Original Article

Comparison of Post-needling Soreness among Three Soreness Reduction Methods: Diclofenac spray with Contract-Relax Stretching, Cold Gel Pack with Self Stretching, and Spray and Stretch Technique in Patients after Upper Trapezius Dry Needling

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ABSTRACT

Objectives: To compare post-needling soreness among three different soreness reduction methods: diclofenac spray with contract-relax stretching, cold gel pack with self-stretching, and spray and stretch technique in patients after upper trapezius dry needling.

Study design: A randomized controlled trial.

Setting: Department of Rehabilitation Medicine, Phetchabun Hospital, Phetchabun Province, Thailand.

Subjects: One hundred and twenty-six participants who had a numeric rating scale (NRS) score of post-needling soreness intensity of 3 or more and who received dry needling as a treatment of myofascial pain syndrome at the upper trapezius.

Methods: Participants were allocated into three groups (42 patients per group) which received different soreness reduction methods: a cold gel pack combined with self-stretching (CP group), a diclofenac spray combined with contract-relax stretching (DCF group), and a spray and stretch technique (SS group). The primary outcome was the post-needling soreness numeric rating scale score. Secondary outcomes were muscle pain NRS and pain-free cervical range of motion (ROM).

Results: No statistically significant difference ($p > 0.05$) among the dependent variables, including post-needling soreness, muscle pain, and pain-free forward neck flexion, was observed among the 3 groups with the exception of pain-free lateral neck flexion which was greater in the DCF and SS group. Pairwise analyses demonstrated that the DCF and SS groups both had significantly greater post-needling soreness reduction immediately after the treatment when compared with the CP group (DCF = -1.9, SS = -1.5, CP = -0.7) and also 24 hours after dry needling (DCF = -2.6, SS = -2.1, CP = -1.3).

Conclusions: DCF spraying with contract-relax stretching can reduce post-dry needling soreness at the upper trapezius muscle at a level comparable to the spray and stretch technique. Both methods were superior to cold gel packs with self-stretching. In addition to the spray and stretch techniques, DCF spraying with contract-relax stretching might be the intervention of choice to effectively reduce post-dry needling soreness at the upper trapezius muscle.

Keywords: post-needling soreness, cold gel pack, spray and stretch technique, diclofenac spray, upper trapezius

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Introduction

The upper trapezius is one of the muscles most commonly affected by myofascial pain syndrome (MPS).[1] MPS at the upper trapezius presents in 93.75% of chronic neck pain patients.[2] Patients mainly present with pain and fatigue at the trapezius region, in some cases also radiating to the neck, occiput, mandible, temporal region, and forehead.[3] Some also report headache, neck pain, dizziness, vertigo, and difficulty in neck and shoulder movement.[4] During physical examination, a trigger point at the upper trapezius muscle is palpated, which potentially reproduces radiating pain to the neck and temporal region.[3] Limitation of the use of the neck and shoulder which affects their job, socialization, and quality of life is usually observed.[5]

One of the most effective and widely used treatments for MPS at the upper trapezius is dry needling, in which a thin solid needle is inserted into a muscle trigger point[5,6] to decrease muscle tightness, increase blood flow and reduce pain. Patients often report immediate relief after dry needling treatment. It has been shown that dry needling has a level of efficacy in alleviating musculoskeletal pain similar to lidocaine injection[7] but without the risk of allergic reactions, muscle infarction,[3] skin depigmentation, tendon atrophy, and serious side effects such as fainting, palpitations, and apnea associated with lidocaine injection.[8] Thus, dry needling is a safer alternative treatment for myofascial pain syndrome.[9]

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Dry needling has, however, been associated with post-needling soreness.[10] Patients may feel continuous dull aching pain only at the dry needling site, which can be distinguished from the tight feeling of muscle pain from pre-existing MPS.[7] In a study by Hong et al., patients who were treated with dry needling reported post-needling soreness which was significantly more severe and had a longer duration than that reported by patients who were treated with lidocaine injection.[7] The duration of the soreness varies from a few hours to 2-3 days.[11] A consequence of this unpleasant adverse effect is that it can make patients feel discomfort and fear, resulting in their eventually refusing to undergo dry needling at subsequent visits or fail to appear for follow-up.[10] Literature reviews have suggested that post-needling soreness is related to hemorrhage caused by tissue damage at the needled site.[1,7] It also stimulates the inflammatory processes, resulting in increased swelling and soreness.[12] Thus it is often necessary to apply an additional technique simultaneously with dry needling to reduce post-needling soreness.

Several techniques are currently used to reduce post-dry needling soreness. Applying cold packs is the oldest and simplest therapy for treating acute soft tissue injuries.[13] It is safe and has a low cost. Physiological effects of cryotherapy include vasoconstricting, decreasing local metabolism and blood flow, reducing nerve excitability, increasing the pain threshold, and reducing muscle contraction, resulting in a reduction in swelling, pain, and inflammation of acutely injured tissues.[14] Although one previous study reported that cryotherapy alone has no significant effect on reducing post-dry needling soreness,[15] applying a cold gel pack for 10 minutes after dry needling is still a conventional method for reducing post-needling soreness. In Phetchabun Hospital, the cold gel pack is followed by five sets of self-stretching for 10 seconds for reducing pain and increasing range of motion.[16] The spray and stretch technique is another safe intervention and has demonstrated a short-term (< 6 hours) effect of post-needling soreness reduction at the latent myofascial trigger points.[11] Vapocoolant spray, abruptly decreases skin temperature and induces transient anesthesia by blocking the spinal stretch reflex and pain sensation. This anesthetic effect allows the physician to passively stretch the affected muscles toward their normal length. Passively stretching the affected muscles also helps to decrease myofascial trigger point sensitivity and the intensity of referred pain.[17]

At present, diclofenac (DCF) spray is increasingly used to treat pain and other symptoms such as inflammation, swelling, and stiffness. Previous evidence has demonstrated that DCF spray can reduce pain and inflammation in the acute phase of injury.[18] Since the mechanism of post-needling soreness is related to tissue inflammation, it is reasonable to hypothesize that DCF spray could be used to reduce post-needling soreness. Using it is considered to be safe if the patient has no history of allergy to DCF. If it is available, it can be used in place of vapocoolant spray which is not available in Phetchabun Hospital. However, there have been no studies demonstrating the efficacy of DCF spray in reducing post-needling soreness. A previous study demonstrated that concentric and eccentric exercises immediately improve post-needling soreness and raise the pain pressure threshold,[19] suggesting the interesting option of combining contract-relax stretching with DCF spray to further increase the efficacy of reduction of post-needling soreness. In our pilot study, DCF spray was applied once in the target region, followed by sets of contract-relax stretching of 10 seconds each, with the protocol repeated five times. Following this treatment, patients reported feeling more comfortable and less sore after dry needling. The present study was conducted to determine whether a combination of DCF spray with contract-relax stretching (the DCF group) has a better effect on post-needling soreness than either the spray and stretch technique (the SS group) or cold gel pack combined with self-stretching (the CP group) in patients who had undergone upper trapezius dry needling.

Methods

This randomized controlled trial was approved by the Institutional Ethic Committee of Phetchabun Hospital (Approval number 06/2565). Patients diagnosed with acute, subacute, or chronic cases of MPS at an upper trapezius muscle based on the Travel and Simon's clinical criteria[3] who visited the Rehabilitation Outpatient Clinic at Phetchabun Hospital between January and September 2022 and were treated by dry needling were invited to join the study.

The sample size was estimated using G*power software version 5.1. Repeated measures and within-between interaction analysis of variance (ANOVA) were used and an effect size of 0.25, power of 0.9, and α value of 0.05 were selected. The estimated necessary sample size was 39 participants plus an estimated 20% loss in follow-up, yielding 42 participants per group, a total of 126 subjects. Simple randomization was used to allocate the participants into one of three groups: 1) the CP group received the cold gel pack combined with self-stretching, 2) the DCF group received the DCF spray combined with contract-relax stretching and 3) the SS group received the spray and stretch technique.

After giving their informed consent, patients were recruited into the study. The inclusion criteria consisted of age between 18-65 years and a soreness intensity score on a numeric rating scale (NRS) of at least 3. Patients with any of the following were excluded from the study: coagulopathy, thrombocytopenia, receiving antiplatelet/anticoagulant, a history of trigger point dry needling/injection in the upper trapezius during the previous seven days, fibromyalgia, cervical disc herniation, cervical stenosis, cervical radiculopathy or radicular pain, cervical myelopathy, a history of neck surgery or trauma during the previous six months, numbness at the upper trapezius region, poor perception or communication, having contraindications for cryotherapy[20,21] or DCF spray.[22] The schematic flow diagram of the study is shown in Figure 1.

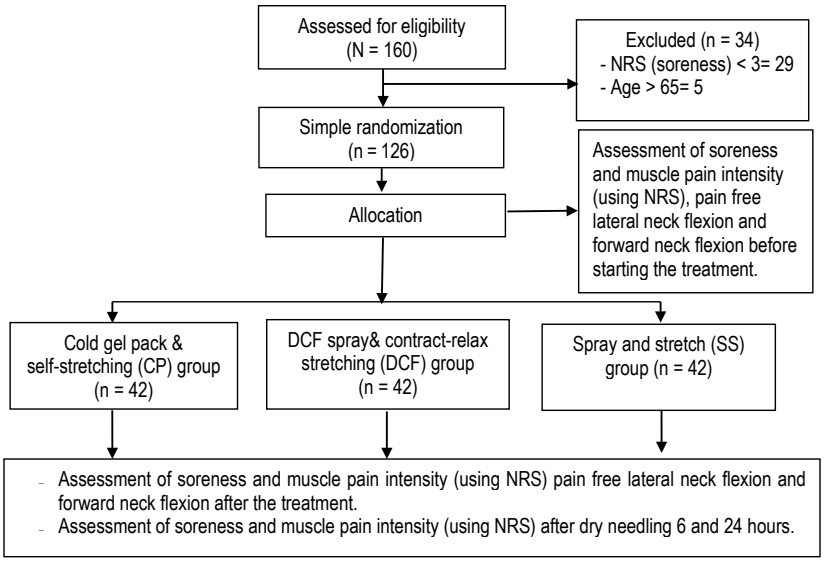


Figure 1. Schematic flow diagram of the study

Procedure

A blinded assessor, a well-trained nurse, interviewed participants regarding their demographic data, including gender, age, BMI, and affected side. The participants were then asked to record their level of post-needling soreness and muscle pain intensity using a numeric rating scale (NRS) where 0 means no pain and 10 means the most severe pain. Next, the participants related the characteristics of the soreness before needling describing it as constant pressure or dull aching as distinguished from a sharp and tight aching experience.[7] The blinded assessor then measured the pain-free active lateral neck flexion and forward neck flexion angles.

Dry needling (fanning technique) using an acupuncture needle at the upper trapezius was performed in all patients by a physiatrist with 11 years of experience. The needle size was selected depending on the trigger point depth and toughness. The number of needles used with each patient depended on the number of palpated active trigger points and patient tolerance. The number of needle insertions in each needling depended on patient responses during needling (e.g., no response, dull sensation, sharp sensation, radiating pain, muscle twitching), level of patient tolerance, and the physiatrist's judgment. Typically, the physiatrist continued needling until muscle responses were observed or until the patient's level of tolerance was reached even if there were no muscle responses, after which needling was stopped. The needling procedure was normally ended within 10 minutes in each case. After the completion of the dry needling, patients who reported a soreness intensity of over 3 were randomly allocated into one of 3 groups by the researcher. Only the researcher had access to the allocation schedule. Due to the nature of the subsequent interventions, patients and treatment providers were not blinded to the treatment allocation.

Subjects in the CP group received a cold gel pack covered with a damp towel[23] for 10 minutes.[24] After that, the patients were advised to perform self-static stretching of the upper trapezius muscle by sitting in the upright position, pulling the chin in and depressing the affected shoulder, then rotating the neck to the opposite side and flexing the neck using the opposite hand to stretch the neck to the point of first feeling tightness[25] and holding in this position for 10 seconds. This protocol was repeated for five times.

Subjects in the DCF group received a spray of 1% diclofenac sodium at the upper trapezius region which was alternated with contract-relax stretching performed by a physiatrist. Patients were sitting in an upright position as in the CP group. The physiatrist instructed the patients to turn their head to one side and bend downwards to stretch the upper trapezius muscle for 10 seconds, then to repeat the exercise turning their head to the opposite side. The physiatrist then asked the patients to contract the upper trapezius muscle exerting approximately 60% resistance and to hold that position for 10 seconds.[26] This protocol was repeated five times.

Subjects in the SS group received vapocoolant spray (Perskindol® cool spray) applied by a physiatrist. Patients were sitting in an upright position as in the CP group. The physiatrist swept the spray parallel to the upper trapezius muscle at a 30º angle from a distance of about 12 inches, moving from shoulder to neck three times. This was alternated with static stretching of the upper trapezius to the end of the range of motion by the physiatrist for 10 seconds.[27] This protocol was repeated five times.

Outcome measures

The primary outcome was subjective soreness intensity measured on a numeric rating scale (NRS) where 0 means no pain and 10 means the most severe pain. The assessor asked the participants to rate the soreness intensity within 2 minutes after the treatment and to use a pain diary to record the intensity at 6 and 24 hours after the dry needling.

The secondary outcomes were subjective muscle pain intensity and pain-free cervical range of motion with lateral

neck flexion and forward neck flexion. Similar to the soreness intensity scoring system, the muscle pain intensity was determined using NRS immediately after the treatments. A pain diary was used to record the muscle pain intensity at 6 and 24 hours after the dry needling. Pain-free lateral neck flexion and forward neck flexion were measured using a standard goniometer immediately after the treatment.

Statistical analysis

SPSS statistical software system version 16.0 (SPSS Inc. Released 2007. SPSS for Windows, Version 16.0, SPSS Inc., Chicago, IL, USA,) was used for all statistical analyses. A 95% confidence interval was employed, and values with a *p*-value < 0.05 were considered statistically significant. The demographic data of the participants in all three groups were analyzed. Baseline quantitative data were described using means and standard deviations and were compared across the groups using one-way ANOVA. Baseline categorical variables were described using frequencies and percentages and compared across the groups using the Chi-square test. Two-way repeated-measures ANOVA was performed to demonstrate the effect of an intervention interacting with a within-subject factor (time of an assessment). The partial eta squared was used as a measure of effect size (d) for each main effect and interaction in the ANOVAs, and post hoc analysis with Bonferroni correction was used in the case of statistically significant ANOVA findings for multiple comparisons between variables.

Results

Subjects' demographic and clinical data

A total of 160 patients were initially screened, of whom 126 were enrolled. The 126 participants were allocated into three groups (Figure 1). All participants were analyzed according to the group they were initially assigned, complying with an intention to treat analysis. Most participants were female (79.4%) with a mean age of 48 years, a mean body mass index (BMI) of 24 kg/m^2, an initial soreness intensity of 4.5, an initial muscle pain intensity of 3.9, and an initial lateral neck flexion of 32 degrees and initial forward neck flexion of 41 degrees. The most frequently affected side was the right (57.1%). Baseline demographic and clinical characteristics as of the beginning of the study are summarized in Table 1. There were statistically significant differences in age (p = 0.039), BMI (p = 0.016), and gender (p = 0.045) among the groups but no statistically significant difference in the outcome parameters across the groups (p > 0.05).

Primary outcomes

Post-needling soreness intensity

Using two-way repeated-measures ANOVA, there was statistically significant group-time interaction for post-needling soreness intensity (F = 2.80, p = 0.020, d = 0.044), indicating a difference in the trend of changes in post-needling soreness over times among the CP, DCF, and SS groups (Table 2). All three interventions statistically significantly reduced post-

Table 1. Comparison of demographic and clinical data of participants between the three groups (n=126)

Demographic and clinical data	Intervention group			*p*-value between groups
	CP (n=42)	DCF (n=42)	SS (n=42)	
Age (years)[1]	50.2 (11.9)	44.4 (11.3)	49.9 (11.8)	0.039[a]
BMI (kg/m^2)[1]	24.2 (3.2)	22.9 (3.3)	24.8 (3.0)	0.016[a]
Gender (male)[2]	6 (14.3)	14 (33.3)	6 (14.3)	0.045[b]
Affected side (right)[2]	24 (57.1)	25 (59.5)	23 (54.8)	0.907[b]
Muscle pain intensity after dry needling(score)[1]	3.9 (1.4)	3.8 (1.8)	4.0 (1.8)	0.927[a]
Post-needling soreness intensity (score)[1]	4.2 (1.5)	4.7 (1.6)	4.7 (2.0)	0.377[a]
Lateral neck flexion after dry needling (degrees)[1]	33.1 (6.5)	32.1 (7.1)	31.6 (6.2)	0.575[a]
Forward neck flexion after dry needling (degrees)[1]	42.9 (4.9)	40.4 (7.9)	41.2 (9.9)	0.346[a]

[1]Mean (SD), [2]number (%); [a]One-way ANOVA, [b]Chi-square

BMI, body mass index; CP, cold gel pack & self-stretching; DCF, diclofenac spray & contract-relax stretching; SS, spray & stretching

Table 2. Primary and secondary outcomes analysis between the three groups with two way repeated-measures ANOVA

Outcomes	Time			Between group			Time x group		
	F (3, 369)	p-value	d	F (2, 123)	p-value	d	F (6, 369)	p-value	d
Primary outcome									
Soreness intensity score	75.94	< 0.001	0.382	0.63	0.532	0.010	2.80	0.020*	0.044
Secondary outcomes									
Muscle pain intensity score	54.12	< 0.001	0.306	0.55	0.577	0.009	1.02	0.403	0.016
Pain-free lateral neck flexion (degrees)	122.49	< 0.001	0.499	0.72	0.491	0.011	18.56	< 0.001	0.232
Pain-free forward neck flexion (degrees)	57.40	< 0.001	0.318	0.24	0.786	0.004	10.23	< 0.001	0.143

CP, cold gel pack & self-stretching; DCF, diclofenac spray & contract-relax stretching; SS, spray & stretch

Between-group analysis used Two-way ANOVA, *statistically significant p < 0.05

needling soreness over time: CP (F = 16.74, $p < 0.001$, d = 0.29), DCF (F = 31.68, $p < 0.001$, d = 0.44), and SS (F = 28.45, $p < 0.001$, d = 0.41). Pairwise analyses demonstrated that the DCF and the SS groups had statistically significantly more post-needling soreness reduction when compared with the CP group immediately after treatment (DCF = -1.9, SS = -1.5, CP = -0.7) as well as at 24 hours after dry needling (DCF = -2.6, SS = -2.1, CP = -1.3).

Regarding effect size, i.e., the post-needling soreness reduction between groups, the DCF group showed the highest magnitude of soreness reduction (d = 0.44), followed by the SS group (d = 0.41) and the CP group (d = 0.29). The highest magnitude of soreness reduction was observed 24 hours after dry needling in all 3 groups. However, there were no statistically significant between-group differences at any of the time points ($p > 0.05$). Data on post-needling soreness is presented in Table 3 and Figure 2 (A).

Secondary outcomes

Muscle pain intensity and reduction of muscle pain intensity

Using two-way repeated-measures ANOVA, there was no statistically significant group-time interaction for muscle pain intensity, indicating that there was no difference in the trend of changes in muscle pain intensity over time among the CP, DCF, and SS groups (Table 2). When the muscle pain intensity among the three groups was compared, there was no statistically significant between-group differences at any of the time points ($p > 0.05$). However, all 3 groups had a statistically significant reduction in post-needling muscle pain intensity over time, including CP (F = 18.28, $p < 0.001$, d = 0.38), DCF (F = 20.36, $p < 0.001$, d=0.33), and SS (F=17.63, $p < 0.001$, d = 0.31). Additionally, the magnitude of within-group post-needling muscle pain intensity reduction was not different among the three groups (d < 0.38) (Table 4 and Figure 2 (B).

Table 3. Comparison of differences in soreness intensity within groups and between-groups

Outcomes	Intervention group mean (SD)			Within group differences (95% CI)			Between group differences (95% CI)	*p*-value between groups
	CP	DCF	SS	CP	DCF	SS		
Soreness intensity score								
Immediately after dry needling	4.2 (1.5)	4.7 (1.6)	4.7 (2.0)	-	-	-	-0.5 (-1.4, 0.5) p=0.240[1] -0.5 (-1.4, 0.4) *p*=0.216[2] -0.0 (-0.9, 0.9) *p*=0.949[3]	F (2, 123) =0.983 *p*=0.377 d=0.016
Immediately after the programs	3.5 (1.7)	2.8 (1.9)	3.2 (2.0)	-0.7 (-1.1, -0.2) *p*<0.001[a]	-1.9 (-2.4, -1.5) *p*<0.001[a]	-1.5 (-1.8, -1.2) *p*<0.001[a]	0.7 (-0.3, 1.7) *p*=0.072[1] 0.3 (-0.6, 1.3) *p*=0.397[2] -0.4 (-1.4, 0.6) *p*=0.335 3	F (0.12, 123) =1.653 *p*=0.196 d=0.026
6 hours after dry needling	4.0 (1.3) 2.9 (1.6)	3.8 (1.9) 2.1 (1.9)	4.3 (1.9) 2.6 (2.0)	-0.2 (-0.4, 0.3) *p*=0.330[b]	-0.9 (-1.3, -0.3) *p*<0.001[b]	-0.4 (-1.0, 0.1) *p*=0.096[b]	0.2 (-0.8, 1.1) *p*=0.709[1] 0.3 (-1.2, 0.6) *p*=0.456[2] -0.5 (-1.4, 0.5) *p*=0.264[3]	F (2, 123) =0.653 *p*=0.522 d=0.011
24 hours after dry needling				-1.3 (-1.9, -0.8) *p*<0.001c	-2.6 (-3.1, -2.0) *p*<0.001[c]	-2.1 (-2.7, -1.6) *p*<0.001[c]	0.9 (-0.2, 1.7) *p*=0.060[1] 0.93 (-0.7, 1.3) *p*=0.478[2] -0.5 (-1.5, 0.5) *p*=0.238[3]	F (2, 123) =1.835 *p*=0.164 d=0.09
		p-value within group		F=16.74, *p*<0.001, d=0.29	F=31.68, *p*<0.001, d=0.44	F=28.45, *p*<0.001, d=0.41		

[a]Immediately after the programs - immediately after dry needling, [b]6 hours after dry needling - immediately after dry needling, [c]After dry needling 24 hours - immediately after dry needling

[1]CP-DCF, [2]CP-SS, [3]DCF-SS

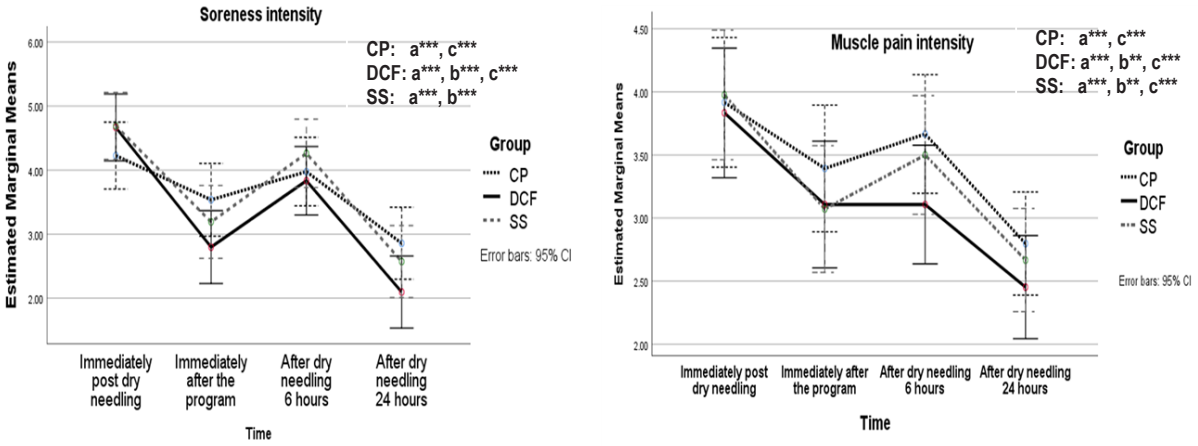


Figure 2. Post-needling soreness (A) and muscle pain intensity (B) in three groups, CP, DCF, and SS, in different times periods; immediately after dry needling; immediately after the programs, after dry needling 6 and 24 hours
a, Immediately after the programs – Immediately after dry needling; b, After dry needling 6 hours – Immediately after dry needling; c, After dry needling 24 hours – Immediately after dry needling, **significance level $p < 0.01$, *** $p < 0.001$

Table 4. Comparison of within group and between-group differences in muscle pain intensity

Outcomes	Intervention group Mean (SD)			Within group differences (95% CI)			Between group differences (95% CI)	*p*-value between groups
	CP	DCF	SS	CP	DCF	SS		
Muscle pain intensity score[1]								
Immediately after dry needling	3.9 (1.4)	3.8 (1.8)	4.0 (1.8)	-	-	-	0.1(-0.8, 1.0) p=0.821 1 -0.1(-1.0, 0.8) p=0.871 2 -0.2(-1.0, 0.8) p=0.698 3	F (2, 123) =0.076 p=0.927 d=0.001
Immediately after the programs	3.4 (1.4)	3.1 (1.7)	3.1 (1.8)	-0.5 (-0.8, -0.2) *p*<0.001[a]	-0.7 (-1.0, -0.4) *p*<0.001[a]	-0.9 (-1.4, -0.4) *p*<0.001[a]	0.3(-0.6, 1.2) *p*=0.427 1 0.3(-0.6, 1.2) *p*=0.372 2 0.0 (-0.9, 0.5) *p*=0.921 3	F (2, 123) =0.482 *p*=0.618 d=0.008
6 hours after dry needling	3.7 (1.5)	3.1 (1.4)	3.5 (1.7)	-0.2 (-0.7, 0.2) *p*=0.843[b]	-0.7 (-1.3, -1.9) *p*=0.003**[b]	-0.5 (-0.9, -0.1) *p*=0.005**[b]	0.6(-0.3, 1.4) *p*=0 .098 1 0.2(-0.7, 0.9) *p*=0.621 2 -0.4 (-1.3, 0.4) *p*=0.245 3	F (2, 123) =1.462 *p*=0.236 d=0.023
24 hours after dry needling	2.8 (1.2)	2.5 (1.3)	2.7 (1.5)	-1.1 (-1.6, 0.6) *p*<0.001[c]	-1.3 (-1.9, -0.8) *p*<0.001 c	-1.3 (-1.8, -0.8) *p*<0.001[c]	0.3(-0.4, 1.1) *p*=0.239 1 0.1(-0.6, 0.8) *p*=0.655 2 -0.2(-0.9, 0.5) *p*=0.464 3	F (2, 123) =0.712 *p*=0.492 d=0.011
	p-value within group			F=18.28, *p*<0.001, d=0.38	F=20.36, *p*<0.001, d=0.33	F=17.63, *p*<0.001, d=0.31		

[a]Immediately after the programs - immediately after dry needling, [b]After dry needling 6 hours - immediately after dry needling, [c]After dry needling 24 hours - immediately after dry needling
[1]CP-DCF, [2]CP-SS, [3]DCF-SS **significance level $p < 0.01$

In the between-group comparisons using one-way ANOVA, there were no statistically significant differences in muscle pain intensity between groups ($p > 0.05$) at the beginning of the study, immediately after the treatments, or after 6 and 24 hours of dry needling. Regarding the reduction of muscle pain intensity, there were no statistically significant differences

Table 5. Comparison of cervical range of motion within groups and between-groups

Outcomes	Intervention group Mean (SD)			Within group differences (95% CI)			Between group differences (95% CI)	p-value between groups
	CP	DCF	SS	CP	DCF	SS		
Pain-free lateral neck flexion (degrees)								
Immediately after dry needling	33.1 (6.5)	32.1 (7.1)	31.6 (6.2)	-	-	-	1.0(-2.5, 4.5) p=0.510[1] 1.5(-1.9, 4.5) p=0.300[2] 0.5(-2.9, 4.0) p=0.704[3]	F (2, 123) = 0.555 p=0.575 d=0.009
Immediately after the programs	34.0 (6.6)	38.1 (5.5)	37.3 (5.9)	0.9 (0.4, 1.4) p<0.001	6.0 (4.1, 7.7) p<0.001	5.7 (4.4, 6.9) p<0.001	-4.1(-7.2, -0.9) p=0.002**[1] -3.3(-6.4, -0.1) p=0.015*[2] 0.8(-2.4, 3.9) p=0.538[3]	F (2, 123) =5.340 p=0.006** d=0.080
	p-value within groups			F=13.65, p<0.001, d=0.25	F=44.54, p<0.001, d=0.52	F=74.99, p<0.001 d=0.65		
Pain-free forward neck flexion (degrees)								
Immediately after dry needling	42.9 (4.9)	40.4 (7.9)	41.2 (9.9)	-	-	-	2.5(-1.7, 6.6) p=0.156[1] 1.7 (-2.5, 5.9) p=0.327[2] 0.8 (-4.9, 3.4) p=0.658[3]	F (2, 123) =1.069 p=0.346 d=0.017
Immediately after the programs	43.2 (5.0)	43.4 (7.2)	43.6 (8.4)	0.3 (-0.7, -0.0) p=0.042	3.0 (1.0, 4.1) p<0.001	2.4 (1.4, 3.6) p<0.001	-0.2(-3.9, 3.5) p=0.877[1] -0.4 (-4.2, 3.3) p=0.768[2] -0.2(-3.9, 3.5) p=0.889[3]	F (2, 123) =0.044 p=0.957 d=0.001
	p-value within groups			F=4.42, p=0.042*, d=0.10	F=35.23, p<0.001, d=0.46	F=19.90, p<0.001, d=0.37		

[1]CP-DCF, [2]CP-SS, [3]DCF-SS *statistical significance level p < 0.05, **p < 0.01

between groups (p > 0.05) throughout the study period. Muscle pain intensity and the reduction of muscle pain intensity are presented in Table 4.

Pain-free cervical range of motion

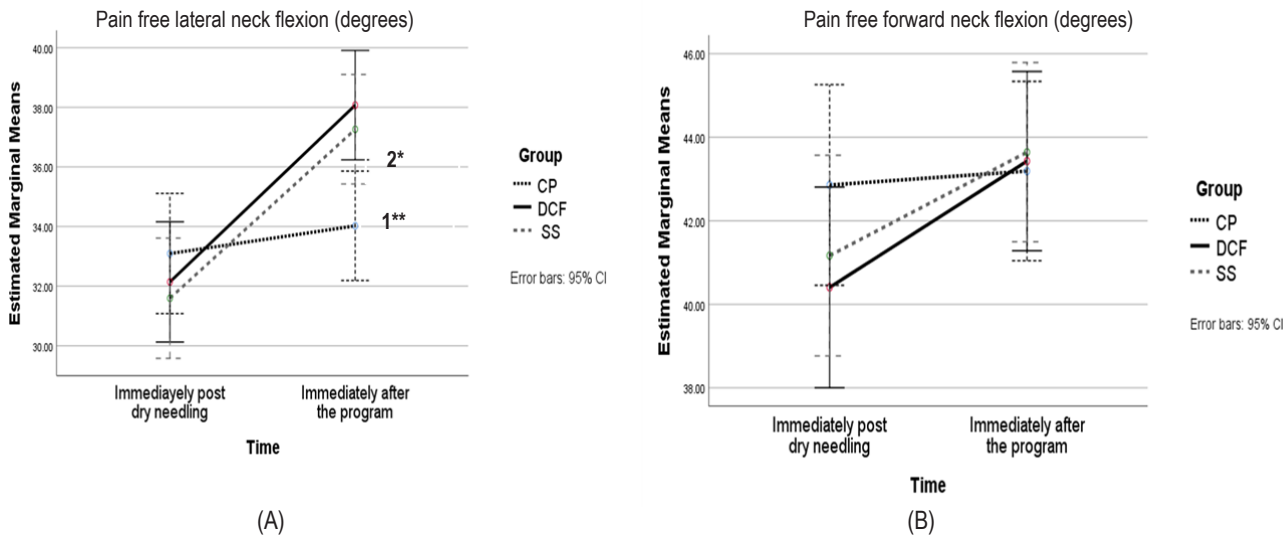
Using two-way repeated-measures ANOVA, there were statistically significant differences in group-time interaction for pain-free lateral neck flexion (F = 18.56, p < 0.001, d = 0.232) and pain-free forward neck flexion (F = 10.23, p < 0.001, d = 0.143), indicating that there was a difference in the trend of the change in pain-free cervical range of motion over time among the CP, DCF, and SS groups (Table 2). In addition, pairwise analyses demonstrated that the DCF and SS groups had a significantly greater increase in pain-free lateral neck flexion cervical range of motion both in increased pain-free lateral neck flexion (DCF = 6.0, SS = 5.7, CP = 0.9) and forward neck flexion (DCF = 3.0, SS = 2.4, CP = 0.3) immediately after the treatment programs.

Regarding the comparative findings for cervical range of motion (ROM) outcomes among three groups, there were statistically significant differences between groups immediately after the treatment programs (F = 5.340 p = 0.006, d = 0.080), but not in pain-free forward neck flexion (p > 0.05). The DCF and SS group had statistically significantly greater increased pain-free lateral neck flexion than the CP group (CP-DCF = -4.1 (95% CI -7.2, -0.9), p = 0.002) (CP-SS = -3.3(95% CI -6.4, -0.1), p = 0.015) but there was no statistically significant difference between the DCF and SS groups (p > 0.05). A large within-group effect size (d > 0.5) was observed in the DCF and SS groups. Data on pain-free cervical range of motion is presented in Table 5 and Figure 3.

Discussion

Baseline characteristics

Although there were statistically significant differences in age, BMI, and gender among the groups, previous evidence



(A) (B)

Figure 3. Pain-free lateral neck flexion (A) and pain-free forward neck flexion (B) in three groups, CP,

DCF and SS in different times periods: immediately after dry needling, immediately after the programs, 6 and 24 hours after dry needling, [1]CP-DCF, [2]CP-SS, *statistically significant $p < 0.05$, **$p < 0.01$

has demonstrated that age, gender, and BMI do not affect post-needling soreness.[28] Therefore, the differences in baseline characteristics were not considered a confounding factor in comparing the baseline post-needling soreness among groups and the data could be analyzed without adjusting for the differences in baseline characteristics.

Post-needling soreness intensity

There was no statistically significant difference in post-needling soreness intensity among the three groups. However, there were statistically significant differences in the reduction of post-needling soreness intensity among the groups. The results show that the DCF and SS groups had significantly greater post-needling soreness reduction over time, particularly at 24 hours post-intervention, compared to the CP group. These differences might be the result of differences in the effect of the different pathophysiologic mechanisms of each of the three intervention techniques.

The mechanism of DCF which has been shown to decrease pain and inflammation after tissue injury,[29] potentially could also reduce post-needling soreness. Another recent study found that applying proprioceptive neuromuscular facilitation (PNF) stretching can effectively reduce pain in patients with chronic low back pain.[30] When combined with contract-relax stretching, one of the PNF techniques with DCF spray produces greater post-needling soreness reduction. The mechanism of pain reduction of contract-relax stretching was presented via gate control theory, in which Golgi tendon organs (GTOs) are activated to reduce injury. PNF stretching decreases nociception or pain by producing an inhibition caused by an activation of the GTOs.[31]

In the SS group, vapocoolant spray provided transient anesthesia by inducing skin cooling from evaporation, thus suppressing pain receptor sensitivity and decreasing pain perception. Cold sensations transmitted via A-delta cold-specific nerve fibers also induce central gating of pain sensation transmitted via C fibers,[32] effectively reducing post-needling soreness. Additionally, stretching exercises can reduce pain by generating a biomechanical and sensory signal, resulting in an analgesic effect explained by the gate control theory.[33] A previous study has shown that the combination of acupuncture and stretching improves cervical movement and reduces trigger point pain in the short-term,[34] and a recent study reported that a single application of the spray and stretch technique had an immediate effect on reducing post-needling soreness after deep dry needling in a latent myofascial trigger points (MTrP) in an upper trapezius muscle.[11]

In the CP group, a cold gel pack increased the pain threshold and decreased the pain sensation by reducing nerve conduction velocity.[15] Stretching exercises have also been shown to reduce pain sensation via biomechanical and neurophysiological mechanisms.[33] Previous evidence has demonstrated that self-stretching can increase the pain pressure threshold immediately after exercise.[35] Therefore, a combination of a cold gel pack and self-stretching could be expected to produce greater soreness reduction, contrary to the results of a previous study which reported that a cold gel pack alone had no significant effect on reducing post-dry needling soreness.[15]

Compared to the SS group, vapocoolant spray caused a greater reduction in skin temperature than ice massage.[36] That is, the cold gel pack in the CP group had less effect on pain reduction than the vapocoolant spray in the SS group. Compared to the DCF group, DCF spray has a rapid onset of absorption, leading to a measurable plasma level of 1 ng/ml in as little as 30 minutes.[37] In contrast, cold gel packs have very short-term and only small continuous effects after removal.[32] Regarding the stretching technique, contract-relax stretching used in the DCF group was more effective in decreasing pain in upper trapezius myofascial trigger points than the self-static stretching technique[16] used in the CP group. That is, post-needling soreness in the DCF group was reduce better than in the CP group.

A literature review found the spray and stretch technique has a short-term (< 6 hours) effect on reducing post-needling soreness.[11] DCF spray was recommended to be used at 4 hour intervals but not more than 4 times a day.[38] A cold gel pack was recommended to be applied for 10 minutes once an hour for the first 72 hours after injury.[39] The upshot is that 6 hours after the dry needling timepoint, there was no significant difference in soreness intensity among the three groups.

Muscle pain intensity

This study showed that muscle pain intensity was not different between the three groups which may be due to the same factors as post-needling soreness and the fact that all groups had a statistically significant reduction in muscle pain intensity. In the DCF group, DCF spray was effective in musculoskeletal pain, and contract-relax stretching was also effective for pain reduction in MPS,[16] indicating that this method can be used in treating MPS in addition to the spray and stretch technique[15] to effectively increase the pain threshold and decrease pain intensity associated with an upper trapezius trigger point among patients.[40] This effect is similar to cold therapy in that it delays nerve conduction and raises the pain threshold. This modality enables muscles to decrease their contractility and to reduce tension in the trigger point.[15] Stretching exercises are also essential to any pain management regime.[15] These three soreness reduction methods can be used as an additional method following dry needling for treating myofascial pain trigger points.

Pain-free cervical range of motion

This study showed that the DCF group and the SS group both had greater improvement in pain-free lateral neck flexion than the CP group immediately after treatment.

A previous study demonstrated that DCF sprays effectively improve ROM after tissue injury.[29] PNF stretching has been shown to improve hip range of motion in patients with chronic low back pain.[30] Another study suggested that a combination of four theoretical mechanisms of PNF, including autogenic inhibition, reciprocal inhibition, stress relaxation, and the gate control theory, are responsible for improving the range of motion.[31] Combining these two methods produces more increase in pain-free cervical ROM.

As in the SS group, the spray and stretch technique abruptly decreases skin temperature at the target area, resulting in temporary anesthesia by blocking the spinal stretch reflex and pain sensation. The physician can then passively stretch the contracted muscles toward their normal length,[16] increasing cervical ROM. Similarly, another study showed an increase in cervical lateral flexion range after spray and stretch treatment on upper trapezius myofascial trigger points.[41]

In the CP group, it had minimal effect on increasing pain-free cervical ROM although cold gel packs can increase the pain threshold.[15] Self-stretching might also effectively increase cervical ROM.[36] However, since patients performed static stretching themselves, the effectiveness of each individual might need to be further investigated.

In comparing the DCF group and the CP group, although there was no statistically significant reduction of post-needling soreness intensity, contract-relax stretching was more effective in decreasing pain than the self-static stretching technique.[16] Contract-relax stretching in the DCF group might have produced more effective stretching, leading to a more significant increase in cervical ROM. Similarly, when comparing the SS group to the CP group, the vapocoolant spray in the SS group caused a more significant reduction in skin temperature than ice massage.[36] Moreover, stretching by a physiatrist in the SS group might have been more effective than the self-stretching in the CP group. The effectiveness of vapocoolant spray combined with stretching by a physiatrist might produce a more significant increase in cervical ROM than applying a cold gel pack and self-stretching. Cervical ROM in both the DCF and SS groups improved more than in the CP group.

Comparison of the DCF group and the SS group found no significant difference in the improvement of the pain-free cervical range of motion in either lateral neck flexion or forward neck flexion. This may be due to the similar effect on post-needling soreness of the methods used with the DCF and SS groups and that in both groups the stretching techniques were performed by a physiatrist.

Clinical application

Regarding the minimal clinically significant change in patient pain severity, a 2.0 NRS score,[42] there was no clinically significant difference between the three groups in post-needling soreness or muscle pain intensity. However, there was a clinically significant difference in post-needling soreness in the DCF and SS groups after 24 hours after dry needling compared to baseline. The minimum clinically significant difference in cervical ROM is forward neck flexion of more than 2 degrees and lateral neck flexion of more than 3 degrees.[43] Thus, there was a clinically significant difference in pain-free lateral neck flexion in the DCF group and the SS group but not in the CP group. There was also a clinically significant difference in pain-free lateral neck flexion and forward neck flexion in the DCF and SS groups immediately after treatment when compared to baseline. Thus, all three methods are recommended for post-needling soreness reduction. In patients with high soreness intensity and greater cervical ROM restriction, however, the DCF and SS methods would be more suitable choices.

Cold gel packs with self-stretching is recommended for patients who do not have contraindications for cryotherapy and who do not have a high BMI as cold gel packs cannot change the temperature of tissue that is deeper than 2 cm from the skin.[44] In addition, it takes at least 10 minutes for a cold gel pack to induce an analgesic effect. A cold gel pack should be applied in combination with effective self-stretching. Although the cost of the cold gel pack is similar to the DCF spray and Perskindol cool spray, it can be reused many times,

making it potentially more cost-effective. Use of a cold gel pack with self-stretching is recommended as a primary soreness reduction method for patients with low to moderate soreness intensity who have no limitations on neck range of motion.

DCF spray combined with contract-relax stretching is recommended for patients who do not have contraindications, have moderate to severe soreness intensity, and have restriction of cervical ROM. This method requires only two minutes to provide an effective analgesic effect and is preferable to the spray and stretch technique as it is more comfortable, requires a lower dosage of spray, and is readily available at most hospitals, including the Phetchabun Hospital.

The spray and stretch technique is recommended for use with patients who do not have contraindications for cryotherapy, have moderate to severe soreness intensity, and have a restriction of cervical ROM. However, this method is unsuitable for patients with sensitive or fragile skin or low-thickness skin folds, e.g., elderly or low BMI patients, because the cooling sensation of the vapocoolant spray may be painful.[32] Additionally, a higher dosage of the vapocoolant spray is needed than of the DCF spray. There is also a potential limitation on use of vapocoolant spray alone at home as to be effective the spraying should be done at least 12 inches away from the upper trapezius region.

Study limitations

This study has some limitations. First, the dry needling and pain reduction treatments were only performed at the upper trapezius muscle. Although this muscle is a common site for developing myofascial pain syndrome, additional muscles can be involved which have not been evaluated. Second, as there was no placebo group, we cannot exclude the placebo effect occurring in all three groups. Third, in this study, a cold gel pack was applied for 10 minutes.[24] However, Otte, et al. found that there was a direct relationship between adipose thickness and adequate cooling time, i.e., greater skin fold thickness requires a longer duration cold pack application.[45] For example, in obese patients, longer duration of application of cold gel packs, e.g., more than 10 minutes is needed. Fourth, the outcomes recorded at 6 and 24 hours after dry needling were subjective outcomes and lacked objective confirmation, e.g., determination of cervical range of motion or pain pressure threshold. Finally, outcomes were recorded only once after the first 6 hours. A further study with more frequent recording of outcomes to investigate each method's effective frequency and duration is needed.

Conclusions

DCF spraying with contract-relax stretching reduces post-dry needling soreness at the upper trapezius muscle which is comparable to the spray and stretch technique. Both methods are more effective than cold gel packs with self-stretching. In addition to the spray and stretch technique, DCF spraying with contract-relax stretching might help further reduce post-dry needling soreness at the upper trapezius muscle, especially in patients with high post-needling soreness.

Disclosure

The author certifies that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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References

1. Sarrafzadeh J, Ahmadi A, Yassin M. The effects of pressure release, phonophoresis of hydrocortisone,and ultrasound on upper trapezius latent myofascial trigger point. Arch Phys Med Rehabil [Internet]. 2011 [cited 2022 Oct 1];93(1):72–7. Available from https://pubmed.ncbi.nlm.nih.gov/21982324/ doi: 10.1016/j.apmr.2011.08.001
2. Cerezo-Téllez E, Torres-Lacomba M, Mayoral-Del Moral O, Sánchez-Sánchez B, Dommerholt J, Gutiérrez-Ortega C. Prevalence of myofascial pain syndrome in chronic non-specific neck pain: a population-based cross-sectional descriptive study. Pain Med [Internet]. 2016 [cited 2022 Oct 1];17(12): 2369-77. Available from https://pubmed.ncbi.nlm.nih.gov/28025371/ doi: 10.1093/pm/pnw114
3. Simons DG, Travell D. Travell and Simons' myofascial pain and dysfunction: the trigger point manual, upper half of body. Baltimore, USA: Williams & Wilkins; 1999.
4. Hanten WP, Olson SL, Butts NL, Nowicki AL. Effectiveness of a home program of ischemic pressure followed by sustained stretch for treatment of myofascial trigger points. Phys Ther [Internet]. 2000 [cited 2022 Oct 1];80(10):997–1003. Available from https://pubmed.ncbi.nlm.nih.gov/11002435/
5. Tough EA, White AR, Richards S, Campbell J. Variability of criteria used to diagnose myofascial trigger point pain syndrome-evidence from a review of the literature. Clin J Pain [Internet]. 2007 [cited 2022 Oct 1];23(3):278. Available from https://pubmed.ncbi.nlm.nih.gov/17314589/ doi: 10.1097/AJP.0b013e31802fda7c
6. Rudin NJ. Evaluation of treatments for myofascial pain syndrome and fibromyalgia. Curr Pain Headache Rep [Internet]. 2003 [cited 2022 Oct 1];7(6):433–442. Available from https://pubmed.ncbi.nlm.nih.gov/14604502/ doi: 10.1007/s11916-003-0059-4
7. Hong C. Lidocaine injection versus dry needling to myofascial trigger point: the importance of local twitch response. Am J Phys Med Rehabil [Internet]. 1994 [cited 2022 Oct 1];73(4):256-63. Available from https://pubmed.ncbi.nlm.nih.gov/8043247/ doi: 10.1097/00002060-199407000-00006
8. Ruane JJ. Identifying and injecting myofascial trigger points. Phys Sportsmed [Internet]. 2001 [cited 2022 Oct 1];29(12):49-50. Available from https://pubmed.ncbi.nlm.nih.gov/20086561/ doi: 10.3810/psm.2001.12.1082
9. Rickards LD. The effectiveness of non-invasive treatments for active myofascial trigger point pain: a systematic review of literature. Int J Osteopath Med [Internet]. 2006 [cited 2022 Oct 1];9(4):120-36. Available from https://www.ncbi.nlm.nih.gov/books/NBK72610/

10. Lai M, Hong C. Additional ultrasound therapy after myofascial trigger point injection for the management of postinjection soreness. J Rehab Med Assoc ROC [Internet]. 1998 [cited 2022 Oct 1];26:111-8. Available from https://www.semanticscholar.org/paper/Additional-Ultrasound-Therapy-after-Myofacial-Point-Lai-Hong/04ddd6539f1c7058dea3e4d234529b8f7afd9ddf
11. Martín-Pintado ZA, Rodríguez-Fernandez AL, García-Muro F, Lopez A, Mayoral O, Mesa-Jimenez, et al. Effects of spray and stretch on postneedling soreness and sensitivity after dry needling of a latent myofascial trigger point. Arch Phys Med Rehabil [Internet]. 2014 [cited 2022 Oct 1];95:1925-32. Available from https://pubmed.ncbi.nlm.nih.gov/24928191/ doi: 10.1016/j.apmr.2014.05.021
12. Gatterman, M, Goe, D. Chiropractic management of spine-related disorders. USA: Williams and Wilkins; 1990. p. 473.
13. McMasters CW. Cryotherapy. Phys Sportsmed. [Internet]. 1982 [cited 2022 Oct 1];10(11):112-9. Available from https://www.tandfonline.com/doi/abs/10.1080/00913847.1982.11947373
14. Cameron MH. Physical agents in rehabilitation: from research to practice. 4th ed. St. Louis, Mo.: Elsevier/Saunders; 2013.
15. Chonan D. The effect of cryotherapy on post dry needling soreness [dissertation]. Masters Degree in Technology. South Africa: Durban University of Technology [Internet]. 2008 [cited 2022 Oct 1]. Available from https://openscholar.dut.ac.za/bitstream/10321/505/1/Chonan_2008.pdf
16. Boonyoung N, Paungmali A, Pichaiya T. The effect of self-stretching and PNF stretching on pressure pain threshold over the trigger point of upper trapezius muscle in women. Bull Chiang Mai Assoc Med Sci [Internet]. 2006 [cited 2022 Oct 1];39(3):71-8. Available from https://www.academia.edu/71983439/The_effect_of_self_stretching_and_PNF_stretching_on_pressure_pain_threshold_over_the_trigger_point_of_upper_trapezius_muscle_in_women
17. Jaeger B, Reeves JL. Quantification of changes in myofascial trigger point sensitivity with the pressure algometer following passive stretch. Pain [Internet]. 1986 [cited 2022 Oct 1] ;27(2):203-10. Available from https://pubmed.ncbi.nlm.nih.gov/3797015/ doi: 10.1016/0304-3959(86)90211-3
18. Panchmatia S. Diclofenac 4% spray for acute pain and inflammation. Nurse Prescribe [Internet]. 2013 [cited 2022 Oct 1];8(9). Available from https://www.magonlinelibrary.com/doi/abs/10.12968/npre.2010.8.9.78305
19. Diciolla NS, Pérez-Clemente C, Cámara-Caballero M, Matienzo-Barreto A, Real-Rodríguez A, Torres-Lacomba M. Efficacy of exercise on postneedling soreness: a randomized controlled trial. J Clin Med [Internet]. 2021 [cited 2022 Oct 1];10(23): 5527. Available from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8658482/ doi: 10.3390/jcm10235527
20. Michlovitz SL. Thermal agents in rehabilitation. 3rd ed. Philadephia: F. A. Davis; 1996.
21. Nadler SF, Weignand K, Kruse RJ. The physiologic basis and clinical applications of cryotherapy and thermotherapy for the pain practitioner. Pain Physician [Internet]. 2004 [cited 2022 Oct 1];7(3):395-9. Available from https://pubmed.ncbi.nlm.nih.gov/16858479/
22. IBM Micromedex. Mayo Clinic. Diclofenac (Topical Application Route) [Internet]. IBM Watson Health; 2022 [cited 2022 Oct 4] Available from https://www.mayoclinic.org/drugs-supplements/diclofenac-topical-application-route/side-effects/drg-20063434?p=1
23. Lavelle BE, Synder M. Differential conduction of cold through barriers. J Adv Nurs [Internet]. 1985 [cited 2022 Oct 1];10(1):55-61. Available from https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2648.1985.tb00492.x
24. Kuo CC, Lin CC, Lee WJ, Huang WT. Comparing the antiswelling and analgesic effects of three different ice pack therapy durations: a randomized controlled trial on cases with soft tissue injuries. J Nurs Res [Internet]. 2013 [cited 2022 Oct 1];21(3):186-94. Available from https://pubmed.ncbi.nlm.nih.gov/23958608/ doi: 10.1097/jnr.0b013e3182a0af12
25. Kisner C, Colby LA. Therapeutic exercise: foundations and techniques. 3rd ed. Philadelphia: FA Davis; 1996.
26. Voss DE, Ionta MK, Myers BJ. Proprioceptive neuromuscular facilitation: patterns and techniques. 3rd ed. Philadelphia: Harper & Row; 1985.
27. Simons DG, Travell JG. Myofascial pain and dysfunction; the trigger point manual: upper half of body. 2nd ed. Baltimore: Williams and Wilkins; 1994. p. 131-56.
28. Vorawanthanachai T. Factors associated with immediate post-needling soreness after dry needling at upper trapezius muscle in patients with myofascial pain syndrome. ASEAN J Rehabil Med. ASEAN J Rehabil Med: 2023;33:23-7.
29. Predel HG, Giannetti B, Seigfried B, Novellini R, Menke G. A randomized, double-blind, placebo-controlled multicentre study to evaluate the efficacy and safety of diclofenac 4% spray gel in the treatment of acute uncomplicated ankle sprain. J Int Med Res [Internet]. 2013 [cited 2022 Oct 1];41(4):1187-202. Available from https://pubmed.ncbi.nlm.nih.gov/23908551/ doi: 10.1177/0300060513487639
30. Kim B, Kang T, Kim D. Effect of proprioceptive neuromuscular facilitation stretching on pain, hip joint range of motion, and functional disability in patients with chronic low back pain. Phys Ther Rehabil Sci [Internet]. 2021[cited 2022 Oct 1];10:225-34. Available from https://www.jptrs.org/journal/view.html? doi=10.14474/ptrs.2021.10.2.225
31. Hindle K, Whitcomb T, Briggs WO, Hong J. Proprioceptive neuromuscular facilitation (pnf): its mechanisms and effects on range of motion and muscular function. J Hum Kinet [Internet]. 2012 [cited 2022 Oct 1];31: 105-13. Available from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3588663/ doi: 10.2478/v10078-012-0011-y
32. Moon YE, Kim SH, Choi WH. Comparison of the effects of vapocoolant spray and topical anesthetic cream on pain during needle electromyography in the medial gastrocnemius. Arch Phys Med Rehabil [Internet]. 2013 [cited 2022 Oct 1];94:919-24. Available from https://pubmed.ncbi.nlm.nih.gov/23262383/doi: 10.1016/j.apmr.2012.12.008
33. Câmara-Gomes LF, Dibai Filho AV, Diniz RR, Alvares PD, Veneroso CE, Torres Cabido CE. Mechanisms of muscle stretching exercises for reduction of low back pain: narrative review. BrJP [Internet]. 2022 [cited 2022 Oct 1];5(1). Available from https://doi.org/10.5935/2595-0118.20220001
34. Wilke J, Vogt L, Niederer D, Hübscher M, Rothmayr J, Ivkovic D, et al. Short-term effects of acupuncture and stretching on myofascial trigger point pain of the neck: a blinded, placebo-controlled RCT. Complement Ther Med [Internet]. 2014 [cited 2023 April 6];22(5):835-41. Available from: https://pubmed.ncbi.nlm.nih.gov/25440373/doi: 10.1016/j.ctim.2014.09.001
35. Buranruk O. A randomized clinical trial of self-stretching with and without mindful breathing - immediate effect on pressure pain and range of motion in myofascial pain syndrome. J Bodyw Mov Ther [Internet]. 2022 [cited 2023 Feb 1];32:29-35. Available from https://pubmed.ncbi.nlm.nih.gov/36180155/ doi: 10.1016/j.jbmt.2022.05.016

36. Olsen, J.E, Stravino V.D. A review of cryotherapy. Phys Ther [Internet]. 1972 [cited 2022 Oct 1];52(8):840-852. Available from https://pubmed.ncbi.nlm.nih.gov/4558889/DOI: 10.1093/ptj/52.8.840
37. Medthority. Drug information; Voltarol [Internet]. UK: EMC; 2017 [cited 2022 Oct 4]. Available from https://www.medthority.com/drugs/m-musculo-skeletal-system/m02/m02a/m02aa/m02aa15/voltarol-active-4-cutaneous-spray/
38. MIMs. Uniren spray [Internet]. Malaysia: MIMs; 2022 [cited 2022 Oct 4]. Available from www.mims.com/malaysia /drug/info/uniren%20spray/
39. Blahd WH, Husney A, Romito K, O'Connor HM, Rigg J. Using Ice and cold packs [Internet]. Canada: HealthlinkBC; 2021 [cited 2022 Oct 4]. Available form: https://www.healthlinkbc.ca/health-topics/using-ice-and-cold-packs
40. Ahmad U, Waqqar S, Rehman M, Abidin SZ, Burki SR, Rehman FU. The effects of the spray stretch and sustained pressure techniques for managing trigger points in the upper part of the trapezius muscle. Adv Rehab [Internet]. 2022 [cited 2022 Oct 1];36(3), 26–34. Available from https://doi.org/10.5114/areh.2022.120066
41. Shah FS. Effects of myofascial release and vapocoolant spray with stretch technique on upper trapezius trigger points. PJR [Internet]. 2016 [cited 2022 Oct 1];5(2):43-8. Available from https://www.researchgate.net/publication/347818687_EFFECTS_OF_MYOFASCIAL_RELEASE_AND_VAPOCOOLANT_SPRAY_WITH_STRETCH_TECHNIQUE_ON_UPPER_TRAPEZIUS_TRIGGER_POINTS/DOI:10.36283/pjr.zu.5.2/004
42. Dworkin RH, Turk DC, McDermott MP, Peirce-Sandner S, Burke LB, Cowan P, et al. Interpreting the clinical importance of group differences in chronic pain clinical trials: IMMPACT recommendations. Pain [Internet]. 2009 [cited 2023 April 6];146(3):238-44. Available from https://pubmed.ncbi.nlm.nih.gov/19836888/doi: 10.1016/j.pain.2009.08.019
43. Jørgensen R, Ris I, Juhl C, Falla D, Juul-Kristensen B. Responsiveness of clinical tests for people with neck pain. BMC Musculoskelet Disord [Internet]. 2017 [cited 2022 Oct 1];18(1):548. Available from https://pubmed.ncbi.nlm.nih.gov/29282073/ doi: 10.1186/s12891-017-1918-1
44. Enwemeka CS, Allen C, Avila P, Bina J, Konrade J, Munns S. Soft tissue thermodynamics before, during, and after cold pack therapy. Med Sci Sports Exerc [Internet]. 2002 [cited 2022 Oct 1];34(1):45-50. Available from https://pubmed.ncbi.nlm.nih.gov/11782646/ doi: 10.1097/00005768-200201000-00008
45. Otte JW, Merrick MA, Ingersall CD, Cordova ML. Subcutaneous adipose tissue thickness alters cooling time during cryotherapy. Arch Phys Med Rehabil [Internet]. 2002 [cited 2022 Oct 1];83(11):1501-5. Available from https://pubmed.ncbi.nlm.nih.gov/12422316/ doi: 10.1053/apmr.2002.34833