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Effects of Electrotherapy on Pain, Anxiety, Mobility, and Proprioception in Young Adults with Mild Neck Pain: A Randomized Controlled Trial

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Background: Mild pain can affect movement leading to disability, and impaired neck proprioception. Transcutaneous electrical nerve stimulation (TENS) has been recommended as an intervention for chronic and subacute neck pain with mobility deficits.

Objective: The purpose was to investigate the effects of transcutaneous electrical nerve stimulation (TENS) for improving cervical spine proprioception and reducing pain, anxiety, and disability in young adults with mild neck pain.

Methods: Twenty-two participants were recruited between the ages of 20-40 years old and randomized into control and intervention groups. Participants had chronic mild neck pain and not receiving pain treatment or medication, and did not have electrotherapy contraindications. The intervention group received a 30-minute TENS intervention and were instructed in a 2-week daily home-based TENS intervention. Outcome measures were visual analog scale, neck disability index, state-trait anxiety inventory, active range of motion (AROM) and joint position error (JPE).

Results: Participants reported reduction in pain, disability, and anxiety post 30-minute intervention. Increase in right lateral flexion AROM and decrease in mean JPE extension post 30-minute intervention. Post 2-week intervention, reduction in pain, an increase in right lateral flexion AROM, and a reduction in mean JPE extension were also detected.

Conclusion: People with chronic mild neck pain had a reduction in pain, anxiety, and disability post 30-minutes TENS treatment. Reduction in anxiety and disability with TENS treatment suggests that TENS may be beneficial in reducing pain, anxiety, and improving neck proprioception in young adults with mild neck pain.

Key Words: Pain, Anxiety, Proprioception, TENS, Mobility

Introduction

Chronic pain is one of the most common medical conditions, [1] however, mild pain (low irritability) generally does not prompt people to seek medical treatment [2-6]. Pain can lead to anxiety, which is often treated with pharmacological interventions and movement avoidance [7-8]. Mild pain may increase with anxiety [9,10] and affect movement, which can lead to disability, and impaired neck proprioception [5-6, 11-15].

Transcutaneous electrical nerve stimulation (TENS) has been recommended as an intervention for chronic and subacute neck pain with mobility deficits and movement coordination impairments [16]. Even though electrical stimulation for pain modulation has been used for many years, there is an "efficacy-impasse" for clinical utilization of TENS, despite fifty years of

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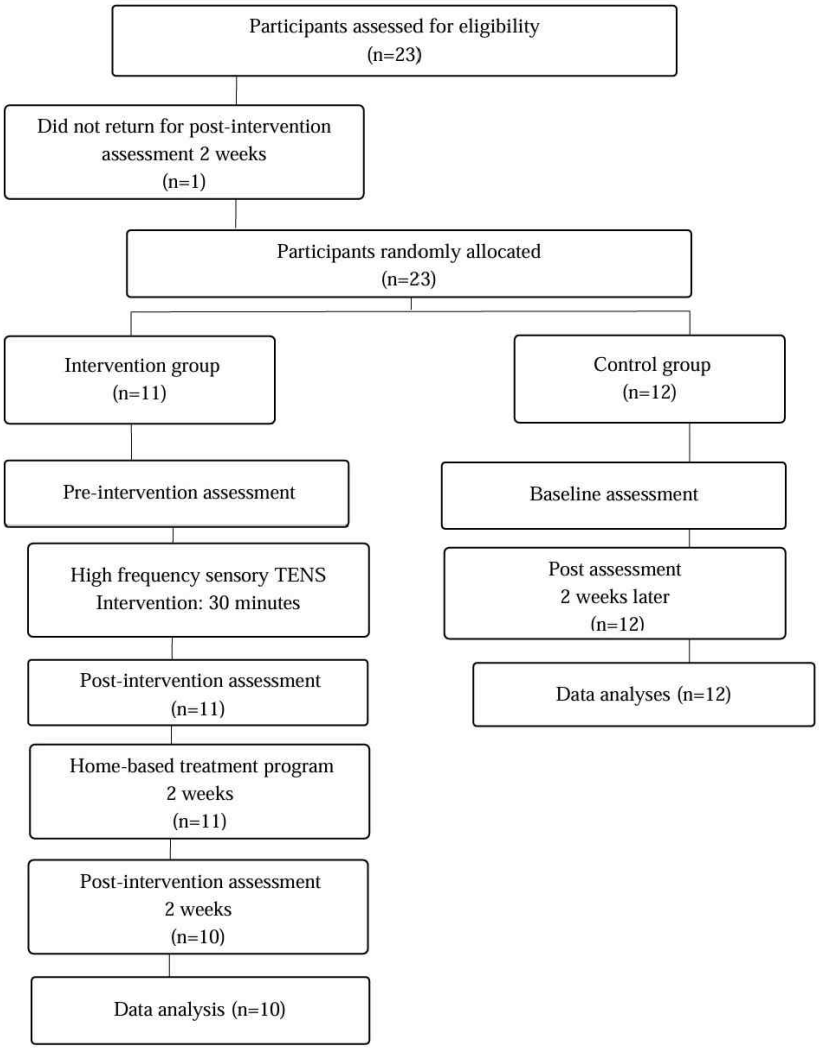

Figure 1. CONSORT diagram

published research [17]. Therefore, the purpose of this study was to investigate short-term effects of electrotherapy, specifically TENS, for improving cervical spine proprioception and reducing pain, anxiety, and disability in young adults with chronic mild neck pain.

Methods

Trial Design

Randomized control trial conducted in the Physical Therapy Department at Loma Linda University (LLU). The study was approved by the LLU Institutional Review Board (IRB# 5220149) and registered with ClinicalTrials.gov (Identifier: NCT05382039). Informed consent was obtained from all participants before inclusion following the Consolidated Standards of Reporting Trials (CONSORT) guidelines [18] (Figure 1). All procedures were applied in accordance with the Declaration of Helsinki. Participants had the opportunity to ask questions before deciding to participate in the study.

Participants

Twenty-three young adults recruited between the ages of 20-40 years old and randomized into a control group and intervention group. Participants were recruited from the student population at LLU through word of mouth, emails and flyers. Inclusion criteria were as

follows: 1) adults between 20-40 years of age currently enrolled as students at LLU and 2) chronic (＞3 months) neck pain of ＜4/10 on the visual analog scale (VAS). Exclusion criteria were follows: 1) currently receiving clinical pain treatment, 2) pain medication usage within six hours of data collection, 3) acute pain (＜3 months), 4) electrotherapy contraindications, and/or 5) unwilling to receive daily SMS text message home program reminder.

Randomization

Twenty-three participants with chronic mild neck pain were randomized into two groups: twelve participants in the control group, and eleven participants in the intervention group. Group assignment was determined using a random number table.

Intervention

Participants in the intervention group were provided with a TENS unit for home use for a period of two weeks and instructed by a licensed physical therapist. In addition, participants were provided a daily log sheet to track TENS usage and received daily text message reminders for compliance. Then, participants received a 30-minute high-frequency sensory TENS treatment on the painful neck area. TENS unit parameters were set to 110 pulses per second, a pulse duration of 80 microseconds, and an amplitude that produced a tingling sensation (sensory stimulation), no muscle contraction. Participants in the intervention group were contacted daily via text message for compliance with high-frequency sensory TENS before session two. Participants in the intervention group returned the TENS unit and daily log sheet to investigators.

Outcomes Measures

Baseline assessments were performed for both groups. The intervention group was also assessed after the 30-minute high-frequency sensory TENS treatment. After two weeks, both groups returned for follow-up assessment.

The VAS was utilized for subjective assessment [19] of pain intensity along a 10-centimeter (cm) line [19] with anchor statements on the left (0cm: no pain) and most pain imaginable on the right (10cm). The distance between the starting point and marking was analyzed and interpreted as participants' pain level [20]. We defined mild neck pain as a VAS score of less than or equal to 4/10 [21]. The VAS exhibits moderate reliability as a self-report instrument when utilized by patients with neck pain, as indicated by the intraclass correlation coefficient (ICC＝0.72; [95 % CI: 0.08-0.90]) [22]. In the context of evaluating outcomes, the Minimally Clinically Important Difference (MCID) for the VAS after a 4-week intervention is a minimum reduction of 2.5 points. This threshold is suggested for clinicians and researchers to determine the clinical significance in VAS score changes [22].

The Neck Disability Index (NDI) has ten different items: pain intensity, personal care, lifting, reading, headaches, concentration, work, driving, sleeping, and recreation. Participants rate the impact of their neck pain on the ten activities using a six-point Likert scale ranging from no impact to worst imaginable [23-25]. The items are measured on a 6-point scale from 0 (no disability) to 5 (full disability) [24]. Numeric responses are added for a score from 0 to 50 [24-25], and scores can be entered as a percentage as well: 0-4 (0-8%), no disability; 5-14 (10-28%), mild disability; 15-24 (30-48%), moderate disability; 25-34 (50- 64%), severe disability; and greater than 35 (70-100%), complete disability [26]. Scores in this study were recorded as percentages. A reduction of at least 5.5 points on the NDI after a 4-week intervention is considered clinically meaningful [22].

The State-Trait Anxiety Inventory (STAI) provides an empirical measure of the anxiety level of "normal" adults through a self-report questionnaire that measures symptoms of anxiety and propensity to be anxious [27-28]. STAI has 2 subscales (20 items for each subscale): 1) State Anxiety Scale (S-Anxiety) which is current state of anxiety and feelings, 2) Trait Anxiety Scale (T-Anxiety) which evaluates "anxiety proneness" and frequency of feelings [27,29]. STAI contains 20 items for each subscale, S-Anxiety and T-Anxiety [27,29]. The range of scores is 20-80 with higher scores indicating greater anxiety [27,29]. Although the

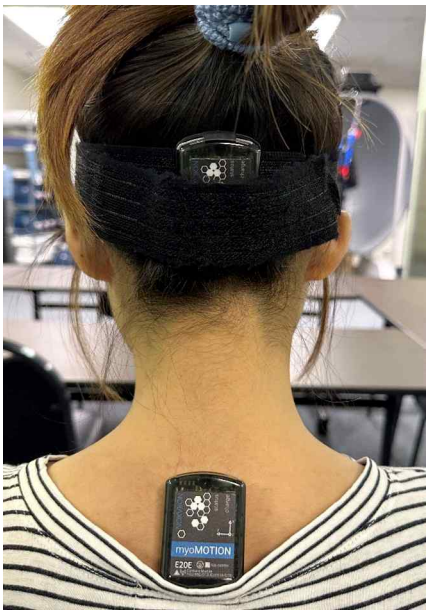

Figure 2. Noraxon myoMOTION^{TM} sensor placement

specific STAI reliability in individuals with neck pain has not been investigated, studies conducted on patients with anxiety disorders have reported excellent reliability with reliability coefficients ranging from 0.87 to 0.93 [30].

The MyoMOTION^{TM} 3D Motion Analysis System (Manufacturer: Noraxon U.S.A Inc.- Scottsdale, Arizona, USA) - Research PRO system (Model 680 MyoMOTION^{TM} Research Receiver/Model 610 MyoMOTION^{TM} sensor) with Noraxon MR3, version 3.16.88 software [31] was utilized to quantify cervical active range of motion (AROM) and joint position error (JPE) by using two Inertial Measurement Unit (IMU) sensors that measured angles and acceleration of joints [31]. One sensor was placed in the middle of the back of the head with a special fixation strap [31] and the other sensor was attached with double sided tape below C7 vertebra in line with the spinal column [31] (Figure 2).

This data is transmitted to the MyoMOTION^{TM} system receiver which detects and records segment angular changes. According to Yoon et al. [32], the MyoMOTION^{TM} 3D Motion Analysis System has shown good to high reliability with relatively small standard error of measurement and reasonable validity in angular measurement of the cervical spine. JPE errors of 4.5 degrees suggest an impairment in the ability to reposition the head [33].

Participants

Twenty-three participants signed the informed consent. One female participant from the intervention group was not able to come back for post 2 weeks' measurements. Thus, 22 participants with a mean ± SD age of 25.8±3.1 years and body mass index of 26.7±6.0 kg/m^2 completed the study. The majority were females (n = 16, 72.7%).

Data Analyses

Data was analyzed using SPSS version 28.0. Data was summarized using frequency (%) for qualitative variables, mean ± standard deviation (SD) for continuous variables, and median (minimum, maximum) when the distribution was not approximately normal. The normality of the outcome variables was examined using the Shapiro wilk test and boxplots. The frequency distribution of gender between the two study groups was compared using Fisher's exact test. Mean baseline characteristics and outcome variables by study group was examined using independent t-test. Median VAS, NDI, and JPE rotation right were compared between

the intervention and control groups using Mann-Whitney U test. For each study group, changes in mean outcome variables (cervical spine AROM, anxiety, neck proprioception, VAS, NDI) over time (post versus pre) were examined using paired t-test or Wilcoxon signed rank test when the distribution is not approximately normal. Changes in outcome variables by group (intervention versus control) overtime (post 2 weeks versus pre) were assessed using 2x2 mixed factorial analysis of variance (ANOVA). If there was a significant interaction between group and time, the changes are significantly different between the two groups. There was a significant difference in mean STAI_T and lateral flexion left between the intervention and control groups at baseline, thus this was controlled for baseline differences using analysis of covariance (ANCOVA). In the intervention group, we examined changes in outcome variables over time (pre versus post 30 minutes versus post 2 weeks) using repeated measures ANOVA or Friedman's test if the data was not approximately normal. If the results were significant, Bonferroni's post hoc comparisons were conducted, or Wilcoxon signed rank test were used to determine what times were significantly different. The level of significance was set at $p \leq 0.05$.

Results

There was no significant difference in mean baseline variables between the intervention and control

Table 1. Mean ± SD of Participants' Characteristics and Baseline Variables by Study Group (N = 22)

Variable	Intervention ($n_1 = 10$)	Control ($n_2 = 12$)	*p*-value (d)
Female; n (%)	5 (50.0)	11 (91.6)	0.056 (0.47)[W]
Age (years)	25.8±3.6	26.0±2.8	0.885 (0.63)
BMI (kg/m^2)	24.4±4.2	28.0±7.0	0.162 (0.62)
VAS[*]	1.2 (0.5,3.8)	2.0 (0.1, 3.5)	0.821 (0.05)
NDI(%)[*]	10 (4,22)	18 (0, 22)	0.093 (0.36)
STAI_S	16.1±8.1	20.3±5.6	0.170 (0.61)
STAI_T	17.3±3	23.3±5.0	**0.007 (1.32)**
Flexion	53.7±9.7	49.2±10.0	0.304 (0.45)
Extension	40.0±11.4	39.5±14.8	0.938 (0.03)
Lateral Flexion Right	36.4±8.6	35.5±5.3	0.761 (0.13)
Lateral Flexion Left	40.1±7.8	34.4±4.8	**0.049 (0.90)**
Rotation Right	68.0±6.4	64.6±8.3	0.310 (0.45)
Rotation Left	66.1±8.8	63.9±8.0	0.538 (0.27)
JPE Flexion	3.5±3.0	6.0±4.9	0.172 (0.61)
JPE Extension	5.1±2.5	5.8±3.5	0.635 (0.21)
JPE Rotation Right[*]	2.5 (1.2,18.0)	2.6 (0.9,8.4)	0.628 (0.11)[Y]
JPE Rotation Left	2.6±1.1	3.1±2.1	0.498 (0.30)

Abbreviations: BMI, Body Mass Index; VAS, Visual Analogue Scale; NDI, Neck Disability Index Scale; STAI_S, State-Trait Anxiety Inventory_State; STAI_T, State-Trait Anxiety Inventory_Trait; SD, Standard Deviation.

[*] Median (Minimum, Maximum)

[Y] Effect Size for Wilcoxon Signed Rand Test

[W] Effect Size for Chi-Square Test.

$d = \frac{Mean\ of\ the\ difference}{SD\ of\ the\ difference}$, $r = \frac{Z}{\sqrt{N}}$, $j = \left(\frac{c\,2}{n}\right)$

Table 2. Changes in Mean ± SD of Outcome Variables by Time and Group (N = 22)

	Intervention (n = 10)				Control (n = 12)					
Variable	**Pre**	**Post 2weeks**	**Mean Difference 95% CI**	***p*-value (d)**	**Pre**	**Post 2weeks**	**Mean Difference 95% CI**	***p*-value (d)**	***p*-value Overtime (η^2)**	***p*-value Time x Group (η^2)**
VAS	1.7±1.1	0.5±0.5	-1.1 (-1.9, -0.4)	**0.011(0.80)**	1.8±1.1	1.6±1.0	-0.2 (-0.6, 0.2)	0.246 (0.34)	**0.001 (0.42)**	**0.02 (0.24)**
NDI (%)*	10.6±5.7	4.2±4.2	-6.4 (-10.1, -2.7)	**0.007(0.85)**	14.8±6.2	14.2±10.2	-0.7 (-6.1, 4.8)	0.673 (0.12)	**0.034 (0.21)**	**0.04 (0.15)**
STAI_S	16.1±8.1	12.4±2.5	-3.7 (-9.5, 2.1)	**0.045 (0.50)**	20.3±5.6	23.3±5.1	3.1 (0.5, 5.7)	**0.024(0.76)**	0.819 (0.00)	**0.019 (0.25)**
STAI_T	17.3±3.8	14.8±2.8	-2.6 (-5.1, 0.0)	**0.026(0.76)**	23.3±5.0	23.9±6.3	0.6 (-1.0, 2.2)	0.430 (0.24)	0.938 (0.00)	**0.039 (0.22)**
Flexion	53.7±9.7	51.3±8.6	-2.4 (-11.0, 6.2)	0.270(0.20)	49.2±10.0	49.5±11.0	0.2 (-6.7, 7.2)	0.942 (0.02)	0.659 (0.01)	0.593 (0.02)
Extension	39.9±11.4	42.2±11.7	2.3 (-2.9, 7.4)	0.171(0.32)	39.5±14.8	38.9±14.8	-0.6 (-7.1, 5.9)	0.847 (0.06)	0.666 (0.01)	0.468 (0.03)
Lateral Flexion Right	36.4±8.6	40.0±6.4	3.6 (1.0, 6.3)	**0.006(0.99)**	35.5±5.3	36.2±4.7	0.7 (-1.9, 3.3)	0.571 (0.17)	**0.017 (0.25)**	**0.045 (0.14)**
Lateral Flexion Left	40.1±7.8	40.6±4.6	0.4 (-2.5, 3.4)	0.372(0.11)	34.4±4.8	33.0±3.1	-1.4 (-3.8, 0.9)	0.206 (0.39)	0.552 (0.02)	0.273 (0.06)
Rotation Right	67.4±9.9	70.9±6.3	2.9 (-0.7, 6.5)	0.050 (0.56)	64.6±8.3	65.0±6.6	0.4 (-3.6, 4.4)	0.818 (0.02)	0.190 (0.08)	0.324 (0.05)
Rotation Left	66.1±8.8	70.2±5.4	4.1 (-1.0, 9.3)	**0.050(0.57)**	63.9±7.9	61.7±9.2	-2.2 (-5.1, 0.6)	0.116 (0.49)	0.464 (0.03)	**0.020 (0.24)**
JPE Flexion	3.5±3.0	4.1±2.6	0.6 (-1.1, 2.2)	0.219(0.26)	6.0±4.9	5.4±2.7	-0.6 (-3.7, 2.5)	0.682 (0.12)	1.000 (0.00)	0.490 (0.02)
JPE Extension	5.1±2.5	3.4±1.2	-1.7 (-3.5, 0.0)	**0.027(0.70)**	5.8±3.5	6.2±3.5	0.4 (-2.1, 2.9)	0.718 (0.11)	0.370 (0.04)	**0.049 (0.10)**
JPE Rotation Right	4.2±5.0	3.7±3.0	-0.6 (-3.4, 2.3)	0.333(0.14)	3.4±2.1	3.3±3.2	-0.1 (-2.0, 1.7)	0.893 (0.04)	0.649 (0.01)	0.764 (0.01)
JPE Rotation Left	2.6±1.1	2.7±1.7	0.2 (-0.7, 1.0)	0.334(0.14)	3.1±2.1	3.4±1.9	0.4 (-1.1, 1.8)	0.584 (0.16)	0.510 (0.02)	0.796 (0.00)

Abbreviations: SD, Standard Deviation; VAS, Visual Analogue Scale; NDI, Neck Disability Index Scale; STAI_S, State-Trait Anxiety Inventory_State; STAI_T, State-Trait Anxiety Inventory Trait

*Median (Minimum, Maximum)

group except for STAI_T and lateral flexion to the left ($p = 0.007$ and $p = 0.049$, respectively) (Table 1). Changes in pain, disability, anxiety, cervical spine AROM, and JPE by study group over time (post 2 weeks versus baseline) are displayed in Table 2. Results of the mixed factorial ANOVA showed that there was a significant change in pain and disability over time ($F_{1,20} = 14.7$, $p = 0.001$ and $F_{1,20} = 5.2$, $p = 0.034$, respectively) and this change differed by group as shown by the significant interaction ($F_{1,20} = 6.4$, $p = 0.02$, and $F_{1,20} = 3.5$, $p = 0.04$). There was a significant reduction in pain and disability in the intervention group post 2 weeks versus baseline (0.5±0.5 versus1.7±1.1, $p = 0.011$; Cohen's d = 0.80, and 4.2±4.2 versus 10.6±5.7, $p = 0.007$, Cohen's d = 0.89; respectively) but no significant changes were detected in the control group for pain and disability ($p > 0.05$). For STAI_S, there was a significant group by time interaction ($F_{1,20} = 6.5$, $p = 0.019$). There was a significant reduction in STAI_S for the intervention group post 2 weeks versus baseline (12.4±2.5 versus16.1±8.1, $p = 0.045$; Cohen's d = 0.50) but a significant increase in STAI_S over time for the control group (23.3±5.1 versus 20.3±5.6, $p = 0.024$; Cohen's d = 0.76). Since there was a significant difference in mean STAI_T between the intervention and control groups at baseline, we controlled for this difference using ANCOVA. Results showed that there was a significant group by time interaction ($F_{1,20} = 4.9$, $p = 0.039$). There was a significant reduction in STAI_T for the intervention group post 2 weeks versus baseline (14.8±2.8 versus17.3±3.8, $p = 0.026$; Cohen's d = 0.76), but no significant change in STAI_T over time for the control group (23.9±6.3 versus 23.3±5.0, $p = 0.430$) (Table 2).

In terms of cervical spine AROM, there was no significant change in mean flexion, extension, lateral flexion left, and rotation right over time or between the study groups ($p > 0.05$). For changes in lateral flexion right, there was a significant group by time interaction ($F_{1,20} = 3.5$, $p = 0.045$) which indicated that the changes differed by study group. There was a significant increase in mean lateral flexion right for the intervention group post 2-weeks versus baseline 40.0±6.4 versus 36.4±8.6; $p = 0.006$, Cohen's d = 0.99), however, there was no significant change in the control group (36.2±4.7 versus 35.5±5.3; $p = 0.571$, Cohen's d = 0.17) (Table 2). When assessing changes in mean rotation left over time by group, we found a significant interaction between time and group ($F_{1,20} = 6.3$ $p = 0.020$). Thus, there was a significant increase in mean rotation left for the intervention group post 2-weeks (70.2±5.4 versus 66.1±8.8; $p = 0.05$, Cohen's d = 0.57), however, no significant change in the control group was found ($p = 0.116$) (Table 2).

For changes in mean JPE extension, there was a significant group by time interaction ($F_{1,20} = 3.6$, $p = 0.049$) which indicated that the changes differed by study group. There was a significant decrease in mean JPE extension for the intervention group post 2-weeks versus baseline (3.4±1.2 versus 5.1±2.5; $p = 0.027$ Cohen's d = 0.70), however, there was no significant change in the control group (6.2±3.5 versus 5.8±3.5; $p = 0.718$, Cohen's d = 0.11) (Table 2). There were no significant changes in mean JPE flexion, JPE extension, and JPE rotation left over time or between the study groups ($p > 0.05$).

In the intervention group, changes in VAS, STAI_S, cervical spine active AROM, and JPE over time (pre versus post versus post two weeks) are displayed in Table 3. There was a significant change in median VAS score over time ($\chi^2 = 10.4$, $p = 0.005$). Post hoc comparisons using Wilcoxon signed rank test showed that there was a significant reduction in pain post 30 minutes compared to baseline (Z = -2.7, $p = 0.007$) and post 2 weeks compared to baseline (Z = -2.6, $p = 0.011$), but there was no significant difference between post 2 weeks and post 30 minutes (Z = -1.2, $p = 0.24$) In addition, there was a significant change in mean lateral flexion right over time ($F_{2,18} = 4.0$, $p = 0.024$). Bonferroni's post hoc comparisons showed that there was a significant increase in mean lateral flexion right post 2 weeks compared to baseline (40.0±6.4 versus 36.4±8.6; $p = 0.036$), however, no significant difference between post 30 minutes versus baseline and post 2 weeks versus post 30 minutes were detected ($p > 0.05$) (Table 3).

Table 3. Changes in Mean ± SD of Outcome Variables for the Intervention Group Overtime (N = 10)

Variable	Pre	Post	Post 2 weeks	*p*-value (η^2)
VAS*	1.2 (0.5,3.8)	0.8 (0.0, 1.5)	0.4 (0.0, 1.7)	**0.005 (0.52)**
STAI_S	16.1±8.1	12.3±3.1	12.4±2.5	0.172 (0.19)
Flexion	53.7±9.7	51.7±6.2	51.3±8.6	0.699 (0.04)
Extension	40.0±11.4	44.7±12.8	42.2±11.7	0.365 (0.11)
Lateral Flexion Right	36.4±8.6	38.2±8.5	40.0±6.4	**0.024 (0.34)**
Lateral Flexion Left	40.1±7.8	40.1±7.2	40.6±4.6	0.939 (0.01)
Rotation Right	68.0±6.4	67.4±9.9	70.9±6.3	0.149 (0.19)
Rotation Left	66.1±8.8	69.2±6.1	70.2±5.4	0.250 (0.14)
JPE Flexion	3.5±3.0	4.2±3.1	4.1±2.6	0.561 (0.06)
JPE Extension	5.1±2.5	2.7±1.7	3.4±1.2	**0.020 (0.35)**
JPE Rotation Right*	2.5 (1.1,18.0)	2.0 (0.8,8.6)	2.3 (0.9,9.0)	0.122 (0.21)
JPE Rotation Left	2.6±1.1	2.5±1.7	2.7±1.7	0.914 (0.01)

Abbreviations: VAS, Visual Analogue Scale; STAI_S, State-Trait Anxiety Inventory_State; SD, Standard Deviation.
*Median (Minimum, Maximum)

In the intervention group, there were no significant changes in mean STAI_S, flexion, extension, lateral flexion left, rotation right, rotation left, JPE flexion, JPE rotation right, and JPE rotation left over time ($p > 0.05$). However, there was a significant change in mean JPE extension over time ($F_{2,18} = 4.9$, $p = 0.020$). Bonferroni post hoc comparisons showed that there was a significant decrease in mean JPE extension post 30 minutes compared to baseline (2.7±1.7 versus 5.1±2.5; $p = 0.035$), however, no significant difference between post 2 weeks versus baseline and post 2 weeks versus post 30 minutes were detected ($p > 0.05$) (Table 3).

Discussion

This randomized controlled trial study provided intervention for young adults with chronic mild neck pain that were not receiving any type of pain treatment. For neck pain with movement coordination impairments [including whiplash associated disorder (WAD)], clinicians may provide TENS to patients with acute pain whose condition is perceived to be at low risk of progressing toward chronicity (Grade C) [16]. For patients with chronic neck pain with movement coordination impairments (including WAD) clinicians may provide TENS as treatment option as well (Grade C) [16]. For patients with chronic neck pain with mobility deficits, TENS was shown to be beneficial if combined with other interventions (e.g., magnetic stimulation, exercise, heat, etc.) [16]. For patients with acute and subacute neck pain with mobility deficits, no studies supported TENS [21].

There was a significant pain decrease in the intervention group after the initial intervention and continued to decrease over the two-week home-based TENS intervention. In the present study, despite not reaching the minimum pain reduction of 2.5 points as recommended by Young et al [22]. for clinically important outcomes, we did observe a mean reduction in pain of 1.1/10 points following the two-week intervention. The present study specifically included individuals with mild neck pain, and the intervention group initially had a baseline VAS score of 1.7/10 (as indicated in Table 2). Given the relatively low baseline pain level, achieving a reduction of 2.5 points was not feasible within the scope of our study. During the two-week period, the VAS scores of the control group did not show a significant change, with only a minimal change of 0.2/10 observed.

The intervention group experienced a significant reduction in disability as well as approaching the MCID of 5.5/50 or a 10% reduction of NDI. Since the intervention group started with mild disability (10.6%), achieving a reduction of 10% points was not feasible within the scope of our study. The control groups' disability remained relatively unchanged over the two-week period (0.6% reduction).

Anxiety and mild neck pain could be a factor when being a student in a higher education institution. In this study, there was a significant reduction in STAI_S and STAI_T (how participant felt at the moment and in general) for the intervention group post 30-minutes of TENS intervention compared to an increase over time in the control group. Also, there was a significant reduction in STAI_T compared to no significant change in the control group.

The timing of data collection may have been influenced by the timeline of the academic quarter. As mentioned previously, chronic pain can be altered by factors in social life along with anxiety and functional disability [7-8].

JPE extension errors in the intervention and control groups ($>4.5^{o}$) suggested an impairment for repositioning of the neck [33]. However, the intervention group showed an improvement in JPE extension of 1.7^{o} and the control group showed an increase in error of 0.4^{o} (Table 2). In contrast to the findings of Quartey et al [34]. who concluded that JPE testing appears to lack utility for patients with mild neck disability, our study reveals divergent results for cervical extension. In conjunction with the decrease of pain, this could have added to the improvement of posture and decrease of head extension. The combination of these factors, such as pain and anxiety, could have the potential to increase mobility problems. Sometimes the strategies used by the students to transition to an unfamiliar higher education environment can be not as effective and may contribute to more anxiety [35].

Study limitations included small sample size and sampled population. Participants in this study were

relatively young students (mostly females), and by design, had low tissue irritability as defined by mild neck pain and low disability so it was not feasible to achieve MCID values as described by Young et al [36,22]. Also, TENS intervention was delivered in a comfortable and relaxed setting which could have contributed to the decrease in pain. Future studies should include an even distribution between males and females, same time of the year and even distribution of students and non-students.

Conclusion

In conclusion, people with chronic mild neck or upper quadrant pain had a reduction in pain and disability post 30-minutes TENS treatment compared to baseline when compared to the group that did not receive TENS treatment. Pain continued to decrease over the two weeks of home-based TENS treatment. In addition, the reduction in anxiety and disability in the intervention group with TENS treatment suggests that TENS may be beneficial in reducing pain, improving proprioception, and decreasing related anxiety in young adults with chronic neck pain with low tissue irritability. The results of this study did not reveal any meaningful differences with movement in participants with mild neck pain compared with controls. Further research is needed on the effects of TENS on different age groups and occupations.

CONFLICT OF INTEREST

There is no conflict of interest.

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