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

-Authors: Pablo Mleziva PT, PhD(c). Department of Physical Therapy, Assistant Professor, Loma Linda University, California, USA. **Eric Glenn Johnson** PT, DSc. Department of Physical Therapy, Professor, Loma Linda University, California, USA. **Everett Lohman III** PT, DSc. Department of Physical Therapy, Professor, Loma Linda University, California, USA.. **Madeha Jaber** Department of Physical Therapy, Professor, Loma Linda University, California, USA. **Lillian Mleziva** Department of Physical Therapy, San Gorgonio Memorial Hospital, 600 N Highland Springs Ave, Banning, California 92220, USA. **Noha Salim Daher** Department of Public Health, School of Allied Health Professions, Professor, Loma Linda University, California, USA

-Institutional Review Board (IRB# 5220149) approved 4/29/2022 at Loma Linda University at University. Registered with ClinicalTrials.gov (Identifier: NCT05382039).

-Financial disclosure and Conflict of Interest: I affirm that I have no financial affiliation or involvement with any commercial organization that has a direct financial interest in any matter included in this clinical trial.

-Corresponding author: Pablo Mleziva Address: 24951 North Circle Drive, Nichol Hall, Loma Linda, California, 92354 Email: pmleziva@llu.edu

-Funding: None

1. PROTOCOL INFORMATION

Title: Effects of electrotherapy on cervical spine proprioception, pain, anxiety, and disability in adults with subclinical neck or upper quadrant pain.

Funding Source: School of Allied Health Professions (SAHP)

Phase of Study: N/A

Version Date of Protocol: N/A

2. PRINCIPAL INVESTIGATOR'S INFORMATION

PI Name: Eric Glenn Johnson, DSc, PT, MS-HPEd, NCS

Title: Professor, SAHP, Physical Therapy Department

Name & Address of Research Institution: Loma Linda University, School of Allied Health Professions, Nichol Hall Room #A-712, Loma Linda, CA 92350

Ext # 47471 FAX # (909) 558-0459

Email Address: ejohnson@llu.edu

3. STUDY PERSONNEL

Name: Eric Johnson. Email: ejohnson@llu.edu

Name: Pablo Mleziva. Email: pmleziva@llu.edu

Name: Everett Lohman. Email: elohman@llu.edu

Name: Lillian Mleziva. Email: LMleziva@llu.edu

Name: Noha Daher. Email: ndaher@llu.edu

Name: Madeha Jaber. Email: mmjaber@students.llu.edu

4. STUDY INFORMATION

Location(s) of Research Activity: SAHP Neuroscience Research Laboratory- Room Nichol Hall A-712, 24951 North Circle Drive, Loma Linda, CA 92354.

Expected Start/Stop Dates of Research: July 1, 2022-June 30, 2023.

Special Time Sensitivities: N/A

Type of Research: Experimental

5. INCLUSION / EXCLUSION CRITERIA

Inclusion criteria: Subjects will be adults between 20-40 years of age currently enrolled as students at Loma Linda University. There will be three groups. The

normal group will include twenty subjects with no neck and/or quadrant pain. The control group will include twenty subjects with neck and/or upper quadrant chronic subclinical pain and the intervention group will include twenty subjects with neck and/or upper quadrant chronic subclinical pain.

Exclusion criteria: Individuals currently receiving clinical pain treatment, pain medications within six hours of data collection, acute pain (control and intervention groups), individuals with electrotherapy contraindications, and unwilling to receive daily SMS text message home program reminder. Exclusion criteria will be determined by self-report using a questionnaire.

6. SUBJECT RECRUITMENT & SCREENING

This study will have a sample size of 60 adults (males and females) between 20 to 40 years of age. This sample size will provide us with enough power to detect the needed effect size. The estimated attrition rate is 15 percent. The participants will be recruited from the student population at Loma Linda University via flyers, posters, hand-outs, mass emails, and word of mouth. The phone script will be used when potential subjects contact us after seeing the flyer.

7. INFORMED CONSENT PROCESS

The informed consent will be conducted by Pablo Mleziva in the SAHP Neuroscience Research Laboratory with a single potential subject at a time. Participants will have the opportunity to ask questions before deciding to participate. Those participants who meet inclusion criteria will be identified by a code on all documents other than their signature on the informed consent. Twenty participants with no pain will be in the normal group. Forty participants with chronic subclinical neck or upper quadrant pain will be randomized (random number table will be used) into two groups: twenty subjects in the control group, and twenty subjects in the intervention group. All participants' records will be stored in a locked cabinet, in a locked office and stored on a secure drive.

8. STUDY DESIGN

a. Background or rationale for this study.

As defined by the International Association for the Study of Pain (IASP) pain is "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage." (IASP, 2021) and one of the most

common reasons people seek medical care is chronic pain. Approximately 50 million adults in United Stated have chronic pain affecting daily lives[1] posting public health problems in costs of pharmacological management.[2,3] The financial cost to care for people with chronic pain is more costly than diabetes, cardiovascular and cancer combined.[4,5]

Chronic pain is persistent or recurrent pain that last longer than 3 months in one or more locations in the body even beyond the period of the expected healing phase.[6,7] Chronic pain can be affected by biological, psychological, and social factors that are accompanied by anxiety, depression, frustration, deconditioning, functional disability, financial problems and opioid use problems.[8,9] As people experience pain, that experience and manifestation of pain is unique to each individual and includes physical and psychological factors[7] making the managing pain and chronic pain can a difficult thing to achieve.[1]

Facing an opioid epidemic, the Centers of Disease Control and Prevention (CDC) reports that studies of 2 weeks to 6 months in duration that utilized effective non-pharmacological treatments for chronic pain were effective.[10] Among the recommendations from the CDC for non-opioid and non-pharmacological treatments for pain, physical therapy is included.[10,11] As physical therapists we find imperative to reinforce the use of non-pharmacologic options for pain relief in people that are tackling the difficult task of managing their pain to continue with their normal lives.

As mentioned previously, one of the most common reasons people seek medical care is chronic pain;[1] however, subclinical pain (mild, low irritability) generally does not prompt people to seek medical treatment.[12,13,14] Subclinical pain can be measured by the visual analog scale (VAS) score of $\leq$3.4/10.[15] In addition, non-pharmacological treatments in physical therapy for chronic subclinical pain have not been studied extensively. Pain can lead to anxiety (which is often treated with pharmacological interventions) and avoidance of movement.[8,9] Pain and local inflammation in the cervical spine or upper quadrant, coupled with avoidance of movement, can lead to reduced cervical spine proprioception. Pain and anxiety are often treated with pharmacological interventions.

We are interested in learning more about people living with “subclinical” pain. According to Grant et al and Browne et al.[16,17] people with neck pain but are not yet receiving any treatment as having minor musculoskeletal or “subclinical” pain.

Subclinical pain may increase anxiety[18,19] and affect movement and can lead to anxiety, disability, and impaired neck proprioception.[12,14,20,21]

People may as what those non-pharmacologic options that physical therapy can offer for pain management, especially for untreated subclinical pain? In the field of physical therapy biophysical agents are agents that apply forms of energy to "modulate or decrease pain" along with the reduction of "risk factors and complications; enhance health, wellness, or fitness; enhance or maintain physical performance; or prevent or remediate impairments in body functions and structures, activity limitations, or participation restrictions."[22] Within the group of biophysical agents is the application and use of electrical currents, more specifically transcutaneous electrical nerve stimulation (TENS).[22]

TENS is the delivery of electrical current through intact skin to stimulate peripheral nerves.[23] TENS delivers electrical currents through the skin with the objective to stimulate peripheral nerves to prevent the transmission of nociceptive information to the brain and by this process achieve pain relief.[24,25,26,27] One of the most accepted theories for the modulation of pain with the use of TENS is the "gate control theory of pain" by Melzack and Wall published in 1965.[28,29] which explains pain relief by electrical stimulation.[28] The authors proposed that by using electrical currents to stimulate low-threshold A-beta axons, it will reduce pain by pre-venting the transmission of nociceptive information in the spinal cord and brainstem.[23] This theory also proposed that the substantia gelatinosa (SG) in the dorsal horn of the spine acts as a gate control system before afferents influence T cells.[28] T cells then activate the system responsible for response and perception.[28] Large-diameter afferent nerve fibers (facilitates SG) and small-diameter afferent nerve fibers (inhibits SG) influence T cells.[30] TENS gives the clinician the option to select the depolarization of afferents nerves through the adjustment of parameters of electrical current deliver with electrodes through the skin.[30] Depolarizing large-diameter (A-beta) sensory afferent nerves via sensory TENS can help gate or block noxious input.[30,31,32] TENS has been used for treating subclinical pain based on studies that have found superiority of TENS over placebo for chronic musculoskeletal pain.[33] Most importantly for our study, TENS is non-prescriptive battery-powered device that uses self-adhering electrodes on the surface of the skin to deliver electrical current. TENS is often self-administered, affordable and safe when compared to medications.[23]

Despite 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 published research.[34] There is an urgent need for randomized controlled trials to investigate TENS effectiveness.[34] Based on this need the purpose of this study is to investigate the effects of electrotherapy for improving cervical spine proprioception, reduce pain, anxiety, and disability in adults with subclinical neck or upper quadrant pain.

b. Objectives.

1) To measure the immediate and short-term effects of TENS on subclinical neck or upper quadrant pain with the VAS, anxiety with the State-Trait Anxiety Inventory for Adults™, disability with neck disability index (NDI), disability and cervical spine proprioception Noraxon 3D Inertial Motion Capture System in subjects 20-40 years of age.

2) To measure pain, anxiety, disability, and cervical spine proprioception in subjects with and without neck or upper quadrant pain.

3) To compare compliance of TENS home usage in groups with and without short message system (SMS), text message, reminders.

c. Procedures involved (Research Interventions)

There will be three groups as follows: twenty subjects with no pain in the normal group; forty subjects with chronic subclinical neck or upper quadrant pain will be randomized into two groups: twenty subjects in the control group, and twenty subjects in the intervention group. The intervention group will be further randomized into two groups: ten subjects will receive instructions for home use of TENS with daily SMS text message reminders and ten subjects will receive instructions for home use of TENS without SMS text message reminders. We will aim for an equal distribution of males and females in each group.

First session (Day 1): Before starting the procedures, participants complaining of pain that are greater than 4/10 in the VAS will be excluded from the study as this will be greater of what we consider to be subclinical pain based on literature review and if the pain has been present less than three months. In addition, if participants with pain less than 4/10 pain receiving clinical pain treatment, have taken pain medication

within six hours of first session, have acute pain or contraindications for electrical stimulation would be excluded from the study. Following completion of the signing procedures, all participants will be given brief explanations before administration of the questionnaires.

First, participants in the normal group (20 subjects) will first be instructed to complete the VAS for pain, a subjective measure of pain intensity consisting of a 10 centimeter (cm) line with anchor statements on the left (no pain) and extreme pain on the right. Pain scores will be determined by measuring the distance in cm from "no pain" to the participant's anchor point. In this group the score must be "no pain" or 0 cm.Participants randomly assigned to the control group (20 subjects) will first be instructed to complete the VAS for pain with a score less than 4/10 required. Participants randomly assigned to the intervention group (10 subjects) that will receive daily SMS text message reminders for compliance during intervention will first be instructed to complete the VAS for pain with a score less than 4/10 required. Participants randomly assigned to the intervention group (10 subjects) that will not receive daily SMS text message reminders for compliance during intervention will first be instructed to complete the VAS for pain with a score less than 4/10 required.

Next, all participants in all groups will complete 2 self-report questionnaires beginning with the STAI-form Y which is a definitive clinical measure of state and trait anxiety in adults. Form Y has 20 items for assessing trait anxiety and 20 for state anxiety. All items are rated on a 4-point scale (e.g., from "Almost Never" to "Almost Always"). Higher scores indicate greater anxiety.

Next, all participants in all groups will complete the NDI questionnaire which consist of 10 sections (pain intensity, personal care, lifting, work, headaches, concentration, sleeping, driving, reading and recreation) with questions that are measure in a 6-point scale from 0 (no disability) to 5 (full disability). The numeric responses will be added with a score varying from 0-50 where 0 is considered "no activity limitation" and 50 is considered "complete disability." Furthermore, 0-4 (no disability), 5-14 (mild disability), 15-24 (moderate disability), 25-34 (severe disability) and greater than 35 (complete disability).

Next, all participants in all groups will be familiarized with the Noraxon myoMotion^{TM} system instrument that utilizes inertial measurement units (IMUs) to

measure angles of motion in joints which will measure cervical spine proprioception utilizing the joint position error (JPE) test.

Participants in the normal group will not receive any interventions in the lab or at home and will not receive education on the use of TENS equipment.

Participants in the control group will not receive any interventions in the lab or at home and will not receive education on the use of TENS equipment.

Participants in the intervention group with daily SMS text message reminders will be provided with a TENS unit by the investigators for home use for a total of 29 days and instructed by a license physical therapist for its use and safety. In addition, you will be provided with a daily log sheet to track its use while receiving SMS text message reminders for compliance. Then, the participants in this intervention group will receive a 30-minute high-frequency sensory TENS treatment in lab on the pain site in the neck and upper quadrant area. After the 30-minute high-frequency sensory TENS treatment, the participants in the intervention group will again complete the VAS, STAI, and NDI. Also, cervical spine proprioception will be measured with Noraxon myoMotion^{TM} system instrument utilizing the JPE test.

Participants in the intervention group without daily SMS text message reminders will be provided with a TENS unit by the investigators for home use for a total of 29 days and instructed by a license physical therapist for its use and safety. In addition, you will be provided with a daily log sheet to track its use without receiving SMS text message reminders for compliance. Then, the participants in this intervention group will receive a 30-minute high-frequency sensory TENS treatment in lab on the pain site in the neck and upper quadrant area. After the 30-minute high-frequency sensory TENS treatment, the participants in the intervention group will again complete the VAS, STAI, and NDI. Also, cervical spine proprioception will be measured with Noraxon myoMotion^{TM} system instrument utilizing the JPE test.

Session 2 (1st follow up) (Day 8): Participants will return on day eight. Participants in the normal group will be asked to complete again complete the VAS, STAI, and NDI. Also, cervical spine proprioception will be measured with Noraxon myoMotionTM system instrument utilizing the JPE test. Participants will not receive any interventions in the lab.

Participants in the control group will be asked to complete again complete the VAS, STAI, and NDI. Also, cervical spine proprioception will be measured with

Noraxon myoMotionTM system instrument utilizing the JPE test. Participants will not receive any interventions in the lab.

Participants in the intervention group with daily SMS text message reminders will be asked to complete again complete the VAS, STAI, and NDI. Also, cervical spine proprioception will be measured with Noraxon myoMotionTM system instrument utilizing the JPE test. Participants will not receive any interventions in the lab.

Participants in the intervention group without daily SMS text message reminders will be asked to complete again complete the VAS, STAI, and NDI. Also, cervical spine proprioception will be measured with Noraxon myoMotionTM system instrument utilizing the JPE test. Participants will not receive any interventions in the lab.

Phone/Email follow up: Participants in the normal, control and intervention (with no SMS text message reminders) groups will be contacted by e-mail and SMS text message during the seventh day period at least one before returning for session two on the eight day and at least three times before returning for the last session on day thirty.

Participants in the intervention group (with SMS text reminders for compliance) will be contacted via SMS text message daily for compliance with high-frequency sensory TENS during the seven-day period before session two and during the twenty-one-day period before last session. We will send a text message to the personal phone. Investigators will be available through phone, text message or email to answer any questions participants may have.

Last session (Day 30): Participants will return on day thirty. Participants in the normal group will be asked to complete again complete the VAS, STAI, and NDI. Also, cervical spine proprioception will be measured with Noraxon myoMotionTM system instrument utilizing the JPE test. Participants will not receive any interventions in the lab and will be given a $50 gift card.

Participants in the control group will be asked to complete again complete the VAS, STAI, and NDI. Also, cervical spine proprioception will be measured with Noraxon myoMotionTM system instrument utilizing the JPE test. Participants will not receive any interventions in the lab and will be given a $50 gift card.

Participants in the intervention group with daily SMS text message reminders will be asked to complete again complete the VAS, STAI, and NDI. Also, cervical spine proprioception will be measured with Noraxon myoMotionTM system instrument utilizing the JPE test. They will return the TENS unit and the daily log sheet to the investigators. Participants will not receive any interventions in the lab. and will be given a $50 gift card.

Participants in the intervention group without daily SMS text message reminders will be asked to complete again complete the VAS, STAI, and NDI. Also, cervical spine proprioception will be measured with Noraxon myoMotionTM system instrument utilizing the JPE test. They will return the TENS unit and the daily log sheet to the investigators. Participants will not receive any interventions in the lab. and will be given a $50 gift card.

d. Alternative procedures, if any, that are not included in the study but might be advantageous to the subject.

n/a

e. Concise review of literature that supports the rationale, objectives, and methodology of the proposed study.

As defined by the IASP pain is "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage." (IASP, 2021) and one of the most common reasons people seek medical care is chronic pain. Approximately 50 million adults in United Stated have chronic pain affecting daily lives[1] posting public health problems in costs of pharmacological management.[2,3] The financial cost to care for people with chronic pain is more costly than diabetes, cardiovascular and cancer combined.[4,5]

Chronic pain is persistent or recurrent pain that last longer than 3 months in one or more locations in the body even beyond the period of the expected healing phase.[6,7] Chronic pain can be affected by biological, psychological and social factors that are accompanied by anxiety, depression, frustration, deconditioning, functional disability, financial problems and opioid use problems.[8,9] As people experience pain, that experience and manifestation of pain is unique to each individual and includes physical and psychological factors[7] making the managing pain and chronic pain can a difficult thing to achieve.[1]

Facing an opioid epidemic, the CDC reports that studies of 2 weeks to 6 months in duration that utilized effective non-pharmacological treatments for chronic pain were effective.[10] Among the recommendations from the CDC for non-opioid and non-pharmacological treatments for pain, physical therapy is included.[10,11] As physical therapists we find imperative to reinforce the use of non-pharmacologic options for pain relief in people that are tackling the difficult task of managing their pain to continue with their normal lives.

As mentioned previously, one of the most common reasons people seek medical care is chronic pain;[1] however, subclinical pain (mild, low irritability) generally does not prompt people to seek medical treatment[12,13,14] Subclinical pain can be measured by the VAS score of $\leq$3.4/10.[15] In addition, non-pharmacological treatments in physical therapy for chronic subclinical pain have not been studied extensively. Pain can lead to anxiety[8,9] (which is often treated with pharmacological interventions) and avoidance of movement. Pain and local inflammation in the cervical spine or upper quadrant, coupled with avoidance of movement, can lead to reduced cervical spine proprioception. Pain and anxiety are often treated with pharmacological interventions.

We are interested in learning more about people living with "subclinical" pain. According to Grant et al and Browne et al.[16,17] people with neck pain but are not yet receiving any treatment as having minor musculoskeletal or "subclinical" pain. Subclinical pain may increase anxiety[18,19] and affect movement and also can lead to anxiety, disability and impaired neck proprioception[12,14,20,21]

People may as what those non-pharmacologic options that physical therapy can offer for pain management, especially for untreated subclinical pain? In the field of physical therapy biophysical agents are agents that apply forms of energy to "modulate or decrease pain" along with the reduction of "risk factors and complications; enhance health, wellness, or fitness; enhance or maintain physical performance; or prevent or remediate impairments in body functions and structures, activity limitations, or participation restrictions."[22] Within the group of biophysical agents is the application and use of electrical currents, more specifically TENS.[22]

TENS is the delivery of electrical current through intact skin to stimulate peripheral nerves.[23] TENS delivers electrical currents through the skin with the objective to stimulate peripheral nerves to prevent the transmission of nociceptive information to the brain and by this process achieve pain relief.[24,25,26,27] One of the

most accepted theories for the modulation of pain with the use of TENS is the "gate control theory of pain" by Melzack and Wall published in 1965.[28,29] which explains pain relief by electrical stimulation.[28] The authors proposed that by using electrical currents to stimulate low-threshold A-beta axons, it will reduce pain by pre-venting the transmission of nociceptive information in the spinal cord and brainstem.[23] This theory also proposed that the SG in the dorsal horn of the spine acts as a gate control system before afferents influence T cells.[28] T cells then activate the system responsible for response and perception.[28] Large-diameter afferent nerve fibers (facilitates SG) and small-diameter afferent nerve fibers (inhibits SG) influence T cells.[30] TENS gives the clinician the option to select the depolarization of afferents nerves through the adjustment of parameters of electrical current deliver with electrodes through the skin.[30] Depolarizing large-diameter (A-beta) sensory afferent nerves via sensory TENS can help gate or block noxious input.[30,31,32] TENS has been used for treating subclinical pain based on studies that have found superiority of TENS over placebo for chronic musculoskeletal pain.[33] Most importantly for our study, TENS is non-prescriptive battery-powered device that uses self-adhering electrodes on the surface of the skin to deliver electrical current. TENS is often self-administered, affordable and safe when compared to medications.[23]

Despite 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 published research.[34] There is an urgent need for randomized controlled trials to investigate TENS effectiveness.[34] Based on this need the purpose of this study is to investigate the effects of electrotherapy for improving cervical spine proprioception, reduce pain, anxiety, and disability in adults with subclinical neck or upper quadrant pain.

f. If an Investigational Device (ID) is involved, provide the following information: (1) name of device, (2) manufacturer, (3) status with Food and Drug Administration and ID#, (4) review of animal studies and previous human studies, (5) reported adverse effects.

n/a

9. DATA COLLECTION

The study will be conducted in the Neuroscience Research Laboratory in the SAHP-Room NH A-712, Loma Linda, California. Informed consent will be obtained prior to

the beginning of the study by the graduate student investigator and other IRB approved researchers. Participants will be recruited if they are adults (males and females) aged 20-40 years old with no pain for the normal group and with neck or upper quadrant pain no greater than 4/10 in the VAS for longer than three months, not receiving clinical pain treatment, have not taken pain medication within six hours of first session, have acute pain or contraindications for TENS.

Study participants will be assessed on visits one, two and three (visit three will be at the end of the thirty-day period).

During participant's visit one, two and three the following clinical assessments will be provided:

- The VAS for pain, a subjective measure of pain intensity
- The STAI-form Y is a definitive clinical measure of state and trait anxiety in adults.
- The NDI questionnaire that measures neck disability.
- JPE test which will measure cervical spine proprioception through the Noraxon myoMotionTM system instrument.

10. LABELING & STORAGE OF DATA & SPECIMENS

Hard copies will be stored in a locked file cabinet in a locked room in the clinic and computer data will be stored on an encrypted computer in a locked room in the clinic.

11. DATA ANALYSIS

All data will be analyzed using SPSS version 28.0. For quantitative data, we will use the statistical test ANOVA and for descriptive statistics we will use means and standard deviations. Also, an expert statistician will be consulted to accurately analyze and interpret the results. The alpha level will be set at 0.05.

12. RISK AND INJURY

Participating in this study will involve the following risks: this study may involve breach of your confidentiality, risk of falls, risk of fatigue during study procedures and discomfort with the application of pain reducing electrical stimulation. This study may involve breach of your confidentiality: your information will be kept in a locked cabinet, in a locked office and store on a secure drive. Risk of falls: all reasonable attempts will be made to prevent you from falling including supervision, as someone will stand closely beside you to provide you with physical assistance as needed, the floor in the neuroscience research laboratory is not slippery. Risk of fatigue during

study procedures: you will be offered rest breaks regularly if the investigators notice signs of fatigue on you. You will be instructed on the use and application of pain reducing electrical stimulation device.

13. BENEFIT(S)

We expect that participants will experience improvements in cervical spine range of motion and proprioception, decreased anxiety and neck disability, and all components of improving wholeness and health as participants carry out functional activities. The expected benefits of this study include the improve of quality of life and functional mobility in people with neck chronic pain. In addition, the study may provide evidence of the efficacious use of electrical stimulation as a non-pharmacological option for the management of chronic pain. This study is expected to provide through electrical stimulation an accessible, affordable, self-administered and non-pharmacological option for the management of chronic pain without the need to go to a clinic for the application of electrical stimulation.

14. COMPENSATION

Participants will receive a $50 gift card at the completion of the study.

15. CONFIDENTIALITY

Efforts will be made to keep participants' personal information confidential, but we cannot guarantee absolute confidentiality. We will use a pseudonym throughout the study for all recorded data so participant's actual name will not be used. Participants will not be identified by name in any publications describing the results of this study. Data in hard copy will be kept in a locked file cabinet, in a locked office and electronic data will be stored on a secure drive and password protected.

16. LITERATURE REVIEW

As defined by the IASP pain is "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage." (IASP, 2021) and one of the most common reasons people seek medical care is chronic pain. Approximately 50 million adults in United Stated have chronic pain affecting daily lives[1] posting public health problems in costs of pharmacological management.[2,3] The financial cost to care for people with chronic pain is more costly than diabetes, cardiovascular and cancer combined.[4,5]

Chronic pain is persistent or recurrent pain that last longer than 3 months in one or more locations in the body even beyond the period of the expected healing phase.[6,7] Chronic pain can be affected by biological, psychological and social factors that are accompanied by anxiety, depression, frustration, deconditioning, functional disability, financial problems and opioid use problems.[8,9] As people experience pain, that experience and manifestation of pain is unique to each individual and includes physical and psychological factors[7] making the managing pain and chronic pain can a difficult thing to achieve.[1]

Facing an opioid epidemic, the CDC reports that studies of 2 weeks to 6 months in duration that utilized effective non-pharmacological treatments for chronic pain were effective.[10] Among the recommendations from the CDC for non-opioid and non-pharmacological treatments for pain, physical therapy is included.[10,11] As physical therapists we find imperative to reinforce the use of non-pharmacologic options for pain relief in people that are tackling the difficult task of managing their pain to continue with their normal lives.

As mentioned previously, one of the most common reasons people seek medical care is chronic pain;[1] however, subclinical pain (mild, low irritability) generally does not prompt people to seek medical treatment.[12,13,14] Subclinical pain can be measured by the VAS score of $\leq$3.4/10.[15] In addition, non-pharmacological treatments in physical therapy for chronic subclinical pain have not been studied extensively. Pain can lead to anxiety[8,9] (which is often treated with pharmacological interventions) and avoidance of movement. Pain and local inflammation in the cervical spine or upper quadrant, coupled with avoidance of movement, can lead to reduced cervical spine proprioception. Pain and anxiety are often treated with pharmacological interventions.

We are interested in learning more about people living with "subclinical" pain. According to Grant et al and Browne et al.[16,17] people with neck pain but are not yet receiving any treatment as having minor musculoskeletal or "subclinical" pain. Subclinical pain may increase anxiety[18,19] and affect movement and also can lead to anxiety, disability and impaired neck proprioception.[12,14,20,21]

People may as what those non-pharmacologic options that physical therapy can offer for pain management, especially for untreated subclinical pain? In the field of physical therapy biophysical agents are agents that apply forms of energy to "modulate or decrease pain" along with the reduction of "risk factors and

complications; enhance health, wellness, or fitness; enhance or maintain physical performance; or prevent or remediate impairments in body functions and structures, activity limitations, or participation restrictions."[22] Within the group of biophysical agents is the application and use of electrical currents, more specifically TENS.[22]

TENS is the delivery of electrical current through intact skin to stimulate peripheral nerves.[23] TENS delivers electrical currents through the skin with the objective to stimulate peripheral nerves to prevent the transmission of nociceptive information to the brain and by this process achieve pain relief.[24,25,26,27] One of the most accepted theories for the modulation of pain with the use of TENS is the "gate control theory of pain" by Melzack and Wall published in 1965.[28,29] which explains pain relief by electrical stimulation.[28] The authors proposed that by using electrical currents to stimulate low-threshold A-beta axons, it will reduce pain by pre-venting the transmission of nociceptive information in the spinal cord and brainstem.[23] This theory also proposed that the SG in the dorsal horn of the spine acts as a gate control system before afferents influence T cells.[28] T cells then activate the system responsible for response and perception.[28] Large-diameter afferent nerve fibers (facilitates SG) and small-diameter afferent nerve fibers (inhibits SG) influence T cells.[30] TENS gives the clinician the option to select the depolarization of afferents nerves through the adjustment of parameters of electrical current deliver with electrodes through the skin.[30] Depolarizing large-diameter (A-beta) sensory afferent nerves via sensory TENS can help gate or block noxious input.[30,31,32] TENS has been used for treating subclinical pain based on studies that have found superiority of TENS over placebo for chronic musculoskeletal pain.[33] Most importantly for our study, TENS is non-prescriptive battery-powered device that uses self-adhering electrodes on the surface of the skin to deliver electrical current. TENS is often self-administered, affordable and safe when compared to medications.[23]

Despite 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 published research.[34] There is an urgent need for randomized controlled trials to investigate TENS effectiveness.[34] Based on this need the purpose of this study is to investigate the effects of electrotherapy for improving cervical spine proprioception, reduce pain, anxiety, and disability in adults with subclinical neck or upper quadrant pain.

REFERENCES

1. Centers for Disease Control and Prevention Website. https://www.cdc.gov/learnmorefeelbetter/programs/chronic-pain.htm. Accessed April 8, 2022.
2. Cheatle MD. Assessing suicide risk in patients with chronic pain and depression. *J Fam Pract.* 2014;63(6 Suppl):S6-S11.
3. Rasu RS, Vouthy K, Crowl AN, et al. Cost of pain medication to treat adult patients with nonmalignant chronic pain in the United States. *J Manag Care Pharm*. 2014;20(9):921-928.
4. U.S. Institute of Medicine Committee on Advancing Pain Research, Care, and Education: Relieving pain in America: a blueprint for transforming prevention, care, education, and research, Washington, DC, 2011, National Academies Press.
5. Gaskin DJ, Richard P. The economic costs of pain in the United States. *J Pain* 2012;13(8)715–24.
6. Treede RD, Rief W, Barke A, et al. Chronic pain as a symptom or a disease: the IASP Classification of Chronic Pain for the International Classification of Diseases (ICD-11). *Pain*. 2019;160(1):19-27.
7. Bellew JW, Michlovitz SL, Nolan TP. *Michlovitz's Modalities for Therapeutic Intervention*. 7th ed. Pages 356. Philadelphia, PA: F.A. Davis Company; 2022.
8. Apfelbaum JL, Chen C, Mehta SS, et al. Postoperative pain experience: results from a national survey suggest postoperative pain continues to be undermanaged. *Anesth Analg*. 2003;97(2):534–540.
9. George SZ, Greenspan AI: Nonpharmacological management of pain: convergence in priorities fuels the drive for more evidence. *Phys Ther.* 2018;98(5):287–289.
10. Dowell D, Haegerich TM, Chou R. CDC Guideline for Prescribing Opioids for Chronic Pain — United States, 2016. MMWR *Recomm Rep*. 2016;65(No. RR-1):1–49.
11. Choose PT Website. https://www.choosept.com/why-physical-therapy/safe-pain-management. Accessed April 8, 2022.
12. Kelley MJ, Shaffer MA, Kuhn JE, et al. Shoulder pain and mobility deficits: adhesive capsulitis. *J Orthop Sports Phys Ther*. 2013;43(5):A1–31.

13. Haavik H, Murphy B. Subclinical neck pain and the effects of cervical manipulation on elbow joint position sense. *J Manipulative Physiol Ther*. 2011;34(2):88–97.
14. Lee H, Nicholson LL, Adams RD, Bae SS. Proprioception and rotation range sensitization associated with subclinical neck pain. *Spine*. 2005;30(3):E60–7.
15. Boonstra AM, Schiphorst Preuper HR, Balk GA, Stewart RE. Cut-off points for mild, moderate, and severe pain on the visual analogue scale for pain in patients with chronic musculoskeletal pain. *Pain*. 2014;155(12):2545–2550.
16. Grant R, Forrester C, Hides J. Screen based keyboard operation: the adverse effects on the neural system. *Aust J Physiother*. 1995;41(2):99–107.
17. Browne CD, Nolan BM, Faithfull DK. Occupational repetition strain injuries. Guidelines for diagnosis and management. *Med J Aust*. 1984;140(6):329–332.
18. Rhudy JL, Meagher MW. Fear and anxiety: divergent effects on human pain thresholds. *Pain*. 2000;84(1):65–75.
19. Metzger S, Poliakov B, Lautenbacher S. Differential effects of experimentally induced anxiety and fear on pain: the role of anxiety sensitivity. *J Pain Res*. 2019;12:1791–1801.
20. Lucchetti G, Oliveira AB, Mercante JP, Peres MF. Anxiety and fear-avoidance in musculoskeletal pain. *Curr Pain Headache Rep*. 2012;16(5):399–406.
21. Paulus I, Brumagne S. Altered interpretation of neck proprioceptive signals in persons with subclinical recurrent neck pain. *J Rehabil Med*. 2008;40(6):426–432.
22. American Physical Therapy Association Website. https://guide.apta.org/interventions/categories-interventions/biophysical-agents. Accessed April 8, 2022.
23. Johnson MI, Claydon LS, Herbison GP, Jones G, Paley CA. Transcutaneous electrical nerve stimulation (TENS) for fibromyalgia in adults. *Cochrane Database Syst Rev*. 2017;10(10):CD012172.
24. Arienti C. Is transcutaneous electrical nerve stimulation (TENS) effective in adults with fibromyalgia? A Cochrane Review summary with commentary. *J Musculoskelet Neuronal Interact*. 2019;19(3):250–252.
25. Coutaux A. Non-pharmacological treatments for pain relief: TENS and acupuncture. *Joint Bone Spine*. 2017;84(6):657-661.

26. American Physical Therapy Association. Guide to physical therapist practice. Physical Therapy. 2nd ed. Vol. 81, Alexandria (VA): American Physical Therapy Association, 2001.
27. Johnson MI. Transcutaneous Electrical Nerve Stimulation (TENS). Research to Support Clinical Practice. 1st ed. Oxford (UK): Oxford University Press, 2014.
28. Melzack R, Wall PD. Pain mechanisms: a new theory. *Science*. 1965;150(3699):971–9.
29. Sluka KA, Walsh D. Transcutaneous electrical nerve stimulation: basic science mechanisms and clinical effectiveness. *J Pain*. 2003;4(3):109–121.
30. Draper DO, Jutte LS, Knight KL. *Therapeutic Modalities: The Art and Science.* 3rd ed. Pages 135,140,261,325. Philadelphia, PA: Wolters Kluwer; 2021.
31. Schmitt LC, Schmitt LA, Rudolph KS. Management of a patient with a forearm fracture and median nerve injury. *J Orthop Sports Phys Ther*. 2004;34(2):47–56.
32. Bellew JW, Michlovitz SL, Nolan TP. *Michlovitz's Modalities for Therapeutic Intervention*. 6th ed. Pages 307,339. Philadelphia, PA: F.A. Davis Company; 2016.
33. Johnson M, Martinson M. Efficacy of electrical nerve stimulation for chronic musculoskeletal pain: a meta-analysis of randomized controlled trials. *Pain*. 2007;130(1-2):157–165.
34. Johnson MI. Resolving Long-Standing Uncertainty about the Clinical Efficacy of Transcutaneous Electrical Nerve Stimulation (TENS) to Relieve Pain: A Comprehensive Review of Factors Influencing Outcome. *Medicina* (Kaunas). 2021;57(4):378.