12.36	65.44 ± 14.39	0.690	0.91 (-3.68, 5.50)	-9.94 (-16.13, -3.74)
	ROEF	22.03 ± 19.96	31.16 ± 19.57	0.016*	-8.38 (-15.10,-1.65)	14.34 (7.20, 21.48)
Cross-tape	Sitting	46.47 ± 12.71	46.34 ± 13.35	0.918	0.13 (-2.33, 2.58)	
	ROF	76.63 ± 9.69	75.38 ± 10.02	0.497	1.25 (-2.46, 4.96)	
	ROEF	16.78 ± 13.43	20.75 ± 9.22	0.540	1.06 (-2.43, 4.56)	
Segmental Amplitude Lumbar Spine (°)						
Dry needling	Sitting	-3.59 ± 13.36	-5.13 ± 12.71	0.364	1.53 (-1.86, 4.92)	5.53 (-0.82, 11.88)
	ROF	15.81 ± 10.33	16.41 ± 11.52	0.601	-0.59 (-2.88, 1.70)	-0.28 (-5.80, 5.23)
	ROEF	47.81 ± 13.48	49.84 ± 12.25	0.258	-1.94 (-5.36, 1.49)	-5.88 (-12.03, 0.28)
Cross-tape	Sitting	-11.50 ± 11.00	-10.66 ± 12.72	0.573	-0.84 (-3.86, 2.18)	
	ROF	17.78 ± 11.24	16.69 ± 10.53	0.523	1.09 (-2.36, 4.55)	
	ROEF	49.00 ± 12.91	49.88 ± 10.48	0.329	2.19 (-2.31, 6.68)	
Segmental Amplitude Thoracic-Lumbar Spine (°)						
Dry needling	Sitting	11.34 ± 4.78	10.84 ± 4.75	0.424	0.50 (-0.76, 1.76)	0.25 (-1.74, 2.24)
	ROF	60.41 ± 14.07	69.41 ± 14.58	0.001*	-9.00 (-13.62,-4.38)	5.63 (-2.00, 13.25)
	ROEF	70.31 ± 19.29	77.34 ± 15.15	0.001*	-9.44 (-13.67,-5.21)	5.38 (-2.88, 13.63)
Cross-tape	Sitting	9.47 ± 3.59	10.59 ± 3.04	0.145	-1.13 (-2.66, 0.41)	
	ROF	63.44 ± 16.68	63.78 ± 15.92	0.846	-0.34 (-3.93, 3.24)	
	ROEF	80.31 ± 21.00	80.97 ± 18.01	0.727	0.66 (-3.15, 4.46)	

*$P < 0.05$. Values are expressed as means ± standard deviation for baseline and one month post-treatment and as mean score change (95% confidence interval) for within- and between-group values. Abbreviations: ROF (range of flexion), and ROEF (range of erect to flexion).

on cytoskeletal structures that causes relaxation of the sarcomers by reducing the amount of overlap between actin and myosin in the muscle with MTrPs (22,23). Our results are in agreement with Ga et al (24), who found that combining the dry needling of trigger points with paraspinal muscle dry needling was more effective in reducing pain than the dry needling of trigger points alone. Dry needling reduces the time and cost requirements in the treatment of MTrPs on the upper trapezius muscle because this technique has similar effects to traditional physical therapy (25). Fernandez-Carnero et al (26) found an increased pressure pain threshold in the masseter muscle of 12 women after the application of dry needling to active MTrPs. It has also been demonstrated that dry needling followed by active stretching is more effective than stretching alone in reducing both sensitivity of MTrPs to pressure and myofascial pain (27). However, research on dry needling in the thoracic region is very limited and there are no studies on patients with FMS. Only one study has combined dry needling and electrical stimulation to treat MTrPs on the thoracic multifidus and paraspinal muscles at the affected levels, with patients exhibiting a reduction in pain after 2 sessions (28).

Previous studies on the effectiveness of dry needling treatment for low back pain have shown mixed results. There is no data available on the clinical characteristics of individuals who may benefit from dry needling therapy (29). Possible associations between patients' histories, demographics, and physical outcome measures may influence the clinical benefits following dry needling therapy in patients with FMS. Koppenhaver et al (30) analyzed the association between 6 variables in patient demographics, histories, and physical examinations with improvement in self-reported disability one week after dry needling treatment and found a small variability in this model, which could be clinically insignificant for individuals with low back pain. In this study, low back pain increased during the multifidus lift test, demonstrating bivariate and multivariate associations with short-term improvement in self-reported disability following dry needling (30). In patients with FMS, we found significant differences between and within groups for MTrPs on multifidus muscles. These findings were consistent with the traditional understanding that active and latent trigger points treated with dry needling therapy cause local hypoalgesia (31,32). A reduction in pain intensity, the number of active MTrPs, and the pressure pain threshold (PPT) could be related to the fact that a greater number of active MTrPs was associated with higher pain intensity in patients with FMS, which suggests a possible segmental and central sensitization mechanism (23,31). However, other authors have established that differences between 20% and 25% are required to indicate a real change in the PPT (33). In our study only a small number of MTrPs were between these percentages.

Both therapies in our study reported an effect size ranging from negligible to small for spinal mobility measures in both groups. These results are in agreement with data obtained in patients with coxarthrosis in the sitting position. However, our results for the standing position were very small, although there were statistical differences post-treatment for the dry needling group in ROF and ROEF only (34). With respect to asymptomatic adults, our data were lower, considering that the normal range of value for the sacral slope is from -32° to -49° (35,36). Several studies using skin-surface devices have established normal values for sagittal curvature of the thoracic spine. Mannion et al (20) obtained an average of 45° for standing kyphosis of the thoracic spine. This result is similar to the one obtained in the cross tape group but is superior to that of the dry needling group. The average of 45° is in accordance with published radiographic measures, which are between 46° and 48° (37-39).

The mean value for the thoracic ROF was established as 30° (40). In our study, however, this was higher, although there are no statistically significant differences in either group. The range of movement (ROM) increased post-treatment with both therapeutic approaches. A good thoracic and lumbar ROM appears to be related to the maintenance of sagittal balance in middle-aged and elderly patients (41). In the sacral slope, the post-treatment values obtained in our study were lower than the data recorded with Isotrak or Fastrak in the study by Mannion et al (20), mainly in the ROF and ROEF. This may be related to the fact that data obtained with the skin surface device tend to show lower values for lumbar lordosis than those measured with x-rays as the curvature may be thicker layers of subcutaneous tissue overlying the lower spine and sacrum (20,39,40,42). Considering the short clinical time needed for measurement and the low health risk to the patient, it has been concluded that the Spinal Mouse could be used as a reliable objective tool for measuring sagittal spinal ROM (43).

We recognize that the current study has some

limitations. Firstly, we did not collect the outcomes over a long-term follow-up period. Secondly, we used dry needling therapy or cross tape alone when in reality physical therapists usually treat FMS patients with a multimodal approach. Thirdly, we did not include a control group that did not receive any treatment. Future studies should continue to examine the effectiveness of multimodal approaches for FMS patients, including dry needling therapy in combination with other accepted physical therapy interventions, such as manual therapy or exercises in management.

Conclusions

In conclusion, this study demonstrates that dry needling therapy reduces algometry of myofascial trigger points on thoracic and lumbar muscles in patients with fibromyalgia syndrome. Dry needling and cross tape approaches reported a similar effect size for spinal mobility measures, with the exception of the dry needling group in a sitting position, where dry needling showed a major improvement. Future trials should investigate the long-term effectiveness of these interventions in FMS patients.

Disclosures/Conflict of Interest

The authors declare no conflict of interest for this study.

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