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Original Research

Duration of Electro-Dry Needling Does Not Change the Pain Response After Repeated Nociceptive Thermal Stimuli in Asymptomatic Individuals: A Randomized Intervention Study

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KEYWORDS
Electro-dry needling;
Physical therapy;
Rehabilitation;
Temporal summation

Abstract *Objective:* To assess the effects of 5 different durations of electro-dry needling (EDN) on asymptomatic individuals' pain response after repeated noxious thermal stimuli.
Design: Randomized, non-controlled intervention trial.
Setting: University laboratory.
Participants: Asymptomatic participants (N=50) were recruited for the study and randomized into 5 groups. There were 33 women with an average age of 26.8 (±4.8) years. To participate in the study, individuals had to be between the ages of 18 and 40, free of any musculoskeletal injury which prevented participation of daily activities, and not pregnant or trying to become pregnant.
Interventions: Participants were randomly assigned to receive 5 different durations of EDN: 10, 15, 20, 25, and 30 minutes. To perform the EDN, 2 monofilament needles were inserted lateral to the lumbar spinous processes of L3 and L5 on the right. Needles were left in situ with electrical stimulation at a frequency of 2 Hz and an amplitude which resulted in a 3 to 6 out of 10 intensity pain rating by the participant.
Main Outcome Measures: The change in the magnitude of pain in response to repetitive heat-pulses before and after the EDN procedure.
Results: There was a significant reduction in the magnitude of pain in response across the groups after EDN ($F_{(1,42)}$=94.12, P<.001, η_p^2=.691). However, the interaction between time and group was not significant ($F_{(4,42)}$=1.019, P=.409, η_p^2=.088), indicating that no duration of EDN was superior to another in reducing temporal summation.
Conclusions: This study suggests that in asymptomatic individuals, performing EDN beyond 10 minutes does not provide any additional benefits in the reduction of the magnitude of pain in

List of abbreviations: cLBP, chronic low back pain; DN, dry needling; EDN, electro-dry needling; TS, temporal summation.
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response to thermal nociceptive stimuli. Additional study in symptomatic populations is required for generalizability in clinical settings.

Electro-dry needling (EDN) is an intervention used by physical therapists treating individuals with chronic low back pain (cLBP).[1-3] While recent studies have shown promise that EDN may be beneficial in the treatment of cLBP,[4-7] a recent review has questioned the superiority of DN to other interventions. The revised clinical practice guidelines written by George et al gave a "C" recommendation for the use of dry needling (DN) cautioning that, as is true with all modalities, it should only be used in conjunction with other treatments.[8,9] One reason for the discrepancy may be because of the lack of standardization in the dosage of DN.[10]

As it relates to dosage parameters for DN, most recommendations come from acupuncture literature.[11,12] However, this may be ill-suited as traditional acupuncture and DN, though similar techniques, have very different underlying philosophies.[11,13] While both interventions use monofilament needles, acupuncture relies heavily on the philosophies of Traditional Chinese Medicine that focus on restoring the circulation of vital energy, or "qi".[14,15] Conversely, DN is based in Western medicine with a focus on resolving myofascial trigger points within the musculature or to have a broader effect on the neuromuscular system.[8,13,16,17] And it is not just the intent; the application is also different. Acupuncture is limited to the insertion of needles into specific acupuncture and ah-shi points, whereas DN has the freedom to target anywhere a change in the neuromuscular system is desired. With such different focuses, purposes, goals, and treatment effects, it may be questionable to rely solely on acupuncture literature to inform the dosage parameters for DN.

One of the purported effects of EDN in the treatment of individuals with cLBP is that it helps desensitize the central nervous system. A common manifestation of central sensitization (CS) in individuals with cLBP is the phenomenon of increased temporal summation (TS).[18] This phenomenon relates to the increased perception of pain after repeated noxious stimuli of equal intensity at a frequency of greater than 0.3 Hz.[19] A recent study has suggested that DN is beneficial in the reduction of TS, so this indirect measure of CS may be well suited to be used as an outcome measure for testing the efficacy of different needling parameters.[20]

One of the difficulties clinicians face in choosing dosage parameters for EDN is a lack of standardization in the reporting of randomized controlled trials.[10] Furthermore, there is a multitude of parameters that may be considered by the clinician. While depth of needle insertion and the size (eg, diameter, length) of needle utilization is largely dependent upon the current patient, parameters such as the number of needles and time left in place have been obfuscated by lack of consistent reporting.[10] As it relates to EDN, there is a broad range of treatment durations reported in the literature, ranging from 10 to 30 minutes.[21-25] However, there has been minimal effort made to compare the different treatment durations against each other. Therefore, the purpose of this investigation was to elucidate any differences in treatment effect—as manifested by a reduction in TS—of different time dosages of EDN in asymptomatic individuals. Our hypothesis was that the longer the duration of EDN, the greater reduction in TS would be found.

Materials and methods

Participants

We recruited healthy adults from the community via word-of-mouth. The inclusion criteria for this study was that the participants must be between the ages of 18 and 40. Exclusion criteria included: (1) have activity limiting musculoskeletal pain which we defined as pain that refers into the muscles, bones, or joints which can be described as a "dull ache" and (2) pregnant, think they might be pregnant, or are actively trying to become pregnant. This study was approved by the University of Tennessee at Chattanooga's Institutional Review Board (IRB# 20-050) and all participants provided both written and verbal consent prior to enrollment into the study.

Heat-pulse administration

Heat-pulses were administered using the Medoc Thermal Sensory Analyzer-II system[a]. A 16 mm × 16 mm TSA thermode delivered the heat pluses to the skin just lateral of the L4 spinous process on the right. Protocols from the literature were adapted to inform our administration sequence.[26-28] Ten identical heat pulses were applied at a rate of 13°C/second with an interstimulus interval of 2 seconds. The baseline temperatures for the heat pulses ranged from 38°C to 40°C and the peak ranged from 49°C to 51°C. The participants were asked to rate their pain on a scale from 0 to 100 after the first and 10th pulse.

To optimize the TS response, the protocol from Kong et al was adapted.[27] First, each participant received an initial TS protocol as described above with a baseline temperature for the heat pulse at 40°C and a peak of 49°C. If the difference in pain rating from the 10th pulse and the first pulse was less than 30 points on a 0-100 NPRS scale, a second trial was run. The baseline for the second trial was 42°C and the peak remained at 49°C, and if the difference was still less than 30 points, a third trial was run with the baseline at 42°C and the peak at 51°C for each heat pulse. If the difference on the initial trial was greater than 70 points, a second trial was run with a baseline of 38°C and a peak of 49°C. If the difference was still more than 70 points, a third and final trial was completed with a baseline at 38°C and peak of 47°C for each heat pulse. The participants rested 2 minutes in between trials

as suggested by Kong et al,[27] and whichever trial parameters resulted in the greatest difference that was less than 70 points was carried forward for the post-test.

Dry needling administration

EDN was administered by 2 physical therapists who were certified in DN and each have 10+ years of experience. The EDN was performed along the lumbar paraspinals; specifically, 2 needles were inserted approximately 1.5 fingerbreadths lateral to the L3 and L5 spinous processes on the right. Sterile, single-use, 0.25 mm × 40 mm stainless steel acupuncture needles were used. The needles were then left in situ with electrical stimulation delivered by an ES-130 electrostimulator[b] at the 2 sites of needle insertion. The frequency for the EDN was set at 2 Hz. The intensity, as measured by amplitude, was adjusted as needed to maintain a level at which the participant could comfortably tolerate.[29] For this study, this was defined as an intensity level between 3-6/10 on the numeric pain rating scale. Participants were monitored throughout the EDN session to ensure safety.

Study flow

The study flow is summarized in figure 1. After informed consent was received, participants were randomized into 1 of 5 treatment groups. Group allocation determined the duration of DN that the participant would receive. Individuals in group 1 received10 minutes of EDN, individuals in group 5 received 30 minutes of EDN, and groups 2 through 4 received EDN in 5-minute increments between 10 and 30 minutes. In order to randomize the participants, an individual not otherwise involved with the trial prepared numbered index cards with group assignments for each participant. The index cards were folded and placed in a sealed envelope with the participant number labeled on the outside. Prior to the participant consenting to the study, neither the participant nor the investigator knew the group allocation for that participant.

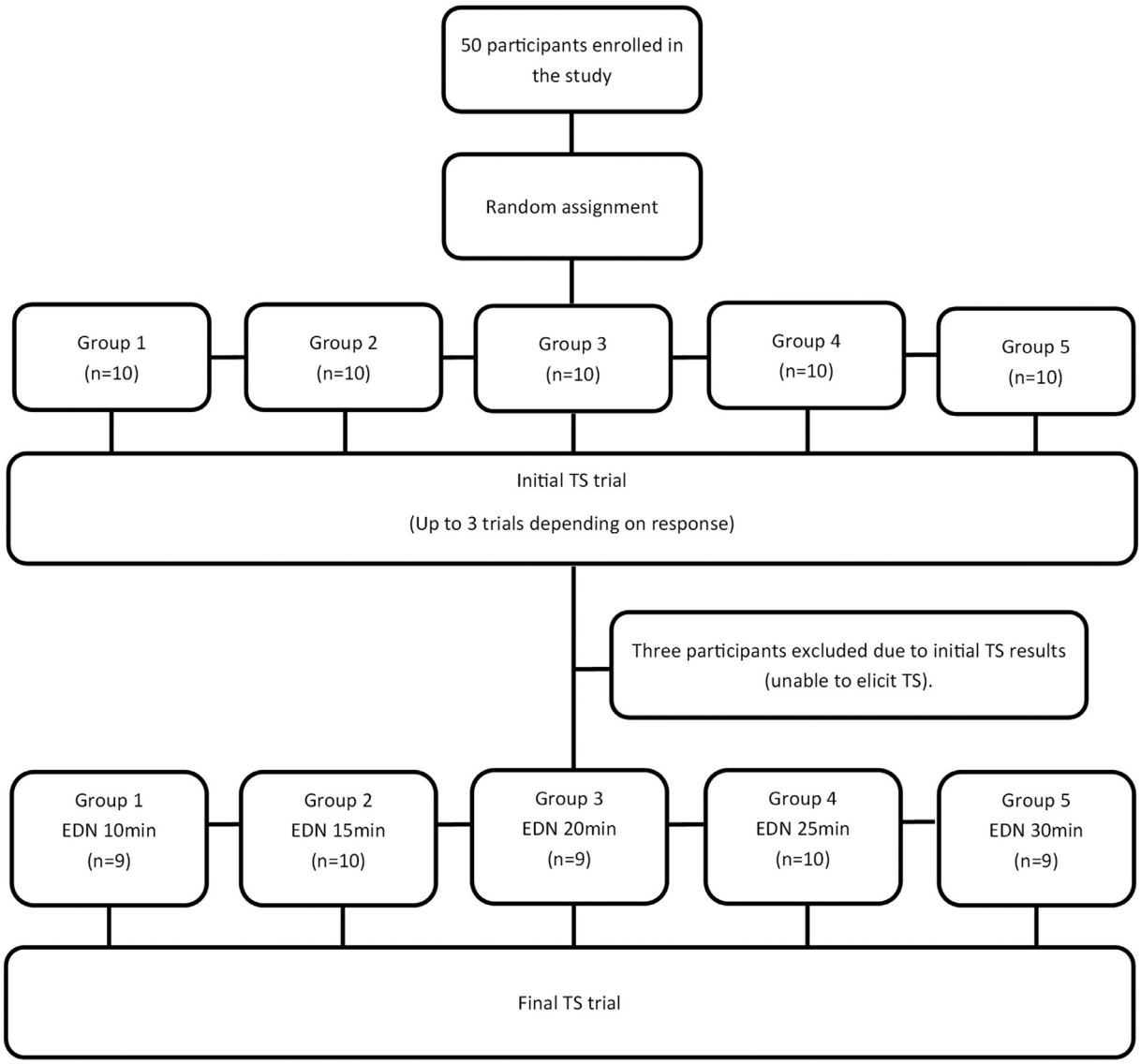

Fig 1 Study flow.

Once the participant was randomized into a group and verbalized understanding of the study procedures, the pre-EDN TS trial was performed as described above. Depending on participant response, 1 to 3 trials of TS was completed. The trial which produced the greatest change in TS was recorded as the pre-EDN TS value. After the initial TS trial, the participant received EDN as described above for the duration that matched their treatment group. Finally, once the EDN was completed, a single post-EDN trial was performed using the parameters of the pre-EDN trial which produced the greatest change in TS.

Data analysis

Data were analyzed using SPSS[c] with descriptive statistics performed on all demographic data (height, weight, sex, etc). To assess the magnitude of our TS (TS_{mag}), we subtracted the verbal rating for the first pulse from the last one.[27,30,31] This method has been shown to demonstrate high within-session reliability.[27] The pre- and post-TS_{mag} was recorded for each participant. A 5 × 2 (group × time) mixed ANOVA was performed to compare the main effect of EDN and the interaction effect between duration and EDN on TS_{mag}. A Scheffe test was used for any post-hoc tests as needed.

Results

Demographic data are outlined in table 1. A total of 50 healthy participants were recruited for this study. Three of the individuals did not exhibit any TS and were therefore excluded from the rest of the study. Thus, 47 health participants (n=33 women) completed the study and were randomized into the 5 groups. The results from the 1-way ANOVAs are summarized in table 1. The results indicate that the age, weight, and height of our 5 groups did not significantly differ.

Table 2 and figure 2 summarize the results from the pre- and post-EDN TS trials. With regard to the 5 × 2 Mixed ANOVA, there was a significant main effect of time ($F_{(1,42)}$=94.12, P<.001, η_p^2=.691), indicating that regardless of duration of EDN there was an overall reduction in the TS experienced by the participants (Δ -16.63, 95% CI -20.09 to -13.17). However, the interaction between time and group was not significant ($F_{(4,42)}$=1.019, P=.409, η_p^2=.088), indicating that no group differed in the treatment effect of EDN.

Because of the disproportionate ratio of men to women within our study we wanted to ensure that sex was not a confounding factor in our analysis. Because the main effect of group in our previous analysis was not significant, the groups were combined and a 2 × 2 Mixed ANOVA (sex × time) was performed to evaluate the potential role of sex. While there was a significant main effect of time ($F_{(1,45)}$=72.395, P<.001, η_p^2=1.0), the interaction effect for sex and time was not significant ($F_{(1,45)}$=.534, P=.469, η_p^2=0.012). This indicates that the sexes did not respond differently from each other.

As the main hypothesis of this study was that there would be a difference in the reduction of TS based on the duration of EDN received, we performed a post hoc power analysis using G*Power 3.1.9.4 on the interaction effect of time × group. Using an effect size of d=0.32, an α error probability of 0.05, an estimate of correlation among the repeated-measures to be 0.5, and a nonsphericity correction of 1, we found the achieved power to be 0.92. This indicates that we had sufficient participants in our study and thus, a decrease in the likelihood of a Type II error.

Table 1 Demographic data for study participants

	Women	Men	Age	Height	Weight
Group 1	5	4	26.8 (4.8)	67.2 (3.2)	158.3 (24.7)
Group 2	6	4	27.3 (5.9)	66.2 (4.2)	146.0 (32.9)
Group 3	9	0	25.5 (5.2)	67.0 (2.1)	145.6 (17.5)
Group 4	6	4	24.9 (4.2)	66.8 (4.5)	155.0 (38.8)
Group 5	7	2	26.9 (6.2)	67.6 (2.9)	176.6 (47.3)
Total	33	14	26.2 (5.1)	66.9 (3.4)	156.0 (34.4)
P value			0.83	0.93	0.3

NOTE. Numbers in parentheses indicate standard deviation. Age is reported in years, height is reported in inches, and weight is reported in pounds. P Value indicates results from 1-way ANOVA.

Discussion

The results of this study suggest that 10 minutes of EDN is equally as effective as up to 30 minutes for reducing participant report of TS in an asymptomatic population. Specifically, this study suggests that EDN can reduce TS in the absence of neuromodulating factors which may alter nociceptive processing (eg, chronic pain). Previous studies have shown that individuals with cLBP often respond differently than asymptomatic individuals to symptom-modulating interventions. For example, while spinal manipulation seems

Table 2 Results from the pre- and post-electro-dry needling temporal summation testing (5 × 2 Mixed ANOVA)

	Duration	Pre-EDN	Post-EDN	Time (*P* Value)
Group 1	10 min	22.89 (10.56)	3.44 (10.73)	94.12 (<.001)
Group 2	15 min	18.50 (10.24)	5.5 (12.11)	
Group 3	20 min	17.33 (14.24)	5.22 (9.64)	Time*Group (*P* value)
Group 4	25 min	20.70 (11.71)	3.0 (10.59)	1.019 (.409)
Group 5	30 min	28.33 (8.41)	7.44 (12.20)	
Total		21.47 (11.37)	4.89 (10.74)	

Values in the Pre- and Post-EDN columns represent the temporal summation magnitude for each group with standard deviations in parentheses. The value in the Time and Time*Group columns represents F Values.

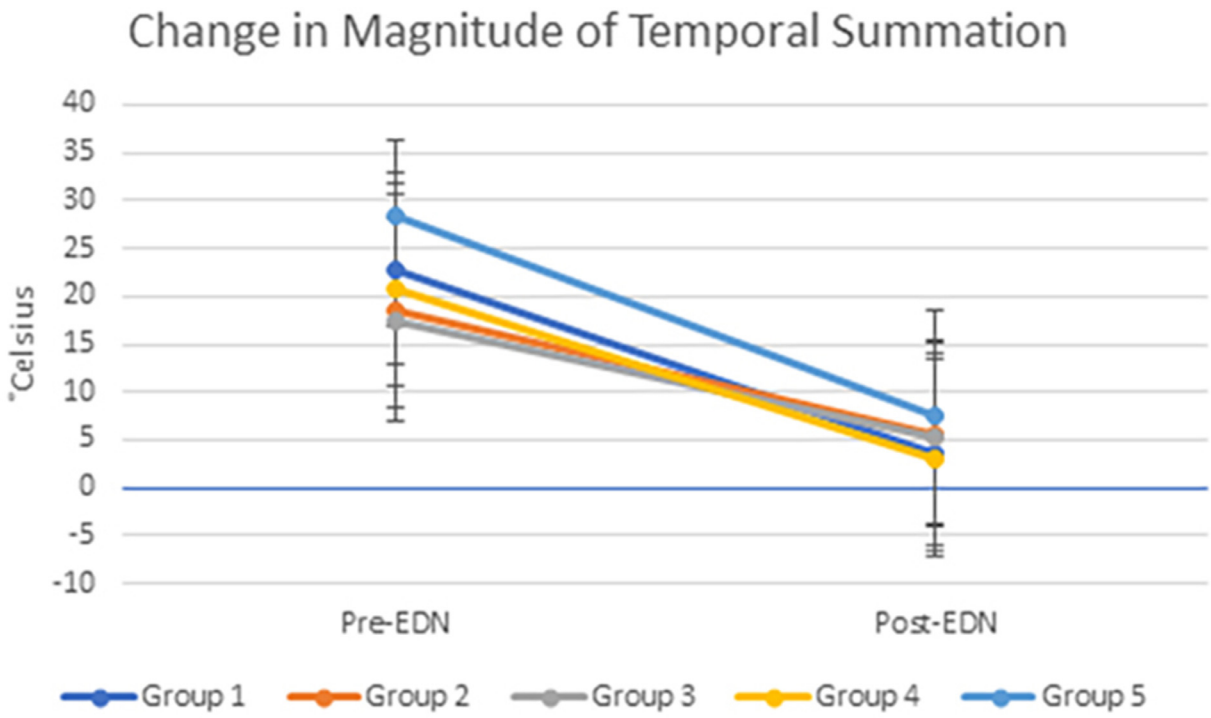

Fig 2 Change in the magnitude of temporal summation for each group.

to have minimal effect on pressure-pain thresholds (PPTs) in asymptomatic individuals,[32,33] it routinely increases PPT in individuals with chronic pain.[34-36] However, the response to manual therapy on dynamic measures of pain regulation seem to be more consistent. Specifically, both healthy individuals and those with chronic pain report improvements in TS after spinal manipulation.[37,38] This study could serve as the basis for improved TS after EDN in an asymptomatic population and help spur on future research in those with cLBP.

One potential mechanism behind the reduction in TS after DN is its purported effects on c-fiber nociceptors. TS classically refers to an increase in the subjective experience of pain from repetitive noxious stimuli delivered at frequencies of 0.33 Hz or higher.[39,40] It is thought that the increase in pain perception represents the facilitation of the responses of wide dynamic range (WDR) neurons to the application of repetitive stimuli of constant intensity.[41] Recent animal studies performed by Qu et al has suggested that electro-acupuncture inhibits c-fiber-evoked activity of the WDR neurons.[42] Thus, if EDN works on similar principles as electro-acupuncture, it could be that the reduction in TS observed in this study is related to the reduced activity of the WDR neurons.

Additionally, Qu et al hypothesized that they were able to have a greater and faster reduction in the firing frequency of WDR neurons than previous research because the area they were stimulating was within the receptive field of the location they were measuring.[42,43] One of the strengths of this study is that the low back was chosen for both the location of the intervention and the measurement of TS. Many trials assessing the responsiveness of TS to different interventions measure it distally from the site of application, in areas such as the thenar eminence and the foot.[44-46] This may detract from the local compounding effects that DN might have and may help explain why our study demonstrated such robust changes in TS.

One possible reason for mixed outcomes from DN studies may be a lack of standardization for intervention procedures.[10,11,47] It is not uncommon to see investigations where needle retention time varies from less than 10 minutes,[48] to 20 minutes,[4] or even up to 60 minutes.[49] What's remarkable is that despite the variation, each of the above studies reported decreases in pain and disability after DN. While needle retention time is just a single component of the overall dosage parameters for EDN, being able to use the same amount of time across studies can help better inform clinicians and provide a basis for future studies.

While direct comparisons of EDN dosages have not been made, Leung et al in 2008 directly compared electro-acupuncture of 3 different durations (5 minutes, 15 minutes, and 30 minutes) on static thermal pain measurements.[50] They found that 5 minutes was too short to elicit significant effects, while 15 minutes was able to generate a greater reduction of pain with an earlier onset of analgesia than the 30 minutes. Thus, they concluded that 15 minutes was the optimal time for needle duration while our study reported no significant difference between the two. While these finding closely resemble ours, 1 potential reason for this difference could be the choice of outcome measure. Leung et al used static pain measurements assessing the perception of pain, while our study used dynamic pain measurements assessing the nervous system's facilitation of nociception.[50] It may be that for dynamic pain measures, there is less of a difference between 15 and 30 minutes of treatment.

Limitations

One limitation to our study was that the distribution of sex was not equal across the groups. We predominantly had women participants and there was 1 group that was all women. This is a potential confounding factor as the difference in pain perception between the sexes has been well documented.[51,52] However, most studies use static pain measurements to determine differences between the sexes, while less is known about the differences in dynamic pain facilitation or inhibition. Furthermore, as described above, we combined all 5 groups and ran a 2 × 5 Mixed ANOVA with sex as the between subject factor. It was demonstrated that at no time points did sex have a significant effect on pain perception.

Additionally, this study excluded anyone with cLBP, which limits the inferences we can make about clinical populations from these data. As EDN is a treatment that can target central sensitization, and cLBP is a population that often exhibits central sensitization, it is possible that EDN will have a different effect with this population. Another limitation is that this study only looked at immediate changes in TS after EDN. Therefore, it remains unknown if different durations of EDN might have longer lasting benefits.

Lastly, this study did not include a control group. While this would have allowed us to determine if the EDN was truly causing a change in TS or if the change was due to time, we opted not to recruit an additional 10 subjects for a control group. This decision was based primarily on the work of Kong et al, whose study the TS protocol was based on.[27] In their study, they found that there was no significant within-day variation of TS scores and between day scores only changed around 5 points out of 100. Thus, we felt confident in the stability of the measure and did not incorporate a control group.

Conclusions

The results from this study suggest that EDN of 10 minutes of duration is just as effective as up to 30 minutes in the immediate term reduction of TS for asymptomatic individuals. For clinicians, this indicates that an effective dose of EDN may be expected at 10 minutes and that the addition of longer needle retention times may not provide any additional clinical benefit for the patient. Future studies should explore how long these changes in TS last, and if similar results are seen in symptomatic patient populations.

Suppliers

a. Medoc Thermal Sensory Analyzer-II; Medoc Advanced Medical Systems.
b. ES-130-Electrostimulator; ITO.
c. SPSS Statistics for Windows, Version 26.0; IBM.

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