Research Article

Anxiety, Mobility, Disability and Proprioception in Adults with Mild Neck Pain: A Cross-Sectional Study

Pablo Mleziva[1]*, Eric Glenn Johnson[1], Everett B. Lohman[1], Madeha Jaber[1], Lillian Mleziva, Noha Salim Daher[2]

1. *Department of Physical Therapy, Loma Linda University, California 92350, USA.*
2. *Department of Public Health, School of Allied Health Professions, Professor, Loma Linda University, California 92350, USA.*
3. *Department of Physical Therapy, Physical Therapist, San Gorgonio Memorial Hospital, Banning, California 92220, USA.*

***Corresponding Author:**
Pablo Mleziva, Associate Professor.
Department of Physical Therapy, Loma Linda University, California 92350, USA.
Tel: *(909)558-4632 x85690*
E-mail: *pmleziva@llu.edu*

ORCID ID:
Pablo Mleziva: 0000-0002-1376-4283
Eric Glenn Johnson: 0000-0002-0865-6456
Everett B. Lohman: 0000-0002-1765-9181
Madeha Jaber: 0009-0007-9051-8645
Lillian Mleziva: 0009-0004-1286-1569
Noha Salim Daher: 0000-0002-5429-3297

Article info:
Received: 5 Jun 2024
Accepted: 25 Jan 2025

Citation: Mleziva P, Johnson EG, Lohman EB, Jaber M, Mleziva L, Daher NS. Anxiety, Mobility, Disability and Proprioception in Adults with Mild Neck Pain: A Cross-Sectional Study. Journal of Modern Rehabilitation. 2025; 19(2):?-?

Running title: Effects of mild neck pain on mobility

Abstract

Background. Studies on subclinical neck pain (SCNP), known as mild pain, are lacking in literature. The purpose of this study was to examine the differences in anxiety, neck movement, disability, and proprioception in people with chronic SCNP (12 females and 4 males, Age: 28.1±4.0) and people without neck pain (17 females and 6 males, Age: 25.8±3.1).

Methods. A cross-sectional study with thirty nine participants was conducted. Participants were instructed to score their pain using the visual analog scale (VAS) (pain group: <4/10 and normal group: 0/10), anxiety level with the State-Trait anxiety inventory (STAI), and neck disability with the neck disability index (NDI). In addition, active range of motion (AROM) and joint position error (JPE) were assessed in participants of both groups.

Results. There was no significant difference in mean baseline characteristics between the two groups. Participants in the pain group reported significantly higher median NDI (p=<0.001) and higher mean current STAI_S (p=0.032) scores than participants with no pain. No significant differences in mean flexion, extension, lateral flexion right, lateral flexion left, rotation right, or rotation left were found between groups (p=0.95, p=0.68, p=0.29, p=0.59, p=0.70, and p=0.17, respectively). In addition, there were no significant differences in mean cervical spine joint position error flexion, extension, rotation right, and rotation left by study group (p=0.65, p=0.33, p=0.26, and p=0.23 respectively.
Conclusion. SCNP can substantially influence functional ability and anxiety levels, especially among students in higher education institutions dealing with additional stressors. The interaction between pain intensity, disability, and anxiety underscores the potential for a detrimental feedback loop, underscoring the significance of early intervention.
Keywords: Subclinical neck pain; Anxiety; Proprioception; Neck mobility

Introduction

According to the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD), neck pain affected approximately 203 million people globally in 2020 [1]. By 2050, there will be an estimated 32,5% increase in neck pain cases affecting 269 million people globally [1]. Neck pain was one of the most expensive conditions treated in the United States in 2016 costing more than $134 billion dollars. In 2017, the global prevalence and incidence rate of neck pain were 3551.1 and 806.6 per 100,000 people, respectively, impacting approximately 15% of the global population [2, 3]. Pain is “an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage” [4]. Neck pain is a complex disorder [2] that can affect individuals physically and emotionally, leading to movement avoidance behaviors and anxiety [5, 6]. Subclinical neck pain (SCNP) is a disorder that doesn’t typically prompt people to seek medical treatment [7-9]. SCNP has been categorized as mild pain, subacute or chronic, with a visual analog scale (VAS) score of ≤3.4/10cm, with 10/10cm meaning the worst pain, that is generally left untreated [7, 8, 10]. SCNP has the potential to increase anxiety, increase disability, decrease neck mobility, and decrease neck proprioception [8, 11-12]. SCNP and its potential effects on neck and upper limbs joint position awareness can lead to impaired integration of sensory input [13].

Chronic neck pain is one of the most common societal problems negatively impacting daily activities and well-being [14]. Chronic pain is defined as pain lasting longer than three months and can persist after the healing process has been completed [15, 16]. According to the literature, causes for neck pain are multifactorial and evidence has demonstrated that psychological factors can affect the musculoskeletal system in a similar manner as physical factors will [1, 17]. These psychological factors also have the potential to influence the way people perceive pain [17]; assuming that this influence can continue after the healing process is completed. More specifically, Alghadami et al [17] findings show that anxiety affects and can increase neck pain symptoms. Managing chronic pain can become a difficult task with a potential increase in patient’s anxiety and functional disability often affecting personal and professional behaviors [5, 6, 14, 18]. Although SCNP is a common disorder, its impact on the combined musculoskeletal and sensory systems has not been studied extensively [13]. The purpose of this study was to examine the differences in anxiety, neck movement, disability, and proprioception in people with chronic SCNP and people without neck pain.

Materials and Methods

Design

A cross-sectional design was used. This study utilized one pain group and one normal group. This study was conducted at the Loma Linda University Department of Physical Therapy.

Ethical approval

The study was approved by the Institutional Review Board (IRB# 5220149) at Loma Linda University at University and registered with ClinicalTrials.gov (Identifier: NCT05382039). Informed consent was obtained from all subjects before participation in this study. All procedures were applied in accordance with the Declaration of Helsinki. Participants had the opportunity to ask questions before deciding to participate and were informed that they could leave the study at any time.

Participants

Forty-three participants signed the informed consent. Four participants from the normal group were excluded because they reported a VAS score above zero. Thus, thirty-nine participants with a mean ± SD age of 25.8±3.1 years and body mass index (BMI) of 26.7±6.0 kg/m^2 enrolled in this study. Most participants were females (n=29, 74.4%). Participant recruitment was conducted using emails, flyers, and word of mouth. The inclusion criteria were adults between 20-40 years of age currently enrolled as students, report of neck chronic subclinical pain or no pain for the normal group. Participants that reported perceived pain intensity of greater than 4/10 on the VAS were excluded from the study as this was considered greater than subclinical pain [17]. Participants were also excluded if they were receiving clinical treatment for their pain, had taken pain medication six hours before data collection, had acute pain of less than three months of duration, and/or reported contraindications for electrotherapy, were unwilling to receive daily text message to their personal phones. Exclusion criteria were assessed based on self-report.

Procedures and data collection

Thirty-nine participants were recruited for this study. There was a total of 23 participants in the subclinical neck pain group and 16 participants in the no pain group as shown in Figure 1. All participants signed the consent form to participate in the study and were educated on the questionnaires to be administered and completed before assessments. First, participants in the pain group were instructed to score their pain and complete the VAS [19]. The pain score was determined by measuring the distance in centimeters (cm) from “no pain” to the participant’s mark on the VAS [20]. The VAS has a moderate reliability as a tool for self-report for people with neck pain, with an intraclass correlation coefficient (ICC=0.72; [95% CI: 0.08-0.90]) [21]. In the pain group scores were required to be $\leq$4/10. Participants in the normal group completed the VAS for pain assessment; a score of 0/10 was required to be included in the no pain group. Next, all participants (pain and normal group) completed 2 questionnaires: the State-Trait anxiety inventory (STAI) form Y for a clinical measure of state (how they feel at the moment) and trait (how they felt in general) anxiety in adults [22, 23]. Form Y (short form) had 10 items for assessing trait anxiety and 10 for state anxiety. Higher scores in the STAI indicate greater anxiety [22-24]. The STAI specific reliability with a focus on people with neck pain has not been investigated; however, STAI shows an excellent reliability, with correlation coefficients ranging from 0.87 to 0.93 in studies with subjects with other anxiety disorders [25]. Then, all participants completed the neck disability index (NDI) questionnaire consisting of 10 sections (pain intensity, personal care, lifting, work, headaches, concentration, sleeping, driving, reading and recreation) with a 6-point scale from 0 (no disability) to 5 (full disability) to measure neck disability. The NDI scores were recorded as percentages [26]. The NDI has excellent reliability with an intraclass correlation coefficient (ICC=0.92; [95% CI: 0.46-0.97]) [21]. Participants in both groups were educated with the Noraxon myoMotion^{TM} system instrument that was used to measure degrees

and angles of cervical spine motion to record active range of motion (AROM) [27]. Also, the Noraxon myoMotion^{TM} system instrument was used to measure the joint position error (JPE) to determine cervical spine proprioception [27]. The MyoMotionTM system (Figure 2) shows a concurrent validity with and excellent agreement (XCORR >0.880) when compared to the gold standard system for human movement [28], a correlation coefficient of 0.99 [29] and good repeatability and reliability [30].

Figure 1 Study diagram recruitment and assessment

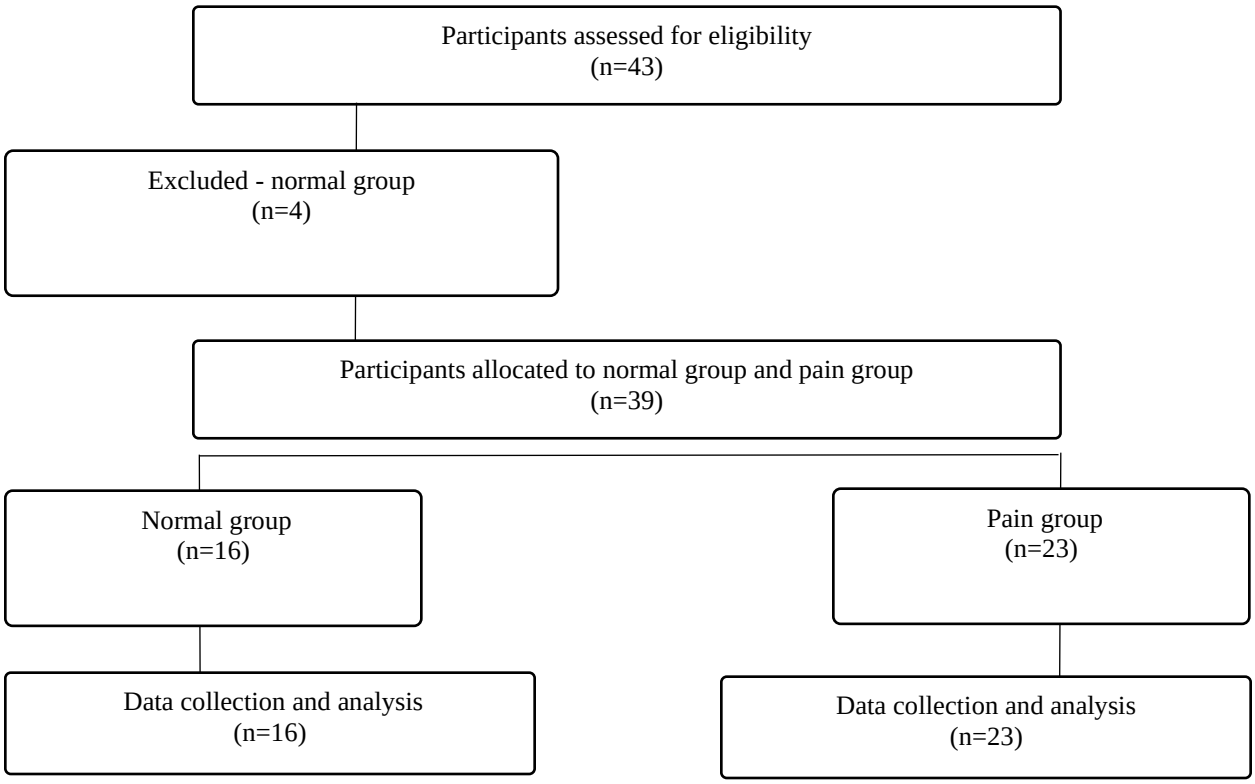

Figure 2 Noraxon myoMotion sensor placement

Outcome measures

Pain Intensity Test

The subjective assessment of participant's pain intensity was recorded on the VAS which consisted of a 10-centimeter (cm) line [19] with the left (0cm) end of the line meaning no pain and worst pain imaginable on the right end (10cm). A measurement was taken from the 0cm point on the scale to the marking made by the participant, which was interpreted as the pain level [20]. In this study, neck or upper quadrant subclinical mild pain was defined as a VAS score of $\leq$4/10.

Disability Test

The NDI instrument considers several factors of daily living: pain intensity, personal care, sleeping lifting, reading, driving, headaches, concentration, work, and recreation. Scores are based on the impact that neck pain has on ten activities in the NDI which uses a six-point Likert scale with a range from no impact to worst imaginable [26]. The NDI displays 5 items taken from the Oswestry Lower Back Pain Index with an additional 5 new items [31, 32]. These items are assessed through questions utilizing a 6-point scale from 0 (no disability) to 5 (full disability) [31]. The range in the scores is from 0 to 50 [31, 32]. These scores can be recorded as percentages with the following interpretation: 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 [33]. This study utilized percentages for the NDI scores.

Anxiety State and Trait Anxiety Index (STAI)

The STAI provides a measure of the anxiety level of "normal" adults who are experiencing it at the moment or the tendency to feel anxious utilizing a self-report questionnaire [22, 23]. The STAI contains 2 subscales; one, State Anxiety Scale (S- Anxiety), which measures the current state of the participants anxiety and feelings. The second subscale, Trait Anxiety Scale (T-Anxiety), measures the frequency of anxiety feelings and evaluates the "anxiety proneness" [22, 24]. The STAI has 20 items for each subscale, S-Anxiety and T-Anxiety [22, 24]. Scores range from 20-80; higher score indicates greater anxiety [22, 24]. For this study the STAI short form was utilized.

Active Range of Motion and Joint Position Error

The MyoMOTION^{TM} 3D Motion Analysis System, (Noraxon U.S.A Inc.- Scottsdale, Arizona-Manufacturer) - Research PRO system (Model 680 MyoMOTION^{TM} Research Receiver/Model 610 MyoMOTION^{TM} sensor; Noraxon MR3, 3.16.88 software version), was utilized to measure cervical spine AROM and JPE by placing two sensors utilized to measure degrees of motion in joints [27]. Two sensors (inertial measurement units (IMUs)) from this system we used to measure degrees of motions and joint position error [27]. Sensors were placed on the back of

participants head with a fixation strap; the second sensor was attached below C7 vertebra in line with the spinal column with double-sided tape [27].

Data Analyses

Data was analyzed using SPSS version 28.0. Assuming a moderate effect size of 0.7, a power of 0.80, and an alpha of 0.05, the estimated sample size was 46 participants. 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 Chi-square test of independence. Mean baseline characteristics and outcome variables by study group were examined using independent t-test. Median VAS, NDI, and JPE rotation right were compared between the pain and normal groups using Mann-Whitney U test. The level of significance was set at $p \leq 0.05$.

Results

Forty-three participants signed the informed consent. Four participants from the normal group were excluded because they reported a VAS score above zero. Thus, 39 participants with a mean ± SD age of 25.8±3.1 years and BMI of 26.7±6.0 kg/m^2 enrolled in this study. The majority were females (n=29, 74.4%) There was no significant difference in mean age and BMI between the two study groups (p=0.06 and p=0.37). Changes in pain, disability, anxiety, cervical spine AROM, and JPE by study group are displayed in Table 1. Results of the independent t-test in Figure 3 shows that participants in the pain group reported higher mean STAT_S scores than those in the normal group (18.0±7.0 versus 13.5±4.8, p=0.032; Cohen's d=0.72), but no significant changes in STAI_T were detected between the two study groups (p=0.23). Participants in the pain group reported significantly higher median (minimum, maximum) NDI scores (Figure 4) than normal participants (16(0,22) versus 1(0,12), p<0.001 (r=0.70)). In terms of cervical spine AROM, there was no significant difference in mean flexion, extension, lateral flexion right, lateral flexion left, rotation right, and rotation left between the study groups (p= 0.95, p=0.68, p=0.29, p=0.59, p=0.70, and p=0.17 respectively). In addition, there were no significant difference in mean cervical spine JPE flexion, extension, rotation right, rotation left by study group (p=0.65, p=0.33, p=0.26, and p=0.23 respectively). (Table 1).

Table 1 Mean ± SD of baseline characteristics and outcome variables by group (N=39)

Variable	Normal (n_1=16)	Pain (n_2=23)	P-value (d)	Power
Female; n (%)	12 (41.4)	17 (58.6)	0.62 (0.01) [W]	0.10
Age (years)	28.1±4.0	25.8±3.1	0.06 (0.65)	0.70
BMI (kg/m^2)	25.1±4.2	26.7±6.0	0.37 (0.30)	0.25
VAS*	0 (0, 0)	2.0 (0.1, 3.8)	**<0.001 (0.87)** [Y]	**0.85**
NDI*(%)	1 (0, 12)	16 (0, 22)	**<0.001 (0.70)** [Y]	**0.80**
STAI_S	13.5±4.8	18.0±7.0	**0.032 (0.72)**	**0.80**
STAI_T	18.3±4.4	20.3±5.6	0.23 (0.40)	0.35
Flexion	51.5±12.5	53.3±9.6	0.95 (0.02)	0.10
Extension	38.0±11.4	39.6±12.7	0.68 (0.14)	0.11
Lateral Flexion Right	38.8±5.9	36.4±7.2	0.29 (0.35)	0.30
Lateral Flexion Left	38.7±6.6	37.5±7.1	0.59 (0.18)	0.15
Rotation Right	67.3±7.1	66.4±7.5	0.70 (0.13)	0.11
Rotation Left	68.1±5.2	64.9±8.0	0.17 (0.46)	0.50
JPE Flexion	4.2±2.3	4.7±4.2	0.65 (0.15)	0.15
JPE Extension	4.8±2.8	5.8±3.3	0.33 (0.32)	0.26
JPE Rotation Right	2.2 (1.1, 8.5)	2.9 (0.9, 18.0)	0.26 (0.18)	0.15
JPE Rotation Left	3.6±2.0	2.8±1.6	0.23 (0.40)	0.35

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.

$\mathbf{d} = \frac{\text{Mean of the difference}}{\text{SD of the difference}}$, $\mathbf{r} = \frac{Z}{\sqrt{N}}$, j= $\sqrt{(\frac{c2}{n})}$

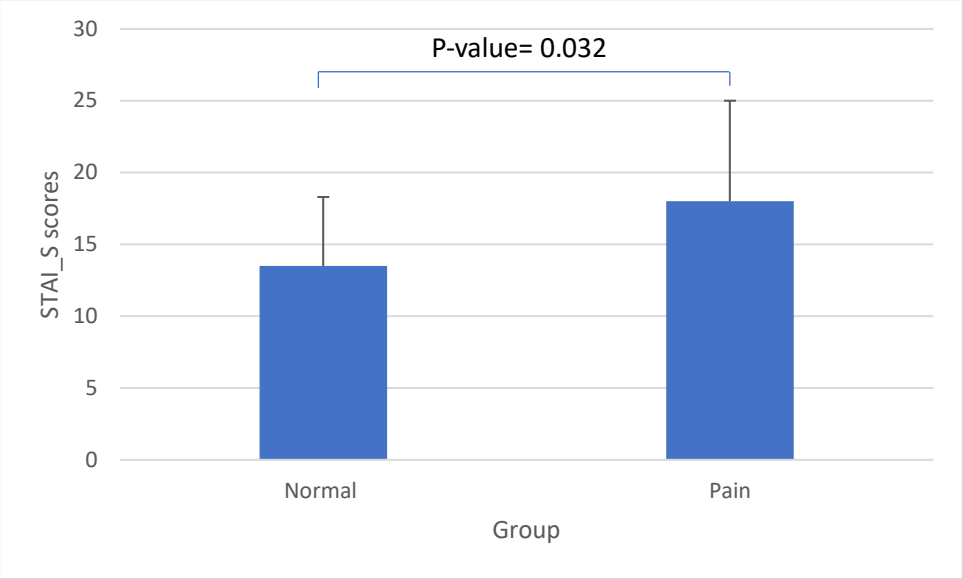

Figure 3 Mean ± SD of State-Trait Anxiety Inventory_State Scores by Group

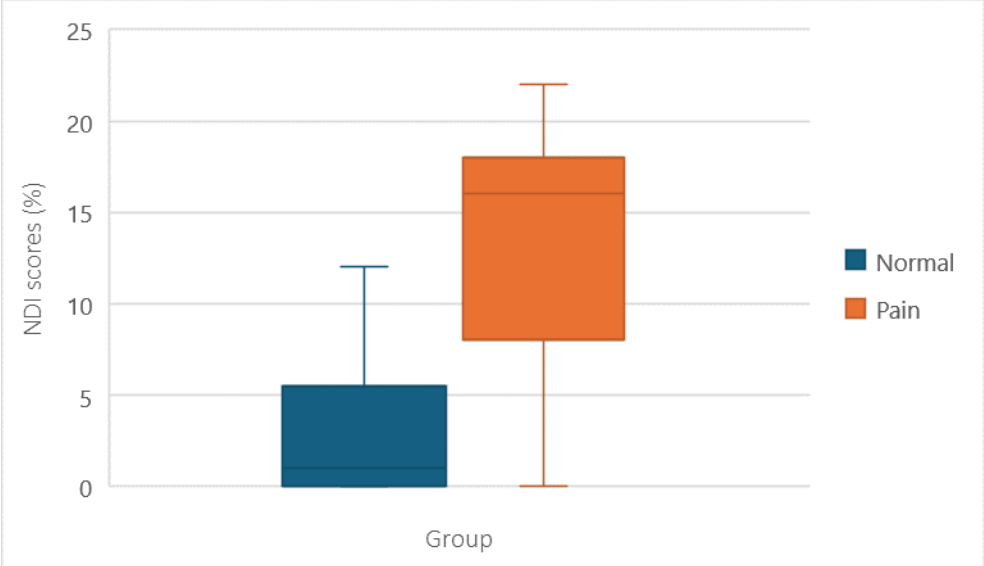

Figure 4 Neck Disability Index scores by Group

Discussion

SCNP does not usually prompt people to seek medical treatment; however, their pain may still affect their activities of daily living. Pain has been linked to an interaction between sensory, emotional, and physical factors that influence physical mobility in people [34]. This interaction has not been fully studied to determine the combined effects on movement [34].

In this study, we hypothesized that neck pain, disability, and anxiety results would demonstrate a negative impact on participants with mild neck pain and no major impact on participants without pain. Wlodyka-Demaille et al. suggested two dimensions in the NDI (French version); these being functional disability and pain [35]. Results showed that the pain group had a significantly higher

median NDI score of 16% falling between 10-28% range, considered to be mild disability [33]. It is important to note that in this study, the NDI results (percentage) in subjects with SCNP appear to be clinically higher than the subjects with no pain; considering the clinical meaningful difference of 10 points and a minimum clinically important difference (MCID) of 7.5 points in the NDI [36].

As mentioned previously, chronic pain can be altered by factors in social life along with anxiety and functional disability [4, 5]. The state of anxiety perceived by participants is described by the STAI_S scores; higher scores indicate higher anxiety at the moment of the test [22, 24]. Results showed that participants in the pain group reported higher mean STAI_S scores when compared to the normal group. Literature has suggested that the expectation of pain alone can cause a cascade of brain activity resulting in "anticipatory anxiety" [37, 38]. This can explain the higher scores in STAI_S, in Table 1, in the pain group compared to the normal group. Anxiety and mild neck pain could be factors students experience in a higher education institution. Poor posture, prolonged periods in a seated position, stress due to academic workload and anxiety could be some of common responses of students in higher education. The timing of data collection may have been influenced by the timeline of the academic quarter and the various anxiety levels potentially caused by examinations. Our findings for neck JPE in participants with SCNP differ from Quartey et al that showed no differences in neck JPE in participants with neck pain versus no pain [39]. In the present study, cervical JPE was decreased in the pain group in all directions tested, except rotation left. Despite no significant difference in cervical spine AROM in participants with SCNP, there was increased AROM in all directions in the normal group.

As suggested in the literature, the negative correlation between pain intensity (VAS), disability (NDI), and anxiety (STAI) [40] increases the chances of a cycle that starts with pain or anxiety ending with disability and a low quality of life. It is important to point out that interventions for SCNP are likely to be of benefit in avoiding the cycle of pain and low quality of life. The absence of interventions for people with SCNP not seeking medical treatment can also lead to this cycle. In particular, non-pharmacological treatments for pain have been underutilized [41].

Limitations of this study included the sampled population. Participants were young students at a higher education institution, and most were females. Also, the academic calendar was not considered (testing weeks versus no testing weeks) when data was collected, which could have impacted anxiety levels.

Conclusion

In conclusion, this study illuminates the frequently overlooked impact of SCNP on individuals' daily lives. While SCNP may not prompt immediate medical attention, it can substantially influence functional ability and anxiety levels, especially among students in higher education institutions dealing with additional stressors. The interaction between pain intensity, disability, and anxiety underscores the potential for a detrimental feedback loop, underscoring the significance of early intervention to enhance the quality of life for individuals experiencing SCNP.

Acknowledgements

None

Conflict of interest

Authors declare they have no conflict of interest.

Funding

None

References

[1] GBD 2021 Neck Pain Collaborators. Global, regional, and national burden of neck pain, 1990-2020, and projections to 2050: a systematic analysis of the Global Burden of Disease Study 2021. Lancet Rheumatol. 2024;6(3):e142-e155. https://doi: 10.1016/S2665-9913(23)00321-1.

[2] Kazeminasab S, Nejadghaderi SA, Amiri P, et al. Neck pain: global epidemiology, trends and risk factors. BMC Musculoskelet Disord. 2022;23(1):26. https://doi.org/10.1186/s12891-021-04957-4

[3] Sang D, Xiao B, Rong T, et al. Depression and anxiety in cervical degenerative disc disease: Who are susceptible?. Front Public Health. 2023;10:1002837. https://doi.org/10.3389/fpubh.2022.1002837

[4] International Association for the Study of Pain. Terminology. https://www.iasp-pain.org/resources/terminology/#pain. (Accessed 28 May 2023)

[5] Apfelbaum JL, Chen C, Mehta SS, Gan TJ. Postoperative pain experience: results from a national survey suggest postoperative pain continues to be undermanaged. Anesth Analg.2003;97(2):534-540. https://doi.org/10.1213/01.ANE.0000068822.10113.9E

[6] George SZ, Greenspan AI. Nonpharmacological management of pain: convergence in priorities fuels the drive for more evidence. Phys Ther. 2018;98(5):287–289. https://doi.org/10.1093/ptj/pzy034

[7] 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. https://doi.org/10.1016/j.jmpt.2010.12.009

[8] Lee H, Nicholson LL, Adams RD, Bae SS. Proprioception and rotation range sensitization associated with subclinical neck pain. Spine (Phila Pa 1976). 2005;30(3):E60–E67. https://doi.org/10.1097/01.brs.0000152160.28052.a2

[9] Daligadu J, Haavik H, Yielder PC, Baarbe J, Murphy B. Alterations in cortical and cerebellar motor processing in subclinical neck pain patients following spinal manipulation. J Manipulative Physiol Ther. 2013;36(8):527-537. https://doi.org/10.1016/j.jmpt.2013.08.003

[10] 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. https://doi.org/10.1016/j.pain.2014.09.014

[11] Rhudy JL, Meagher MW. Fear and anxiety: divergent effects on human pain thresholds. Pain. 2000;84(1):65–75. https://doi.org/10.1016/S0304-3959(99)00183-9

[12] 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. https://doi.org/10.2340/16501977-0189

[13] Karellas AM, Yielder P, Burkitt JJ, McCracken HS, Murphy BA. The Influence of Subclinical Neck Pain on Neurophysiological and Behavioral Measures of Multisensory Integration. Brain Sci. 2019;9(12):362. https://doi.org/10.3390/brainsci9120362

[14] Centers for Disease Control and Prevention. Prevalence of Chronic Pain and High-Impact Chronic Pain Among Adults — United States, 2016. https://www.cdc.gov/mmwr/volumes/67/wr/mm6736a2.htm. (accessed 27 September 2023)

[15] 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. https://doi.org/10.1097/j.pain.0000000000001384
[16] Bellew JW. Michlovitz's Modalities for Therapeutic Intervention. 7th ed. Philadelphia, PA: F.A. Davis Company; 2022, 356.
[17] Alghamdi MS, Alghamdi AF, Almalawi AM, et al. The Association Between Neck Pain and Psychological Distress Experienced by King Abdulaziz University Students: A Cross-Sectional Study. Cureus. 2023;15(3):e35685. https://doi: 10.7759/cureus.35685.
[18] Elbinoune I, Amine B, Shyen S, Gueddari S, Abouqal R, Hajjaj-Hassouni N. Chronic neck pain and anxiety-depression: prevalence and associated risk factors. Pan Afr Med J. 2016;24:89. https://doi.org/10.11604/pamj.2016.24.89.8831
[19] Alghadir AH, Anwer S, Iqbal A, Iqbal ZA. Test-retest reliability, validity, and minimum detectable change of visual analog, numerical rating, and verbal rating scales for measurement of osteoarthritic knee pain. J Pain Res. 2018;11:851-856. https://doi.org/10.2147/JPR.S158847
[20] Delgado DA, Lambert BS, Boutris N, McCulloch PC, Robbins AB, Moreno MR, Harris JD. Validation of Digital Visual Analog Scale Pain Scoring with a Traditional Paper-based Visual Analog Scale in Adults. J Am Acad Orthop Surg Glob Res Rev. 2018;2(3):e088. https://doi.org/10.5435/JAAOSGlobal-D-17-00088.
[21] Young IA, Dunning J, Butts R, Cleland JA, Fernández-de-Las-Peñas C. Psychometric properties of the Numeric Pain Rating Scale and Neck Disability Index in patients with cervicogenic headache. Cephalalgia. 2019;39(1):44-51. https://doi.org/10.1177/0333102418772584
[22] Julian LJ. Measures of anxiety: State-Trait Anxiety Inventory (STAI), Beck Anxiety Inventory (BAI), and Hospital Anxiety and Depression Scale-Anxiety (HADS-A). Arthritis Care Res (Hoboken). 2011;63 Suppl 11(0 11):S467-S472. https://doi.org/10.1002/acr.20561
[23] Metzger R. A reliability and validity study of the State-Trait Anxiety Inventory. Journal of Clinical Psychology. 1976;32(2):276-278. https://doi.org/10.1002/1097-4679(197604)32:2<276::AID-JCLP2270320215>3.0.CO;2-G
[24] Spielberger C. Manual for the State-Trait Anxiety Inventory (rev. ed.). Palo Alto (CA): Consulting Psychologists Press; 1983.
[25] Guillén-Riquelme A, Buela-Casal G. [Meta-analysis of group comparison and meta-analysis of reliability generalization of the State-Trait Anxiety Inventory Questionnaire (STAI)]. Rev Esp de Salud Publica. 2014;88(1):101-112. https://doi.org/10.4321/s1135-57272014000100007.
[26] Jones C, Sterling M. Clinimetrics: Neck Disability Index. J Physiother. 2021;67(2):144. https://doi.org/10.1016/j.jphys.2020.09.001.
[27] NORAXON. Available at: https://www.noraxon.com. (accessed 31 May 2023)
[28] Heuvelmans P, Benjaminse A, Bolt R, Baumeister J, Otten E, Gokeler A. Concurrent validation of the Noraxon MyoMotion wearable inertial sensors in change-of-direction and jump-landing tasks. Sports Biomech. 2022;3:1-16. https://doi.org/10.1080/14763141.2022.2093264.
[29] Balasubramanian S. Comparison of angle measurements between Vicon and Myomotion systems. 2013. Arizona State University.
[30] Donaldson B, Bezodis N, Bayne H. Within-subject repeatability and between-subject variability in posture during calibration of an inertial measurement unit system. ISBS. 2021;39(1):224-227.

[31] MacDermid JC, Walton DM, Avery S, et al. Measurement properties of the neck disability index: a systematic review. J Orthop Sports Phys Ther. 2009;39(5):400-417. https://doi.org/10.2519/jospt.2009.2930.
[32] Vernon H. The Neck Disability Index: state-of-the-art, 1991-2008. J Manipulative Physiol Ther. 2008;31(7):491-502. https://doi.org/10.1016/j.jmpt.2008.08.006.
[33] Vernon H, Mior S. The Neck Disability Index: a study of reliability and validity. J Manipulative Physiol Ther. 1991;14(7):409-415. PMID: 1834753
[34] Butera KA, Fox EJ, George SZ. Toward a Transformed Understanding: From Pain and Movement to Pain with Movement. Phys Ther. 2016;96(10):1503-1507. https://doi.org/10.2522/ptj.20160211.
[35] Wlodyka-Demaille S, Poiraudeau S, Catanzariti JF, Rannou F, Fermanian J, Revel M. French translation and validation of 3 functional disability scales for neck pain. Arch Phys Med Rehabil. 2002;83(3):376-82. https://doi.org/10.1053/apmr.2002.30623
[36] Young BA, Walker MJ, Strunce JB, Boyles RE, Whitman JM, Childs JD. Responsiveness of the Neck Disability Index in patients with mechanical neck disorders. Spine J. 2009;9(10):802-808. https://doi.org/10.1016/j.spinee.2009.06.002
[37] Karacaoglu M, Meijer S, Peerdeman KJ, et al. Susceptibility to Nocebo Hyperalgesia, Dispositional Optimism, and Trait Anxiety as Predictors of Nocebo Hyperalgesia Reduction. Clin J Pain. 2023;39(6):259-269. https://doi.org/10.1097/AJP.0000000000001112.
[38] Enck P, Benedetti F, Schedlowski M. New insights into the placebo and nocebo responses. Neuron. 2008;59(2):195-206. https://doi.org/10.1016/j.neuron.2008.06.030. PMID: 18667148.
[39] Quartey J, Ernst M, Bello A, et al. Comparative joint position error in patients with non-specific neck disorders and asymptomatic age-matched individuals. S Afr J Physiother. 2019;75(1):568. https://doi:10.4102/sajp.v75i1.568
[40] Beltran-Alacreu H, López-de-Uralde-Villanueva I, Calvo-Lobo C, et al. Prediction models of health-related quality of life in different neck pain conditions: a cross-sectional study. Patient Prefer Adherence. 2018;12:657-666. https://doi.org/10.2147/PPA.S162702
[41] Mleziva P, Johnson EG, Lohman E, Jaber M, Mleziva L, Daher NS. Effects of Electrotherapy on Pain, Anxiety, Mobility, and Proprioception in Young Adults with Mild Neck Pain: A Randomized Controlled Trial. Phys Ther Rehabil Sci. 2024;13:274-284.