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Research article

Combination of Manual Therapy and Dry Needling Effectively Improves Acute Neck Pain and Muscular Tone and Stiffness in Combat Sports Athletes: A Randomized Controlled Study

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Abstract

This study aimed to compare the effects of manual therapy combined with dry needling (MTDN) to a control group, focusing on the impact on pressure pain threshold (PPT), muscle tone (MT), muscle stiffness (MS), muscle strength, and range of motion in the neck muscles of adult combat sports athletes. A randomized controlled study design was employed, with one group of athletes (n = 15) receiving MTDN intervention, while the other group (n = 15) underwent a control treatment (CG) involving a quasi-needle technique combined with manual therapy. Both groups participated in three sessions, either in the MTDN intervention or the control condition. All athletes, who were experiencing neck pain, were evaluated at rest, after one session, after three sessions, and again 72 hours after the third session. Muscle tone (MT) and muscle stiffness (MS) were measured using myotonometry, pressure pain threshold (PPT) was assessed with an algesiometer, muscle strength was evaluated using a handheld dynamometer, and range of motion was measured with an electronic goniometer. Group comparisons revealed significantly higher MT in CG compared to MTDN after the 3rd session ($p < 0.001$; $d = 1.50$). Additionally, CG showed significantly greater MS than MTDN after the 3rd session ($p < 0.001$; $d = 1.75$) and at 72 hours post-session ($p < 0.001$; $d = 2.45$). Conversely, MTDN exhibited significantly greater PPT than CG at 72 hours post-session ($p < 0.001$; $d = 1.80$). Our results suggest that MTDN is significantly more effective in improving muscle tone, stiffness, and acute pain compared to manual therapy alone. However, no significant impact was observed on maximal strength or neck range of motion. A combined approach may offer benefits by more rapidly reducing neck pain and better preparing muscle properties for future activities.

Key words: Martial arts, exercise recovery, muscle strength, physical therapy modalities, therapeutics.

Introduction

In combat sports, muscular neck pain often results from overload due to repetitive head and shoulder movements, impacts, and specific training demands (Brown et al., 2022). Neck pain can manifest as acute (lasting less than four weeks), subacute (4 - 12 weeks), or chronic (over 12 weeks), leading to disability and significant performance impacts (Liu et al., 2015). Left untreated, this condition can lead to severe consequences such as discopathy, prolonged training interruptions, surgical intervention, or even career-ending outcomes (Jensen et al., 2017; Andrade et al., 2019). Previous research suggests that excessive physical exertion can lead to the formation of myofascial trigger points (MTrPs) (Ballyns et al., 2012). The most widely accepted definition of an MTrP is a hypersensitive point in skeletal muscle, characterized by a palpable knot in a taut band that is painful to manual pressure. This can lead to referred pain, tenderness, stiffness, motor dysfunction, and other autonomic symptoms (Hong, 2004). The MTrPs impair muscle function by increasing stiffness and reducing strength, which may impair performance and also raises the risk of injury (Cagnie et al., 2013; Albin et al., 2020).

Physical therapy is often the first line of treatment for myofascial neck pain (Miake-Lye et al., 2019). Various treatments are available, including manual compression, friction techniques (Xu et al., 2023), and dry needling (DN) (Gerber et al., 2015), which can be used either individually or in combination (Fernández-De-Las-Peñas et al., 2021). According to the American Physical Therapy Association, DN involves the use of a fine acupuncture needle to stimulate MTrPs and connective tissue for treating neuromusculoskeletal disorders (Fernández-de-las-Peñas and Dommerholt, 2018). In contrast, ischemic compression (IC), a common and effective non-invasive technique, involves applying manual pressure on the MTrP for about 90 seconds, gradually increasing pressure until discomfort or maximum tissue resistance is reached (Velázquez Saornil et al., 2023). Both DN and IC target MTrPs to alleviate muscle tension and pain, but they operate through different mechanisms. The DN releases muscle tightness and enhances local blood flow via needle insertion (Trybulski et al., 2024c), while IC reduces tissue ischemia and boosts oxygenation through sustained pressure (Behrangrad and Kamali, 2017), with both methods aiming to normalize neuromuscular activity and reduce pain.

A recent systematic review and meta-analysis compared the effects of combining DN with other physical therapy interventions versus using either therapy alone for treating MTrPs linked to neck pain (Fernández-De-Las-Peñas et al., 2021). The review concluded that while evidence

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is low to moderate, adding DN to physical therapy may improve short- and medium-term pain intensity and short-term pain-related disability, compared to physical therapy alone (Mansfield et al., 2019; Navarro-Santana et al., 2022). However, the benefits of DN for increasing pressure pain thresholds and neck range of motion were only observed in the short term (Fernández-De-Las-Peñas et al., 2021). The authors noted that the literature remains inconsistent and imprecise due to gaps in clinical studies (Wilhelm et al., 2023).

Some researchers argue that the effects of DN, when added to a physiotherapy approach, are minor in the short- and medium-term for treating neck pain associated with MTrPs (Fernández-De-Las-Peñas et al., 2021). The impact of DN on neck range of motion is minimal and may not be clinically significant. Additionally, few studies have explored the link between cervical pain and weakened neck muscle strength (Jensen et al., 2017), which can increase injury risk in combat sports (Multanen et al., 2021) and negatively affect performance (Trybulski et al., 2024c). While DN may influence muscle biomechanical properties by reducing tension (Kelly et al., 2021), stiffness (Jiménez-Sánchez et al., 2021), and increasing flexibility (Roch et al., 2022), there is insufficient evidence supporting its superiority over manual trigger point therapy in sports medicine.

Previous studies in combat sports have examined the effects of DN in isolation and compared it to other techniques. One study (Kużdżał et al., 2024), for instance, compared DN with compression contrast therapy in the recovery of forearm muscles. It found that the combination of DN and compression contrast therapy significantly enhanced muscle tone (MT) and perfusion units just five minutes after inducing muscle fatigue. Another study (Trybulski et al., 2024a), which compared DN to a control group, revealed that a single session of DN improved the recovery of the flexor carpi radialis muscle, increased muscle strength, and raised the pressure pain threshold (PPT) in Mixed Martial Arts athletes. Similarly, a study (Trybulski et al., 2024c) comparing DN with a control group found that a single DN session effectively enhanced the biomechanical properties of the gastrocnemius muscle, leading to faster muscle power recovery.

Despite the findings reported above, the actual benefits of DN compared to manual therapy remain unclear, as DN is inherently more invasive. It is crucial to determine whether the benefits of DN justify its use. Therefore, study designs should focus not just on comparing DN to control groups but also on evaluating how DN combined with other therapies or techniques may offer advantages. This represents a significant gap in current research that needs to be addressed. Furthermore, there is limited knowledge about the effects of DN combined with manual therapy for neck pain, a common issue for combat athletes due to their activities. Understanding its potential impact on recovery and recovery speed could be particularly beneficial for athletes and help inform practitioners' decisions. Finally, since most research on DN in athletes has concentrated on lower limb muscles and primarily reported pain outcomes, there is a pressing need for randomized clinical trials to investigate its effects on muscle function (e.g., force, range of motion [ROM], or properties) of athletes experiencing neck pain (Tang and Song, 2022).

Considering these points, this study aimed to assess the effects of combining manual therapy (pressure and friction) with DN (MTDN) on range of motion, isometric strength (Fmax), muscle stiffness (MS), MT, and PPT in combat athletes with acute, unilateral myofascial neck pain and active MTrPs in the upper trapezius muscle. We hypothesized that combined IC/DN therapy would produce better outcomes than manual therapy alone.

Methods

This research adhered to the CONSORT guidelines for reporting randomized trials (Merkow et al., 2021).

Study design

This research employed a single-blind, randomized, parallel design with repeated measures. In this study, a single-blind design was used because the intervention involved physiotherapy treatments, which required the therapist to be aware of the group assignment (experimental or control) in order to administer the appropriate treatment. However, to reduce potential bias, participants were blinded to their group assignment, ensuring that their expectations did not influence their responses or outcomes. A double-blind design was not feasible, as it would not have been possible to blind the therapists to the treatment they were administering. Participants were randomly allocated into one of two groups - MTDN, or control group (CG) - using a simple randomization method (1:1 ratio) via randomizer.org, a tool for unbiased participant assignment. Randomization was completed prior to baseline measurements to ensure proper concealment of group allocation. Participants remained unaware of their specific intervention throughout the study. They were also instructed to refrain from training for 48 hours before and after the intervention. Each participant was assessed at four different time points: at rest (baseline), 5 minutes after the end of the first intervention session, 5 minutes after the end of the third intervention session, and 72 hours following the third intervention session. The athletes underwent three intervention sessions, with a 3-day rest period between each session. Figure 1 illustrates the study design.

Ethical aspects

The study obtained initial approval from the ethical committee of the Polish National Council of Physiotherapists (consent no. 26/2022 of January 12, 2023) and was registered with the clinical trials register (ISRCTN) under ISRCTN10378682. The study was also conducted in accordance with the Declaration of Helsinki. Participants were thoroughly briefed on the study's objectives, potential risks, and benefits before giving their informed consent. This consent included acknowledgment of their right to withdraw from the study at any time without facing any consequences. Measures were implemented to safeguard the privacy and confidentiality of the collected data, with procedures in place to maintain its integrity through blinded methods.

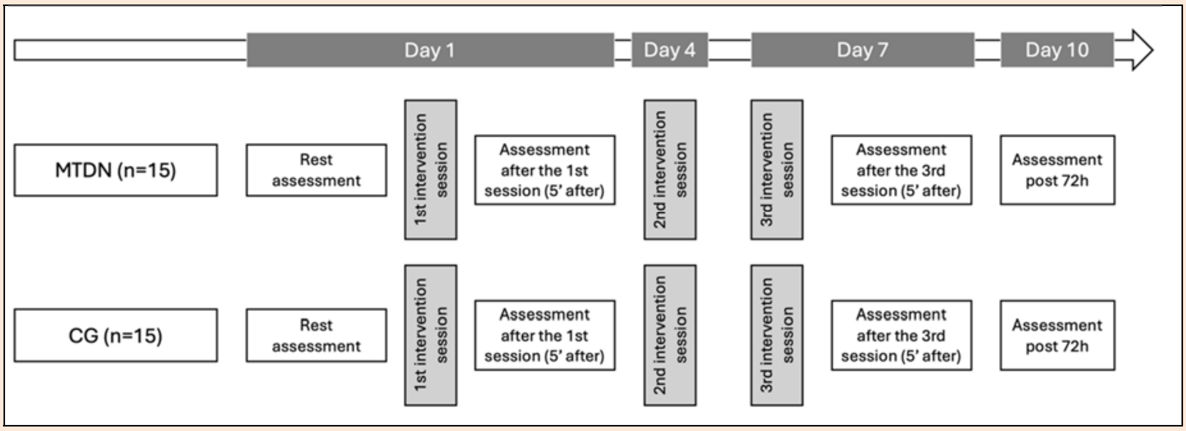

Figure 1. **The study design. MTDN: manual therapy + dry needling; CG: control group.**

Participants

The sample size for this study was determined in advance, based on a prior investigation of DN in combat sports (Trybulski et al., 2024c). Utilizing a repeated measures ANOVA to examine within-between interactions across two groups and four measurement points, with an effect size (f) of 0.758 - derived from a partial eta squared of 0.365 observed in stiffness (Trybulski et al., 2024c) - and setting a significance threshold of 0.05 and a desired power of 0.95, the G*power software indicated a minimum requirement of 6 participants. Although only 6 participants were statistically necessary, we aimed to recruit additional individuals to account for potential dropouts and ensure adequate sample size throughout the study. Thus, we have focused on achieving a final sample size of 30, which is often considered sufficient for the Central Limit Theorem to ensure the sampling distribution approximates a normal distribution (Maroco, 2012).

Following the determination of the required sample size, the recruitment phase began (see Figure 2). Prospective participants underwent screening to verify their eligibility. Participants were included in the study if they met the following criteria: (i) unilateral neck pain persisting for more than one month; (ii) neck pain rated at least 3 on the Numeric Rating Scale (NRS); (iii) presence of a palpable tight band within the muscle; (iv) identification of a hypersensitive, tender point within the tight band; (v) local or referred neck pain triggered by pressure; (vi) restricted rotational mobility of the neck; (vii) at least three years of experience in combat sports; and (viii) training at least three times per week. Exclusion criteria were: (i) receipt of DN treatment within the past three months; (ii) presence of radicular diseases or radicular pain; (iii) neck pain associated with cervical spine injury; (iv) dizziness; (v) history of neck surgery; (vi) other connective tissue disorders such as systemic sclerosis or fibromyalgia; (vii) pain from cervical discopathy; (viii) nickel allergy; and (ix) needle phobia.

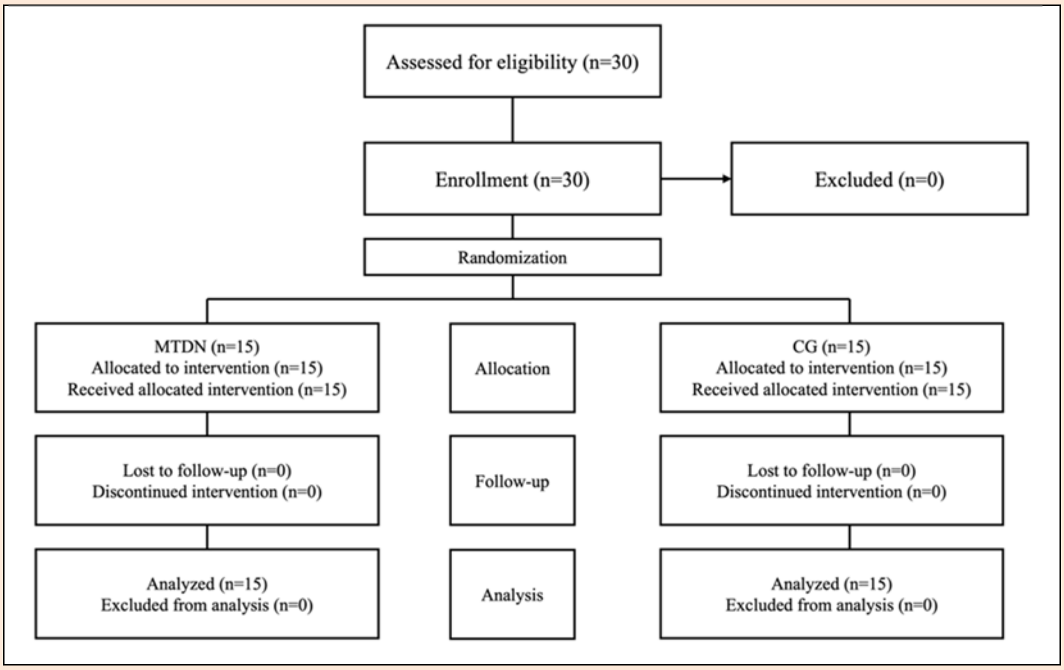

Figure 2. **Participants flowchart. MTDN: manual therapy + dry needling; CG: control group.**

Table 1. Descriptive statistics (mean ± standard deviation) of the groups.

	MTDN (n = 15)	CG (n = 15
Men (n)	11	12
Women (n)	4	3
Age (years old)	24.3 ± 3.2	26.6 ± 4.4
Height (cm)	176.1 ± 11.6	176.6 ± 9.6
Body mass (kg)	68.7 ± 13.8	79.3 ± 16.0
Body mass index (kg/m²)	22.6 ± 1.5	26.1 ± 3.6
Experience (years)	7.0 ± 2.0	11.4 ± 4.9

MTDN: manual therapy + dry needling; CG: control group

After the recruitment phase, 30 volunteers were successfully selected, all of whom met the inclusion criteria. The participants included 23 males and 7 females, aged between 18 and 35 years, and were athletes in disciplines such as mixed martial arts, judo, and Brazilian jiu-jitsu. The group had a mean age of 26.4 ± 4.4 years, an average height of 176.4 ± 10.4 cm, and a mean body mass of 74.0 ± 15.6 kg. Their average body mass index was 24.3 ± 3.2 kg/m², and they had an average of 9.2 ± 4.3 years of training experience (see Table 1). All participants were classified as Tier 2 status (Highly Trained/National Level) (McKay et al., 2022). They reported engaging in training sessions 3 to 4 times per week, primarily focused on competition preparation.

Experimental regenerative therapies

After a 24-hour rest period of the latest training session, the MTDN group received DN therapy, which involved puncturing the painful and active MTrP in the upper trapezius muscle using a sterile SOMA needle (0.30 x 0.30 mm). This was followed by applying ischemic pressure and rubbing the taut band within the muscle. The DN procedure followed to strict safety protocols, including disinfecting the puncture site and the physiotherapist wearing protective gloves. Patients were positioned supine, with their heads supported at an angle of approximately 15 degrees. Each MTrP was punctured with a single needle, while monitoring for a local twitch response (LTR). If no LTR occurred after a maximum of five needle insertions without removing the needle, the needle was replaced, and the insertion site was adjusted to fulfill the criteria for identifying MTrPs (Perreault et al., 2017). An MTrP was defined as palpable tenderness in the taut band along the upper trapezius, typically located in the middle section of the muscle. The entire DN procedure lasted about one minute. The procedure was halted if the patient experienced a burning sensation or any adverse reaction, with the number of such events recorded.

Following the DN therapy, manual therapy was performed using IC with the thumb for up to 90 seconds on the MTrP, followed by three rubbings of the taut band with the thumb. This manual therapy lasted between three to five minutes (Velázquez Saornil et al., 2023). In the days following the intervention, the athletes refrained from training, similar to the control group (CG), and resumed their training only after the final evaluation, 72 hours after the initial intervention.

After a 24-hour rest period following the most recent training session, athletes in the CG were exposed to a quasi-needle, which was a specially designed instrument that resembled a needle but did not penetrate the skin. The quasi-needle contained a spring that, along with a unique technique, simulated the sensation of actual needle insertion (telescopic needle - sham therapy) (Braithwaite et al., 2019). Additionally, participants were unable to see the needle due to their supine position. The manual therapy procedure for the CG was conducted in the same manner as in the MTDN. Each participant underwent a total of three therapy sessions at three-day intervals (Figure 1). All measurements and therapies were conducted in the Medical Center between 10 AM and 1 PM, in a room electronically monitored to maintain a temperature of 21°C.

Throughout the experiment, participants were instructed to avoid sparring during training and focus only on task-specific exercises and physical conditioning to prevent overloading the neck muscles. In cases where bilateral pain was reported, the side with the lower recorded PPT was selected for evaluation.

Measurements

The measurements taken from all study participants included: (i) muscle tone (MT) [Hz], (ii) muscle stiffness (MS) [N/m], (iii) pressure pain threshold (PPT) [N/cm], (iv) maximum isometric force (Fmax) [kgf], and (v) range of motion (ROM) [°]. These assessments were conducted at four intervals: (I) at rest, (II) five minutes after the first intervention session, (III) five minutes after the third intervention session, and (IV) 72 hours after the third session. All evaluations took place between 10 AM and 1 PM at the Medical Center, where the ambient temperature was consistently maintained at 21°C. Trained physiotherapists, who remained the same throughout the study to minimize variability, administered the measurements.

Assessment of muscle tone and stiffness

After identifying the MTrP according to the previously described criteria, the measurement site on the upper trapezius muscle was marked with a marker. Biomechanical properties, including muscle tension and stiffness, were then measured using the MyotonPRO myotonometer (Myoton Ltd, Estonia, 2021). The MyotonPRO is a digital device consisting of a main body and a 3 mm push-in probe. Its reliability and consistency have been validated in scientific literature (Melo et al., 2022).

The measurement process begins with the probe applying an initial pressure of 0.18 N to the skin, compressing the underlying tissue. This is followed by the release of a mechanical impulse (0.4 N, 15 ms), causing a brief deformation of the tissue (Melo et al., 2022). The device measures resting MT by detecting the frequency of muscle oscillations in a relaxed state (with a silent EMG signal) (Bartsch et al., 2023). Muscle stiffness (MS) is then determined by calculating the tissue's resistance to deformation using a logarithmic formula (Trybulski et al., 2024b). All measurements were taken in the therapeutic position. The outcomes obtained from the data collection was the MT, measured in Hz and the MS measured in N/m.

Assessment of pain pressure threshold

The PPT was assessed using an FDIX algesiometer (Wagner Instruments, Greenwich, CT, USA). Each participant underwent three pressure tests with a probe (r = 4 mm) applied to the designated tissue area. The force, expressed in kg or N/cm², was calculated as the average of the three trials and displayed digitally. If a significant deviation occurred, the device signaled the need to repeat the test. The pressure was gradually increased until the participant reported discomfort (Suzuki et al., 2022).

Algesiometer devices have been extensively used in clinical practice for nearly a century (Park et al., 2011). They are commonly applied to assess conditions such as myofascial pain syndrome and musculoskeletal disorders, with studies confirming their high reliability in repeat measurements (Fischer, 1987). All measurements were performed while the participant was in the treatment position.

Isometric muscle strength assessment

The isometric muscle strength test was conducted using a handheld dynamometer (Kinvent K-Forse Push, France), a tool accepted for its reliability and consistency (de Almeida et al., 2023; Olds et al., 2023). While seated, the device was positioned on the upper arm of the tested side. The participant was instructed to perform an upward arm movement, engaging the upper trapezius muscle. Each contraction was held for 3 seconds. The test was performed twice, and the average of the two measurements was recorded. The Fmax was measured as kgf.

Range of motion assessment

ROM was measured using an electronic goniometer (Kinvent K-Forse Move v3, France), which was attached to the participant's forehead via a headband with a sensor. Electronic goniometry is a simple and reliable method for assessing joint mobility (Shamsi et al., 2019; Koong et al., 2020). This device, combined with its application, enabled measurement of movement control through biofeedback. The assessment was conducted in a seated position, where the participant performed lateral flexion and rotation movements, stopping at the first point of pain discomfort and holding the position for 3 seconds. The ROM for lateral flexion and rotation was measured in degrees (º).

Statistical procedures

Descriptive statistics, including mean values and standard deviations, were calculated. Normality of the data was verified using the Kolmogorov-Smirnov test (p > 0.05), and Levene's test (p > 0.05) was applied to assess variance homogeneity. Once both assumptions were met, a mixed-design ANOVA (time × group) was employed to compare outcomes before and after the intervention across the different groups. The Bonferroni test was used as a post-hoc test for pairwise comparisons. Effect sizes were measured using partial eta squared (η_p^2), with the following benchmarks: 0.04 for small effects, 0.25 for moderate effects, and 0.64 for large effects (Ferguson, 2009). Pairwise comparisons were analyzed using Cohen's d, with effect sizes categorized as (Hopkins et al., 2009): 0.0 - 0.2 (trivial), 0.2 - 0.6 (small), 0.6 - 1.2 (moderate), 1.2 - 2.0 (large), and greater than 2.0 (very large). All statistical tests were performed using SPSS software (version 28.0.0.0, IBM, USA), with a significance level set at p < 0.05.

Results

Significant interactions between time and groups were found in MT (F = 4.188; p = 0.008; η_p^2=0.130), MS (F = 10.264; p < 0.001; η_p^2 = 0.268), PPT (F = 14.506; p < 0.001; η_p^2 = 0.341), Fmax (F = 4.921; p = 0.026; η_p^2 = 0.149), lateral-flexion ROM (F = 2.010; p = 0.123; η_p^2 = 0.096), and rotation ROM (F = 0.742; p = 0.477; η_p^2 = 0.038).

Table 2 presents the descriptive statistics for the main outcomes measured at four assessment points in the MTDN and CG groups. No significant differences were observed between groups at baseline (rest) for any of the outcomes (p > 0.05). Group comparisons revealed significantly higher MT in CG compared to MTDN after the 3rd session (mean difference: 0.867 Hz [95%CI: 0.391;1.391]; p < 0.001; d = 1.50, large effect size). Additionally, CG showed significantly greater MS than MTDN after the 3rd session (mean difference: 0.139 N/m [95%CI: 0.077;0.203]; p < 0.001; d = 1.75, large effect size) and at 72 hours post-session (mean difference: 0.153 N/m [95%CI: 0.111;0.209]; p < 0.001; d = 2.45, very large effect size). Conversely, MTDN exhibited significantly greater PPT than CG at 72 hours post-session (mean difference: 7.407 N/cm [95%CI: 4.32;10.49]; p < 0.001; d = 1.80, large effect size).

Figure 3 illustrates the descriptive statistics for MT, MS, and PPT across the four assessment points in the MTDN and CG groups. In both groups, within-group analysis revealed that MT was highest at the baseline (rest) assessment, showing significantly greater values compared to after the 1st session (p < 0.001), the 3rd session (p < 0.001), and 72 hours post-session (p < 0.001). For MS, both the MTDN and CG groups exhibited significantly lower values at the 72-hour post-session assessment, with these values being significantly lower than those at rest (p < 0.001), after the 1st session (p < 0.001), and after the 3rd session (p < 0.001). For PPT, the MTDN group showed significantly higher values at the 72-hour post-session assessment compared to rest (p < 0.001; d = 3.363, very large effect size), after the 1st session (p < 0.001; d = 2.855, very large effect size), and after the 3rd session (p < 0.001; d = 1.649, large effect size). In the CG group, results revealed that only the rest value was significantly lower than after the 1st session (p < 0.001; d = 0.842, moderate effect size), the 3rd session (p < 0.001; d = 1.625, large effect size), and 72 hours post-session (p < 0.001; d = 1.864, large effect size), with no significant differences observed between the latter assessments, except for the comparison between the 1st session and the 72-hour post-session (p = 0.010; d = 0.434, small effect size).

Figure 4 shows the descriptive statistics for Fmax, lateral-flexion ROM, and rotation ROM across the four assessment points in the MTDN and CG groups. In both groups, within-group analysis revealed that Fmax was smaller at the baseline (rest) assessment, showing significantly greater values compared to after the 1st session (p < 0.001), the 3rd session (p < 0.001), and 72 hours post-session (p < 0.001). For lateral-flexion ROM, both the MTDN and CG groups showed significantly higher values at the 72-hour post-session assessment compared to rest (p <

0.001) and after the 1st session ($p < 0.001$). However, in the MTDN group, these values were also significantly different from those after the 3rd session ($p < 0.001$; d = 1.333, large effect size), while no significant difference was found in the CG group ($p = 0.179$). For rotation ROM, both the MTDN and CG groups exhibited significantly greater values at the 72-hour post-session assessment, with these values being significantly lower than those at rest ($p < 0.001$), after the 1st session ($p < 0.001$), and after the 3rd session ($p < 0.001$).

Table 2. Descriptive statistics (mean ± standard deviation) for the main outcomes measured at four assessment points in the MTDN and CG groups.

		MTDN (n = 15)	CG (n = 15)	*p-value*	*ES* (d)
Muscle Tone (Hz)	**Rest**	19.6 ± 0.8	19.5 ± 0.6	0.615	0.14, trivial
	After 1st session	17.7 ± 0.6	18.4 ± 0.8	0.007	1.00, moderate
	After 3rd session	16.4 ± 0.7	17.3 ± 0.5	*<0.001	1.50, large
	Post 72h	16.1 ± 0.6	16.9 ± 0.7	0.002	1.23, large
Muscle Stiffness (N/m)	**Rest**	1.83 ± 0.12	1.83 ± 0.10	0.924	0.00, trivial
	After 1st session	1.64 ± 0.09	1.77 ± 0.10	0.001	1.37, large
	After 3rd session	1.56 ± 0.09	1.70 ± 0.07	*<0.001	1.75, large
	Post 72h	1.40 ± 0.07	1.56 ± 0.06	*<0.001	2.45, very large
PPT (N/cm)	**Rest**	76.9 ± 7.6	78.9 ± 5.8	0.424	0.30, small
	After 1st session	80.2 ± 7.3	83.7 ± 5.6	0.149	0.54, small
	After 3rd session	87.9 ± 6.0	86.7 ± 3.8	0.537	0.24, small
	Post 72h	95.9 ± 3.7	88.5 ± 4.5	*<0.001	1.80, large
Fmax (kgf)	**Rest**	30.1 ± 5.1	32.3 ± 4.4	0.210	0.46, small
	After 1st session	32.1 ± 4.6	33.0 ± 4.2	0.550	0.20, small
	After 3rd session	34.8 ± 4.9	34.2 ± 3.9	0.706	0.14, trivial
	Post 72h	35.5 ± 4.8	35.1 ± 4.3	0.791	0.09, trivial
Lateral-Flexion ROM (º)	**Rest**	36.9 ± 2.7	37.3 ± 2.1	0.713	0.17, trivial
	After 1st session	39.0 ± 2.4	39.9 ± 1.9	0.348	0.42, small
	After 3rd session	41.7 ± 2.1	41.7 ± 1.7	0.975	0.00, trivial
	Post 72h	43.7 ± 0.9	42.9 ± 1.5	0.142	1.01, moderate
Rotation ROM (º)	**Rest**	40.8 ± 2.6	40.1 ± 2.6	0.535	0.27, small
	After 1st session	43.8 ± 2.7	43.0 ± 2.8	0.504	0.29, small
	After 3rd session	46.6 ± 2.4	46.9 ± 1.9	0.784	0.14, trivial
	Post 72h	50.5 ± 1.8	50.6 ± 3.1	0.896	0.04, trivial

MTDN: manual therapy + dry needling; CG: control group; Fmax: maximal force; ROM: range of motion; PPT: pressure pain threshold; ES: Effect size; *: significantly differences between groups (p < 0.05).

Discussion

This experimental study aimed to compare the effects of MTDN and manual therapy alone on muscle properties (MT and MS), PPT, isometric muscle strength, and ROM in lateral flexion and rotation among combat sports athletes with neck pain. The findings revealed that MTDN was significantly more effective than manual therapy alone in improving MT, MS, and PPT after the third intervention session. However, there were no significant differences between MTDN and manual therapy alone in terms of maximal strength and ROM. Additionally, the within-group analysis indicated that all therapies positively affected the outcomes by the end of the third session, regardless of the group. However, improvements in MS, PPT, and lateral-flexion ROM continued to improve significantly up to the 72-hour period following the third intervention. In contrast, for MT and Fmax, recovery was achieved immediately after the third session and maintained at similar levels after 72 hours.

Our results showed that MT was significantly improved by MTDN, with MTDN performing better than the CG. Additionally, within the MTDN group, recovery levels were achieved immediately after the third session and were maintained at similar levels 72 hours later. Our results are consistent with a previous study (Kużdżał et al., 2024), which showed that DN was significantly effective in improving MT in combat athletes experiencing muscle fatigue, whether used alone or in combination with contrast therapy. Additionally, our findings align with a previous meta-analysis of post-stroke patients, which reported a moderate positive effect of DN on improving MT (Fernández-de-las-Peñas et al., 2021).

The observed improvement in MT through the use of DN with the MTDN technique can be attributed to DN's targeting of MTrP (Jiménez-Sánchez et al., 2021). This approach likely induces local twitch responses and promotes biochemical changes that help reduce muscle hypertonicity and alleviate pain (Perreault et al., 2017). DN is also associated with the release of endogenous opioids and other pain modulators, as well as the normalization of abnormal muscle spindle activity (Dommerholt et al., 2006), which further decreases muscular tension and enhances function. On the other hand, manual therapy employs techniques designed to enhance joint mobility, reduce muscle tension, and improve blood circulation (Bialosky et al., 2009). When DN and manual therapy are used together, they can complement each other by simultaneously addressing both the biochemical and mechanical aspects of muscle dysfunction. The immediate recovery noted after the third session, and its sustained effect 72 hours later, can be attributed to the combined therapeutic impact of both treatments, leading to a more effective reduction in MT and pain.

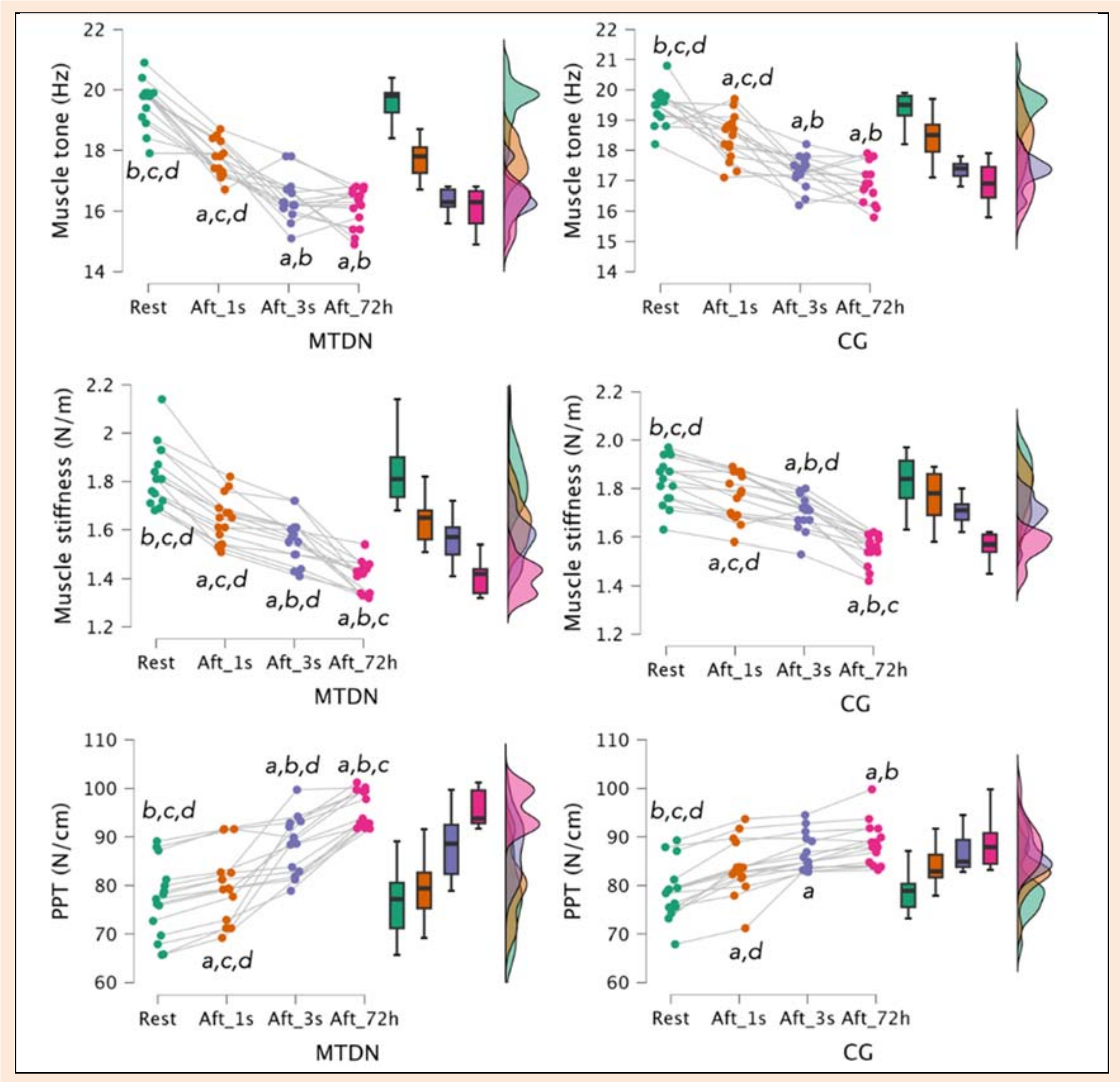

Figure 3. Descriptive statistics of muscle tone, muscle stiffness and pressure pain threshold (PPT) over the four assessment points in muscle therapy + dry needling (MTDN) and control (CG) groups. *a*: significantly ($p < 0.05$) different from rest; *b*: significantly ($p < 0.05$) different from after 1 session; *c*: significantly ($p < 0.05$) different from 3rd session; *d*: significantly ($p < 0.05$) different from post 72 hours.

Our results also showed significantly better effects of MTDN on improving MS compared to the CG. Interestingly, within-group analysis revealed that improvements continued up to the final assessment, which was 72 hours after the third intervention session. This suggests that restoring muscle stiffness may require a longer period. Our results align with previous studies suggesting that DN significantly improves MS. For instance, a study (Albin et al., 2020) comparing DN with sham DN in the recovery of gastrocnemius muscle stiffness with latent trigger points supports this finding. Our results also align with other studies that found DN directly targeting the MTrP area to be effective in reducing stiffness compared to a control group (Jiménez-Sánchez et al., 2021).

The superior effects of MTDN on MS compared to the control group can be attributed to the increased blood flow stimulated by DN, which helps alleviate muscle tension (Cagnie et al., 2012). This increased blood flow and vasodilatation can break the cycle of persistent contraction and ischemia, leading to a reduction in muscle stiffness (Perreault et al., 2017). Manual therapy further enhances this effect by mechanically mobilizing soft tissues and joints, improving their pliability, and reducing stiffness through the manipulation of connective tissues and normalization of joint mechanics (Kogo and Kurosawa, 2010). The continued improvement in muscle stiffness up to 72 hours after the third intervention suggests that the recovery process involves ongoing physiological adaptations. These include the gradual reduction of muscle hypertonicity and remodeling of connective tissues, which can take time to fully manifest.

The PPT also showed significant improvement after three sessions of MTDN compared to the control group, with these differences becoming evident only 72 hours after the final intervention session. Our results also confirm that a single session can produce significant improvements, as observed in within-group analysis. This finding is consistent with a previous study (Stieven et al., 2021) that found DN effective in generating both local and distant hypoalgesic responses, reducing neck pain intensity in individuals with chronic neck pain.

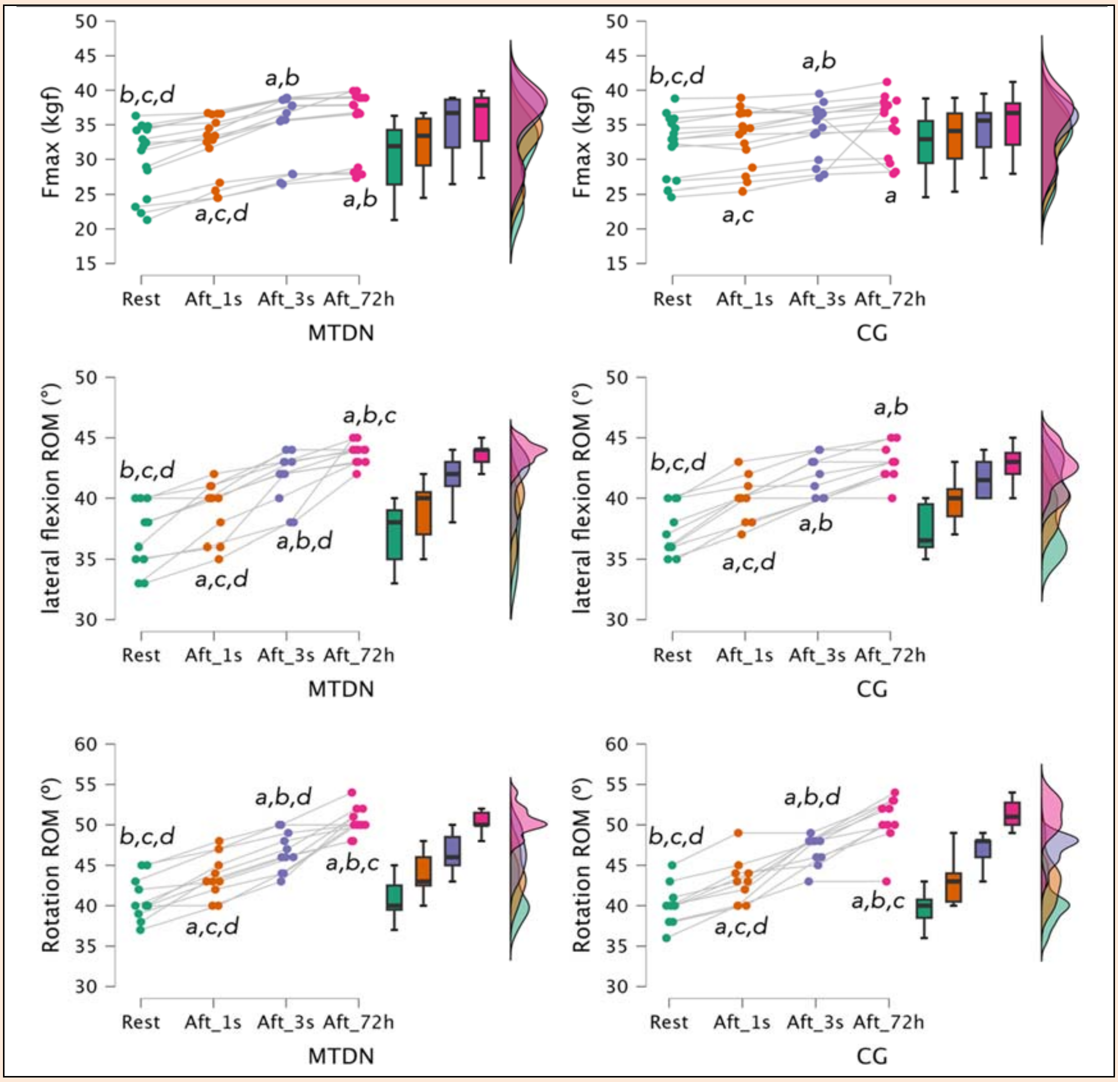

Figure 4. Descriptive statistics of maximal force (Fmax), lateral-flexion range of motion (ROM), and rotation ROM over the four assessment points in muscle therapy + dry needling (MTDN) and control (CG) groups. *a*: significantly ($p < 0.05$) different from rest; *b*: significantly ($p < 0.05$) different from after 1 session; *c*: significantly ($p < 0.05$) different from 3rd session; *d*: significantly ($p < 0.05$) different from post 72 hours.

The significant improvement in PPT observed with MTDN compared to the CG can be attributed to the reduction of peripheral nociceptive input (Fernández-de-Las-Peñas and Nijs, 2019). This occurs through the normalization of dysfunctional muscle activity and the promotion of endogenous analgesics, such as endorphins, particularly with the DN technique (Tang and Song, 2022). Manual therapy complements this by reducing muscle tension, enhancing blood flow, and modulating the central nervous system's pain perception through mechanoreceptor stimulation (Bialosky et al., 2009). The delayed improvement in PPT, occurring 72 hours after the third intervention, may reflects the time required for these therapeutic effects to translate into measurable changes in pain sensitivity, however further studies are required to understand the main mechanisms for this latency.

The lack of significant differences in isometric maximal strength and ROM for lateral flexion and rotation suggests that DN interventions may not substantially impact these specific capacities. Isometric maximal strength relies on factors such as motor unit recruitment and neural drive, which are not theoretically and directly influenced by DN. DN primarily focuses on alleviating muscle pain and reducing muscle tone, without specifically targeting the neural mechanisms crucial for enhancing strength which confirms previous review reporting a lack of evidence about the effects of DN in force production (Mansfield et al., 2019). Similarly, ROM - particularly in specific directions like lateral flexion and rotation - can be affected by structural and mechanical factors, such as joint capsule stiffness, ligamentous constraints, and the integrity of connective tissues (Rohe et al., 2015). Although DN can improve muscle flexibility and reduce stiffness, it may not address the limitations imposed by joint capsules or ligaments that restrict movement in these specific planes. Significant improvements in ROM may require targeted stretching, joint mobilizations, or comprehensive rehabilitation strategies that address a broader range of musculoskeletal constraints beyond the scope of DN. Thus, while MTDN effectively modulates muscle tone, reduces stiffness, and increases PPT, its impact on isometric strength and ROM may be limited due to its specific focus and the nature of the underlying physical capacities involved.

Although this study provides interesting findings into the efficacy of MTDN compared to manual therapy alone (CG) for combat sports athletes with neck pain, it has several limitations that should be addressed in future research. Firstly, the study's sample size was limited to regional-level athletes, which may affect the generalizability of the findings to professional athletes. The number of participants, set at 30, was justified by an a priori sample size calculation and supported by the central limit theorem. However, we acknowledge that a larger sample could enhance the diversity and generalizability of the findings. In adult athletes, though, achieving a larger sample size is particularly challenging due to scheduling constraints, interference with training routines, and the costs and potential disruptions associated with therapy.

One limitation of our study design is the use of a sham therapy control group instead of a true no-treatment control. While a true-control group may offer a more direct comparison, the use of a sham therapy is also scientifically accepted for ethical reasons, ensuring that participants received some form of treatment rather than being denied care. This approach also minimized expectation bias by blinding participants to whether they were receiving the active intervention or the placebo, helping to isolate the true effects of the therapy. Furthermore, the use of a sham group maintained participant engagement and retention, while providing a more accurate assessment of the intervention's physiological effects by accounting for psychological factors. This method is widely accepted in physiotherapy research and aligns with best practices, ensuring that our findings are both valid and relevant to real-world clinical settings (Dincer and Linde, 2003; Braithwaite et al., 2020).

The study also lacks mechanisms to identify potential causes for recovery timings and to justify the effectiveness of the DN strategies. Moreover, the short-term follow-up period restricts the assessment of long-term effects and the sustainability of the interventions. The three intervention sessions were made possible by the athletes' willingness to participate and their availability to adjust their schedules, pausing their usual practices during this period. Working with athletes often involves time constraints, but future research should aim to explore the effects of longer treatment durations. Future research should include a more diverse participant pool (e.g., high-level athletes), longer follow-up periods, and a broader range of outcome measures to provide a more comprehensive understanding of the interventions' impacts. Additionally, the specific mechanisms underlying the delayed improvements in PPT observed 72 hours post-intervention warrant further investigation.

Despite the limitations, the significant improvements observed in MT, MS, and PPT with MTDN compared to manual therapy alone suggest that MTDN may offer superior outcomes for addressing muscle hypertonicity and pain in combat sports athletes with neck pain. Clinically, this implies that practitioners might consider prioritizing MTDN, especially in cases where rapid and sustained improvements in muscle function and pain relief are desired. The immediate and lasting effects of MTDN observed in this study underscore its potential as an effective intervention for enhancing muscle recovery and reducing pain. However, the lack of significant differences in isometric strength and ROM indicates that MTDN is not worth it for enhancing such parameters. Therefore, practitioners should exercise caution when selecting DN for athletes with neck pain, prioritizing this technique primarily for enhancing PPT, MT, and MS. It is also advisable to utilize at least three sessions to observe progressive improvements.

Conclusion

The results of our experimental study reveal that incorporating dry needling into regular manual therapy significantly benefits the recovery of muscle tone and stiffness, as well as increases pain pressure threshold in combat sports athletes with neck pain. However, combining dry needling with manual therapy did not show any statistically significant improvement in isometric maximal strength or range of motion in lateral flexion and rotation movements. This evidence suggests that practitioners should exercise caution when choosing recovery techniques. Dry needling is recommended as a complementary technique primarily for increasing pain pressure threshold or reducing muscle tone and stiffness. For other recovery goals, manual therapy alone may be sufficient to achieve progress over three sessions, thereby avoiding the need for a more invasive technique. Future studies could increase the sample size and diversity of competitive levels, as well as extend the duration of the interventions.

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The experiments comply with the current laws of the country in which they were performed. The authors have no conflict of interest to declare. The datasets generated during and/or analyzed during the current study are not publicly available but are available from the corresponding author who was an organizer of the study.

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Key points

- MTDN was significantly more effective than the control group in reducing muscle tone, stiffness, and pain in combat sports athletes.
- No significant differences were found between MTDN and the control group for muscle strength or neck range of motion.

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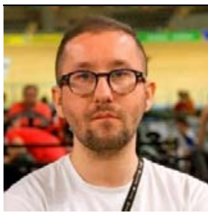

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