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Effect of Electrical Stimulation with Trigger Point Dry Needling on Pain and H-Reflex Muscle Activity

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Article

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Abstract

Background: The aims of this study were to determine the effects that trigger point dry needling (TpDN) with and without electrical stimulation (ES) has on pain threshold and to assess the effect the TpDN has on muscle activity (MA) in people with identified painful trigger points (Tp) within thesoleus and gastrocnemius muscles complex.

Methods: This study was a randomized controlled trial. Forty volunteers, aged 18-55 were recruited, signed an informed consent and randomly placed in four equal groups: TpDN with simultaneous ES, DN only, ES only, and a Sham treatment (Tx).

The parameters for ES were set to a frequency of 30 Hz, a pulse width of 0.6ms at an intensity causing a slight muscle contraction. Pain was assessed before and at 10 and 30 mins post Tx. MA was assessed using the H-reflex technique before, during and at 10 and 30 mins post-Tx. Data were analyzed using two 2-way repeated-measures ANOVA (pain and H-reflex). Post-hoc analysis followed when alpha <0.05. Cohen's Ds was also calculated.

Results: No significant change among the groups were found in the pain or H-reflex data ($p > 0.5$). However, the H-reflex showed significant changes within all groups over time, with DNES and ES showing the largest amplitude increase (DNES, Cohen's D = 1.1; ES, Cohen' D = 0.5). The other two groups showed smaller changes.

Conclusions: TpDN Tx facilitated the H-reflex in all groups, with DNES showing the largest change. Thus, clinicians need to be cognizant of the facilitatory effect on MA when performing DNES. In addition, TpDN coupled with ES appears to have a synergistic effect on MA. As for pain thresholds, TpDN appears not to have an effect after one Tx. More may be necessary. Further research is needed to validate TpDN effect on pain.

Trial Registration: This study was designed and conducted prospectively with IRB approval obtained in 2022 (Approval No. IRB 2122-042). Following the regulatory update in 2025, the study was retrospectively registered and assigned an NCT number (NCT07384247)to ensure compliance with current requirements.

Background

DN is one of the most commonly used physical therapy (PT) interventions for managing trigger points (Tp). Several studies have demonstrated that DN reduces pain, disability, and range of motion (ROM) deficits, while increasing pain pressure thresholds (PPT).[1–4] It has been suggested that DN modulates pain through peripheral, spinal and supraspinal mechanisms.[4] Evidence suggests that DN was equally effective as other PT interventions, compared to no treatment or Sham-DN.[2] Studies have shown that it can modulate pain associated with myofascial Tp in stroke, tension headache, temporomandibular pain,

mechanical neck pain, upper quadrant, and lower quadrant conditions even with existing controversies according to the needling technique, number of needles, patient population, and Tp detection.[3]

Additionally, previous research suggests that DN techniques especially for the gastrocnemius and soleus complex are minimally invasive and have low associated risks because of the muscle bulk and minimal penetrating vasculature.[5] A meta-analysis has shown that DN alone is an effective treatment for Tp pain.[2]

Electrical stimulation (ES) is also a commonly used non-invasive method for pain management during PT.[6] Recently, several studies [7–10] suggested that combining DN with ES may be more effective in trigger point release than DN alone. Brennan[7] showed that DN with ES amplified physiological effect of neuromuscular ES associated with pain resolution and improved function in myofascial pain syndrome. Another multicenter, randomized controlled study showed that adding trigger point DN (TpDN) to ES had a longer-term effect (3 months) than manual therapy and exercise combined with ultrasound alone for plantar fasciitis.[11] Conversely, Lopez-Martos [9] suggested that DN with ES resulted in short-term (28 days), but not sustained improvement (70 days) in pain when applied to patients with myofascial pain syndrome. Although the effect of DNES is controversial, it has shown clinical potential for improving pain, PPT, blood flow, disability, and ROM through neurochemical and neuromotor changes.[8,9,12,13]

TpDN and ES has also been shown to have a positive effect on muscle activity.[7,14] In this study we used the Hoffmann reflex (H-reflex), a non-invasive electrophysiological technique, to assess muscle activity (MA), is commonly used in evaluating neuromuscular function for therapeutic responses.[15,16] Additionally, recent studies show that DN with ES may modulate H-reflex parameters, with potential benefits for motor control and spasticity.[14,17,18]

Despite these advancements in understanding DN with ES in clinical applications, to the best of our knowledge, the effects of DN with and without ES on PPT and MA in healthy participants has not been studied. The primary purpose of this study was to examine the effects of TpDN, with or without ES, has on PPT in the soleus and gastrocnemius muscles. In addition, a second goal was to quantify the influence that TpDN with and without ES on MA using the H-reflex as the assessment technique.

METHODS

This study was conducted in the Physical Therapy (PT) Department's neuromuscular laboratory, located on the campus of the University, and was approved by the university's Institutional Review Board (IRB). This investigation was conducted in 2022.

Participants

Participant recruitment was conducted in the local community by placing flyers within the university's PT Department and other local physical activity centers (e.g., gyms). The sample size was determined using

Sigma Stat software (version 2.0). Forty healthy volunteers (16 males and 24 females) participated in the study. All the participants signed an informed consent form approved by the university's IRB. The inclusion criteria were that all participants were between the ages of 18 and 55 years, had at least two identifiable trigger points (Tp) in their soleus and/or gastrocnemius muscles, and had no other neuromuscular or musculoskeletal abnormalities in the lower extremities.

Procedure

Participants were randomly assigned to four treatment groups (10 for each group). Group 1 received TpDN with simultaneous ES (the DNES group). Group 2 received TpDN with placebo ES (DN only). Group 3 received ES with placebo TpDN (ES only). Group 4 received placebo TpDN and placebo ES (Sham). Groups receiving TpDN had the needle inserted into the Tp and left in the muscle for 10 min, while the placebo TpDN groups had the needle touch the skin to cause a prick over the muscle and were held there for 10 min. For groups receiving ES. The placebo ES parameters involved initiating ES but removing it instantaneously. The dependent variable of muscle activity (MA) was assessed at baseline, during treatment (9 min), and at 10 and 30 min post-treatment, whereas pain pressure threshold (PPT) was assessed at baseline and at 10 and 30 min post-treatment. MA was assessed using the standard H-reflex recording method. PPT was assessed from the most painful Tp of the two muscles. DN was performed by a physical therapist trained as a certified DN practitioner. Figure 1 shows a flowchart of the study.

Set-up

The experiment began with participants comfortably positioned in a prone posture, with their legs resting on an angled support so that their knees were slightly flexed at 50° and their ankles remained neutral. Tp were identified by recognizing pain in the typical referred pain patterns of the triceps surae muscles (Fig. 2). A minimum of two trigger points were identified and marked with a permanent ink pen for future ES electrode placement.

Baseline pain assessment

Once the Tps were marked, a PPT assessment was conducted. This involved pressing a 0.5cm blunt object [a] (Omegadyne, LC 101 – 100, USA) over the marked sites into two or more soleus/gastrocnemius trigger point sites. Participants held a switch with a button connected to a Bluetooth-enabled PS 850 Data Log (Biometrics Ltd., UK) data acquisition software system, where all pain recordings were analyzed and stored. The software allowed the researcher to record the force exerted by a blunt object as it was pressed into a marked location. As the force increased, participants pressed the button on the switch when they perceived the intensity to be 50% of their maximum pain, based on a 1–10 analog pain scale. This intensity was defined as the pain threshold for each participant. The PPT was measured

three times and averaged. This process was repeated for each identified Tp. Figure 3 shows an example of the PPT assessment monitoring setup. Our lab found that coupling the VAS with precise quantitative force data was more accurate than using the VAS alone (unpublished data).

Electromyography (EMG):

The skin overlying the soleus muscle was cleaned and shaved before electromyography (EMG) electrode placement. The skin was disinfected using 70% alcohol swabs. Two 9 mm cup Ag-AgCl EMG surface electrodes filled with conductive gel were then placed approximately 3 cm apart on the skin overlying the distal soleus muscle belly in alignment with the Achilles tendon (Fig. 4).[14] A rectangular metal plate (3 × 5 cm) was used as the ground electrode and was placed on the skin over the fibular head. The EMG electrical activity was amplified at 1000× magnification and digitized at a sampling frequency of 4,000 Hz with a bandwidth of 3–20,000 Hz using an AD Instruments data acquisition analysis system [b] (Colorado Springs, Colorado, USA). The recorded data were numerically coded, stored, and analyzed using the data acquisition and analysis software.

Baseline muscle activity assessment: Soleus H-reflex

Surface electrodes were used to stimulate the tibial nerve and record the H-reflex data. The H-reflex was elicited by a 2.5 cm monopolar stimulating ball electrode placed on the skin over the tibial nerve in the popliteal fossa. A 10 x 10 cm sponge reference electrode was fixed to the distal anterior thigh, just proximal to the patella (Fig. 4).

The H-reflex was evoked using a rectangular 1 ms pulse at 0.17 Hz (one pulse every 6 s) [c]. Proper cathode positioning was determined when (1) the direct motor reflex (M-wave) and H-reflex displayed similar wave configurations, (2) the H-wave was evoked before the M-wave, and (3) the lowest current was required to elicit the H-reflex. At this point, the stimulation intensity was increased until a maximal M-wave (Mmax) was observed. Ten Mmax responses were recorded. The electrical intensity was lowered such that the H-reflex amplitude was on the H-reflex recruitment curve's ascending limb approximately 50% of H-max ($H_{50\%}$) dependent upon an observable small M-wave. This M-wave amplitude corresponded to a 10–25% of Mmax. The M-wave was monitored during recording and any observable change it its amplitude (> 1SD) caused the experiment to be terminated. Ten $H_{50\%}$ responses were recorded, and their averages served as the baseline data to which all other recordings were compared.

ES treatment parameters

A Great Wall KWD 8081 electroacupuncture stimulation machine (Changshanshi, China) was used for TPs stimulation [d]. Electrical stimulation parameters were set at a frequency of 30 Hz, a pulse width of 0.6 ms, and an intensity that caused small muscle contractions. The placebo ES parameters were as

follows: ES was initiated but quickly removed. The needle was left on the skin for 10 min treatment duration.

DN treatment

Once baseline pain and H-reflex recording assessments were performed, treatment was initiated in each group. As stated previously, participants received either DN with ES, DN only, ES only or Sham treatment, depending on the group to which they were randomly assigned. The treatment duration was 10 min. If assigned to the DNES, a needle was inserted at the trigger point, and electrode clips from the machine were directly attached to each needle to provide an electrical impulse. H-reflexes were recorded during the treatment at 9 mins.

Follow-up data collection

After the treatment intervention for each group, the second and third PPT and H-reflex assessments were conducted at 10 and 30 min post-treatment. This assessment followed the same procedure previously describe. Once this was done, the experiment was concluded.

Statistical analysis

A Systat 13 statistical software was used for all data analyses. Ten H-reflex amplitudes (peak-to-peak) were measured and averaged for each of the three treatment and compared to the baseline H-reflex averages using two-way analysis of variance (ANOVA) for repeated measures. Post hoc t-tests (with Bonferroni correction for multiple comparisons) were used when significant F values were demonstrated. The level of significance for post hoc testing was set at .017 for the H-reflex data and .025 for the pain data. Owing to the small sample size, Cohen's D effect sizes were also calculated. We used deletion for missing data.

RESULTS

Table 1 shows the demographic information for participants whose data were analyzed in this study.

Pain pressure threshold:

Statistical analysis of the pain threshold data showed that all groups responded similarly throughout the treatment period when compared with baseline values ($p > 0.05$). Effect sizes were also minimal, except during the 30 min post-treatment period for the DNES group, which showed a modest decrease (Fig. 5). These data suggest that DN, with or without ES, had a minimal effect on pain thresholds.

H-reflex:

Statistical analysis of H-reflex amplitudes showed that all groups responded similarly to the average reflex peak-to-peak amplitudes. Thus, no significant differences were observed among the groups ($p >$

0.05). However, both ES groups (DNES and ES only) showed significant increases over time, with DNES showing increases of more than 60% above baseline and effect size data showing increases greater than 40% during and after 10 min of treatment. The DN-only and sham groups did not show significant changes, with increases below 40% compared with baseline values (Fig. 6).

Cohen's D values for the H-reflex data were consistent with the statistical findings, showing large effect sizes of 0.81, 0.82, and 1.07 for the DNES group and 0.56, 0.50, and 0.40 for the ES-only group. Interestingly, the Sham group showed moderate effect size (0.50, 0.41, 0.41) during and after treatment. The DN group demonstrated effect sizes below 0.30. Therefore, we suggest that electrical skin stimulation may be primarily responsible for the increase shown in the H-reflex data.

DISCUSSION

DN is a common physical therapy (PT) technique. It has been shown to decrease pain, increase range of motion (ROM) and improve quality of life in persons with various disabilities.[3] DN techniques vary widely, ranging from trigger points (Tp) - piston like DN, to superficial, deep and DN coupled with ES to name a few.[4,19,20] This study investigated the effect of DN coupled with ES on reducing pain from latent Tp within the muscles. An additional goal was to investigate its effect on muscle activity (MA) using the H-reflex neurophysiological technique to quantify changes in motoneurons reflex excitability. As stated in the Methods section, four groups were studied and compared. The groups included participants receiving DNES, DN only, ES only and no treatment (Sham). The results showed no differences in pain threshold or magnitude among the groups. H-reflex data increased in all four groups with the DNES group having the greatest change.

Pain pressure threshold:

The pain assessment results in this study were unexpected since many previous studies show that DN, in any form, positively affects pain threshold and intensities.[2,4,5,19] In this study, the pain assessment method was unique in that force levels were measured and compared when participants reached a pain level of 5 on a 10-point visual analogue scale (unpublished). Based on our laboratory pain assessment data, we believe that this method may be superior to others because the force data can be quantitatively evaluated objectively through statistical analysis. Therefore, discrepancies between our findings and existing literature on the pain-modulation effects of DN may result from our method having a higher sensitivity and intra-rater reliability.

Second, a discrepancy may exist between our findings and the existing literature on the pain-modulating effects of DN, as many referenced studies measured pain levels after 4 to 6 weeks of treatment. [4,8,11] The cumulative effects of repeated treatments and physiological adaptations over time may contribute to pain relief. Conversely, our study evaluated pain 10–30 minutes following only one treatment. One DN treatment may not be enough to produce pain relief; rather, DN may require a cumulative response to multiple treatments as previous studies have illustrated.[4,8,11]

Finally, the lack of change in pain levels in this study may be attributed to a learning effect rather than a direct therapeutic effect of the intervention. This learning effect may have stemmed from the repeated application of our pain assessment method during the course of the study. Repeated measurements may heighten pain awareness, thereby impeding accurate reporting of any decrease in pain intensity. We feel that this learning effect is unlikely since many studies use multiple pain assessments during their investigations and have not observed this phenomenon.[10] However, it remains a possibility that some learning effect could have occurred to some extent.

In summary, our findings showed that DN, with or without ES, had minimal impact on pain thresholds and intensities after a single treatment session. These results suggest that pain from Tp may require more than a single DN treatment. However, further studies are needed to fully understand these effects.

H-reflex:

The results showed that DNES significantly facilitated the H-reflex during and after treatment (Fig. 6; $p < 0.05$; effect size = 0.81, 0.82, 1.07), with increases of more than 60% compared with baseline, whereas the ES only group showed a more modest amplitude increase of approximately 40% (Fig. 6; $p < 0.05$; effect size = 0.56, 0.50, 0.40). The DN-only group showed minimal increases with low effect sizes, while the Sham group, interestingly, showed mean increases comparable to the DN group (Fig. 6; $p > 0.05$; effect size = 0.50, 0.41, 0.41). However, the sham group values were not significantly different, owing to high participant variability.

The H-reflex is known for its ability to reflect neuromuscular activity.[16] An increased in H-reflex amplitude is thought to result from an increased motor neuron reflex excitability and thus is associated with enhanced MA.[16,17] Clinically, this may be interpreted as the restoration of muscle function, improvement in motor control, and physiological evidence of treatment responses.[16,17]

Research shows, that most forms of skin stimulation, especially ES, stimulates skin receptors, thereby increasing motoneuron reflex activity and thus increasing MA, as demonstrated by an increased the H-reflex.[16,17] It is also possible that the Sham group experienced summation effects from either ES or DN due to the experimental setup, which may explain why the DN-only group did not show as significant an effect as the Sham group.

Moreover, these findings suggest that the DNES group was more effective in enhancing neuromuscular activity than other groups. This aligns with a study by Al Amin et al., which investigated the effects of DN, ES, and DNES on H-reflex amplitude in patients with post-stroke spasticity, demonstrating the superiority of DNES.[14] Al Amin et al., suggested that the increased facilitation was likely due to synergistic spinal circuit activation or amplified afferent input due to ES.[14] Numerous studies have supported the synergistic effects of DN and ES. Our results further support this synergistic effect of DN with ES, as evidenced by the largest post -treatment increase in H-reflex amplitude.[7,21,22] While the results may vary depending on the specific DN technique, needle count, number of treatments, baseline patient

population, and underlying mechanisms, evidence consistently suggests that DN with ES is more efficacious than DN or ES alone.[7,8,10,14,21]

Although the precise underlying mechanisms are still being explored, our findings, in conjunction with previous studies, suggest that DNES may be the preferred therapeutic option for treating trigger points. Further research is needed to validate these effects and investigate their mechanisms more thoroughly in other neuromuscular disorders.

Study limitations

Our study had a limitation in that we used latent Tp, and therefore the results may differ from those obtained with active Tp. In addition, we only administered treatment once (10 minutes), which may not have been enough to obtain a positive result in effecting pain thresholds.

CONCLUSIONS

In conclusion, this study examined the effects of DNES on neuromuscular excitability in latent trigger points in a healthy population. The results showed that DNES significantly facilitated the H-reflex compared to DN only, ES only, and Sham, but it did not affect pain threshold in any of the groups during the testing period. Clinicians should recognize that pain thresholds may decrease after DNES, rather than increase as expected. With a better understanding of TpDNs in DN with and without ES, clinical application of this modality will become more appropriate.

Abbreviations

TpDN
Trigger point dry needling
DN
Dry needling
ES
Electrical stimulation
DNES
Dry needling with electrical stimulation
MA
Muscle activity
PPT
Pain pressure threshold
H-reflex
Hoffmann reflex
ANOVA
Analysis of variance
IRB

Institutional Review Board

Tp

Trigger point (s)

EMG

Electromyography

VAS

Visual analog scale

Mmax

Maximal M-wave

H25%

H-reflex amplitude at 15–25% of Mmax

ROM

Range of motion

Declarations

Ethics approval and consent to participate: This study was designed and conducted prospectively with IRB approval obtained in 2022 (Approval No. IRB 2122-042). Following the regulatory update in 2025, the study was retrospectively registered and assigned an NCT number (NCT07384247) to ensure compliance with current requirements.

Consent for publication: All participants signed an informed consent approved by the University IRB.

Availability of data and materials:

The datasets generated and/or analyzed during the present study can be obtained from the corresponding author upon reasonable request.

Competing interests: Not applicable

Funding: Not applicable.

Declaration of generative AI in scientific writing: Not applicable**.**

Authors' contributions: JA analyzed and interpreted the patient data regarding the H-reflex and pain threshold. JYL had recruited volunteers, performed study and collected data. Both JA and JYL were major contributors in writing the manuscript. All authors read and approved the final manuscript.

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Figures

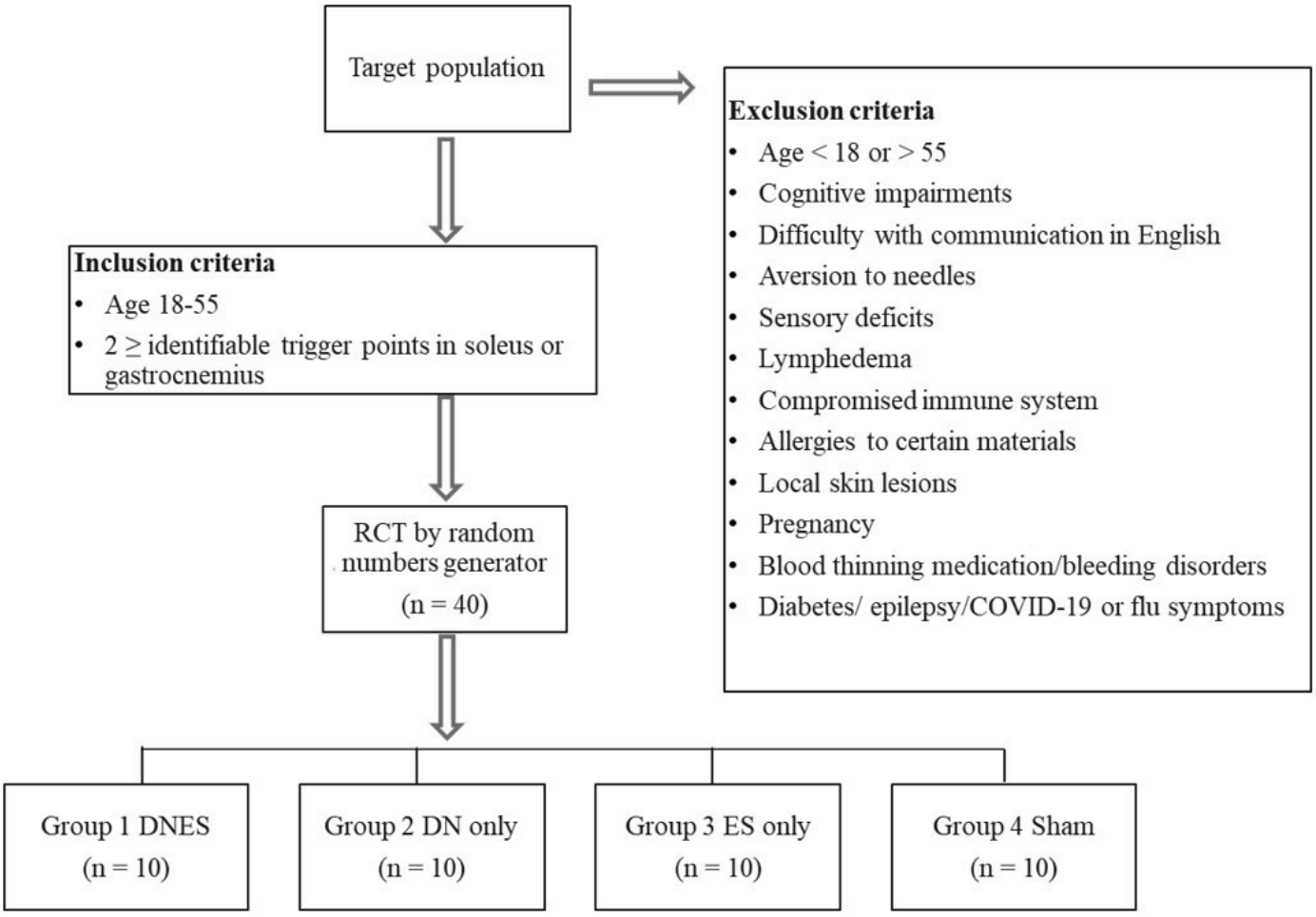


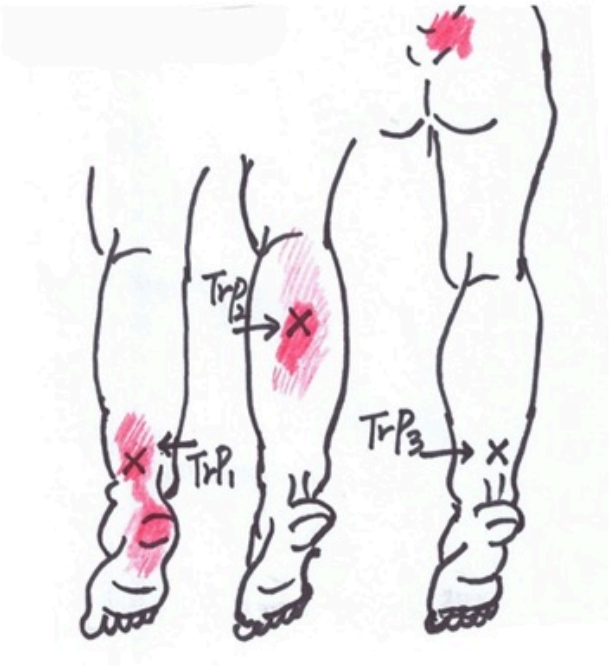
Figure 1

CONSORT Flow chart of the study

Participants were randomly assigned to four treatment groups. Group 1 received TpDN with simultaneous ES (DNES). Group 2 received TpDN with placebo ES (DN only). Group 3 received ES with placebo TpDN (ES only). Group 4, Sham group received placebo DN and placebo ES.

Abbreviations: RCT, Randomized Controlled Trial; DNES, Dry Needling with Electrical Stimulation; DN, Dry Needling; ES, Electrical Stimulation

a. Soleus



b. Gastrocnemius

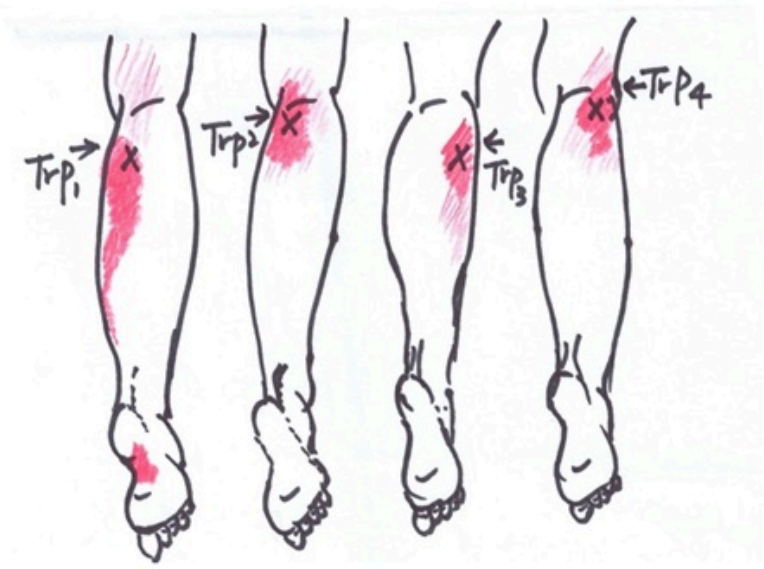


Figure 2

Trigger point identification

As illustrated in the figure, regions where trigger points commonly occur were pre-marked, and pain threshold as well as muscle activity were measured at these sites.

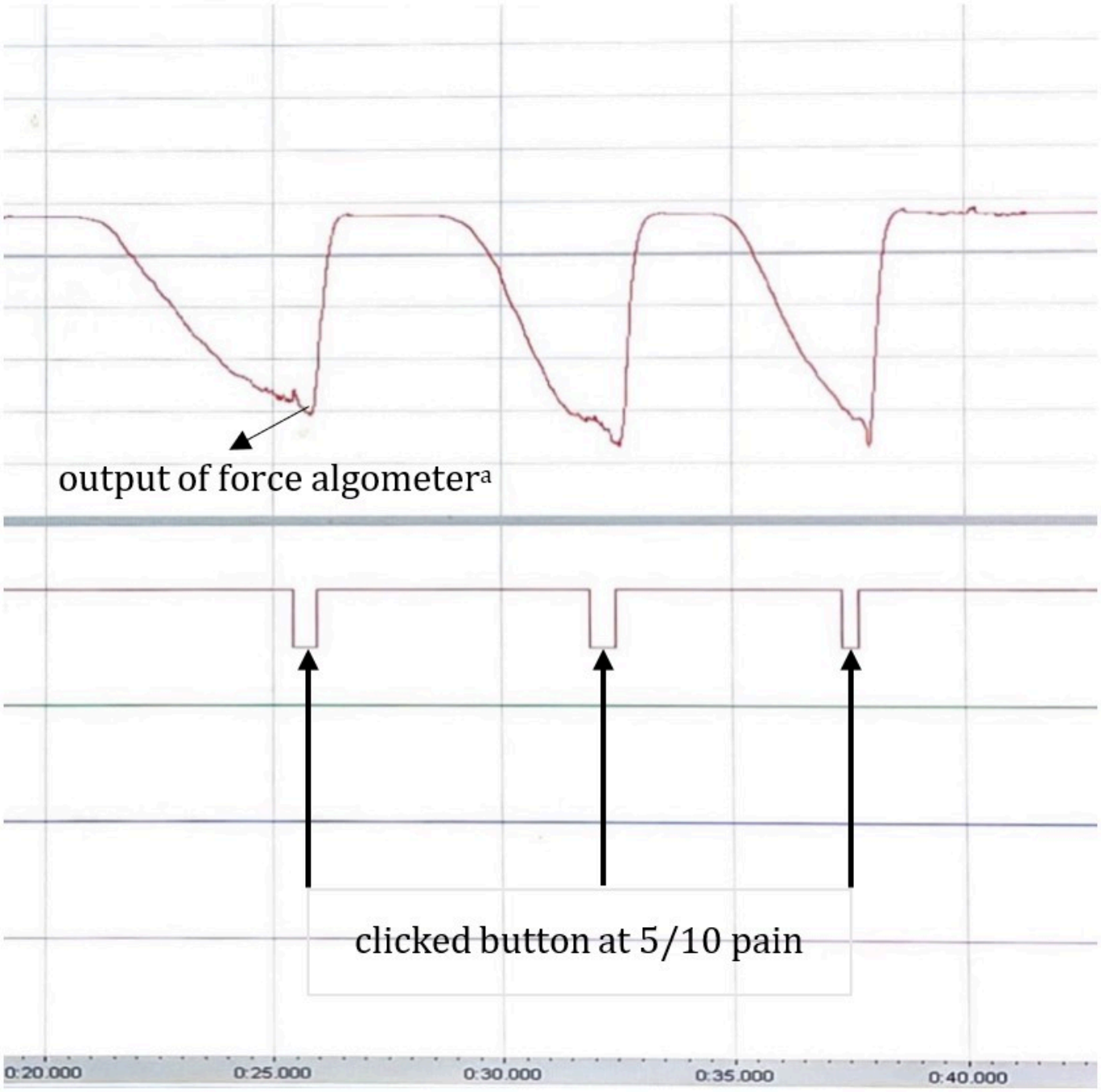


Figure 3

Example of pain assessment data

Pain pressure threshold assessment using ~0.5 cm blunt probes[a] applied to soleus/gastrocnemius trigger points. Participants pressed a Bluetooth-enabled switch upon reaching 50% of perceived maximum pain (1–10 scale). Force data were recorded, and thresholds averaged over three trials.

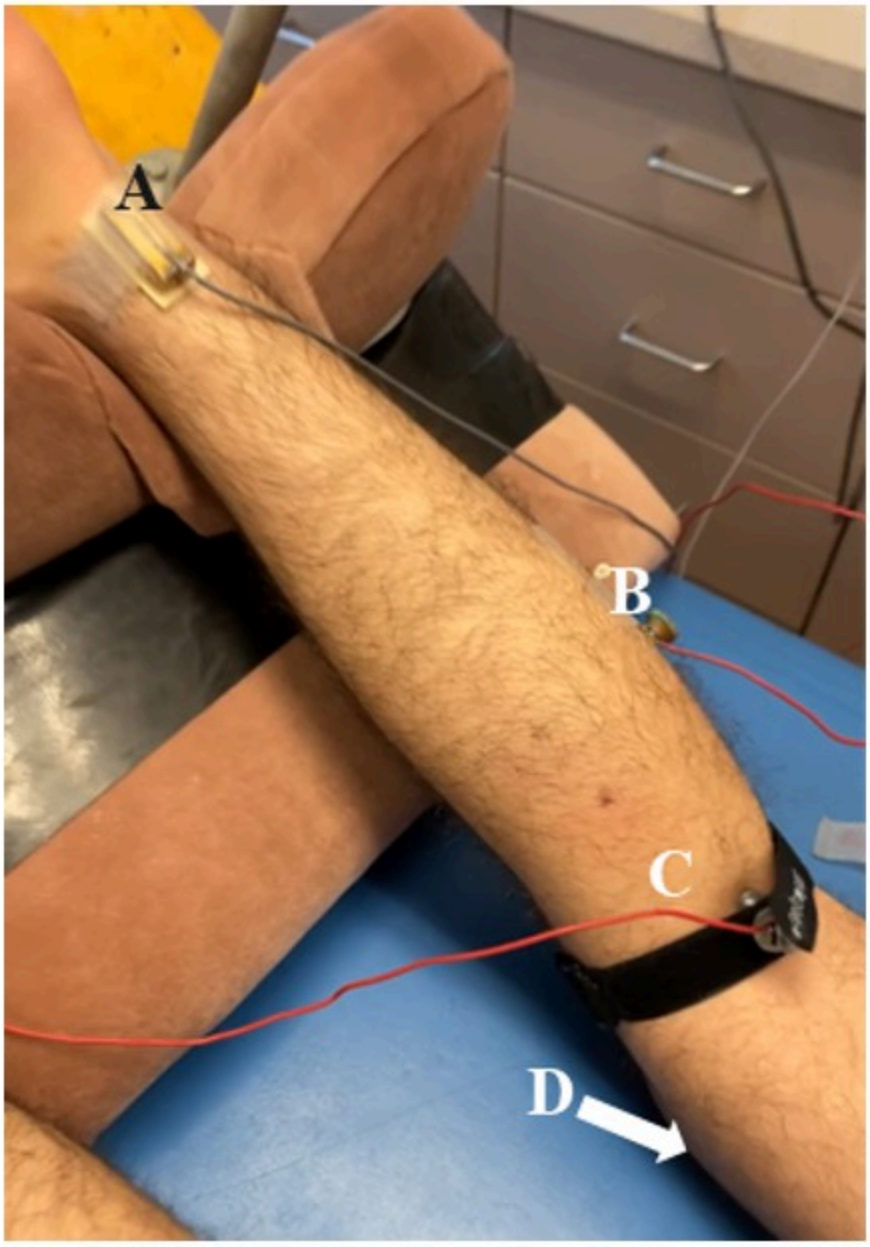


Figure 4

Electrode placement

A. EMG recording [b] electrode placed approximately 3 cm apart on the skin overlying the distal soleus muscle belly in alignment with the Achilles tendon.

B. Ground electrode was placed on the skin over the fibular head.

C. H-reflex stimulating electrode [c] (Cathode; a 2.5 cm monopolar ball electrode) was placed on the skin over the tibial nerve in the popliteal fossa.

D. For H-reflex anode (anterior thigh just above the knee), a 10 x 10 cm sponge reference electrode was fixed to the distal anterior thigh, just proximal to the patella

Abbreviations: EMG, ElectroMyoGraphy

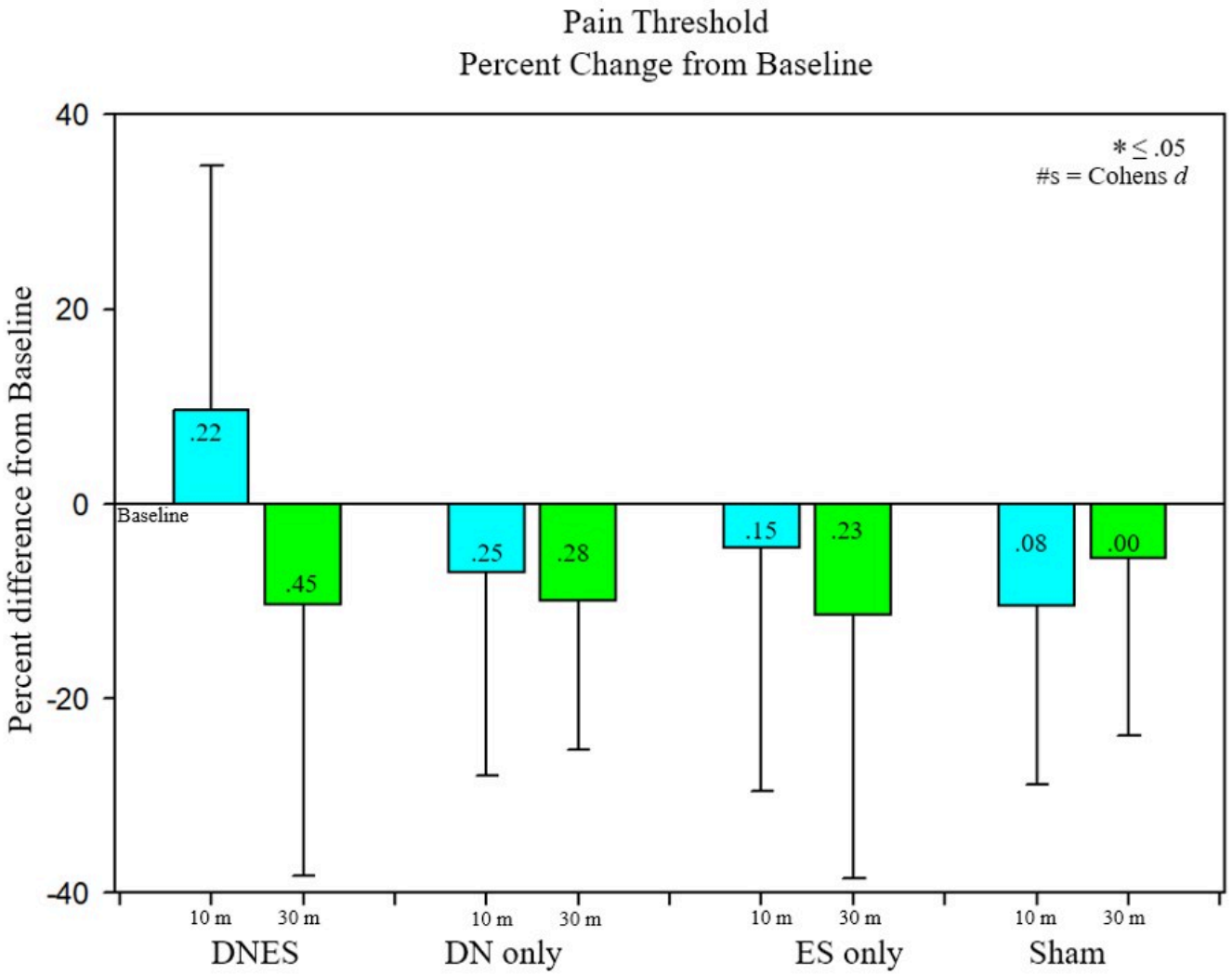


Figure 5

Pain pressure threshold (percent difference from baseline)

The pain threshold data showed that all groups responded similarly throughout the treatment period when compared with baseline values ($p > 0.05$). Effect sizes were also minimal, except during the 30 min post-treatment period for the DNES group.

Abbreviations: DNES, Dry Needling with Electrical Stimulation; DN, Dry Needling; ES, Electrical Stimulation

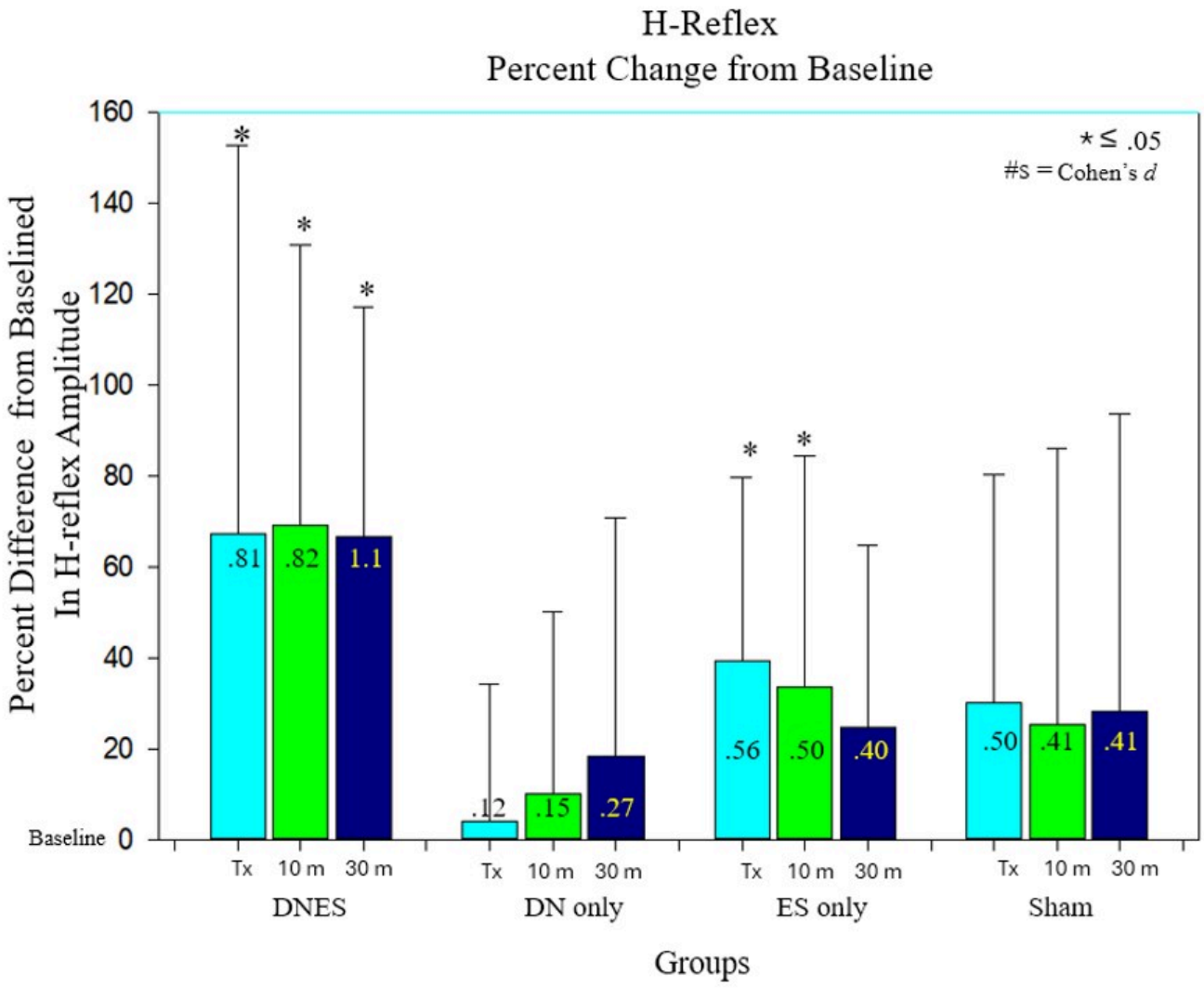


Figure 6

H-reflex (percent difference from baseline).

Significant differences were not observed between the groups. During and after 10 minutes of treatment, the DNES showed increases of more than 60% above baseline. In the DN only and Sham groups, the changes were below 40% compared to baseline.

Cohen's D values showed large effect sizes of 0.81 to 1.07 for the DNES group and 0.40 to 0.56 for the ES-only group. The Sham group showed moderate effect size (0.41 to 0.50).

Abbreviations: DNES, Dry Needling with Electrical Stimulation; DN, Dry Needling; ES, Electrical Stimulation

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- DNESdata1.xlsx
- SUPPLLIERS.docx