Med. J. Cairo Univ., Vol. 91, No. 4, December: 1435-1441, 2023
www.medicaljournalofcairouniversity.com

Relationship between Pain, Functional Disability, Proprioception, and Scapular Muscle Strength in Patients with Chronic Mechanical Neck Pain

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Abstract

Background: Chronic mechanical neck pain (CMNP) is an increasing health problem, causing functional disability in large populations.

Aim of Study: The aim of this cross-sectional and correlational study was to investigate the relationship between pain, disability, proprioception, and scapular muscle strength in patients with chronic mechanical neck pain.

Material and Methods: Twenty-three patients of both genders were included in this study. Their mean age was 34.93± 7.93, and their mean BMI was 27 .80±5.39. They were referred by orthopedic surgeons with a diagnosis of CMNP. All subjects were assessed for pain intensity using the Arabic version of the numeric pain rating scale, function and disability using the Arabic version of the neck disability index (NDI), cervical proprioception using an inclinometer to calculate the joint position error sense (JPE), and scapular muscle strength of the serratus anterior, upper, middle, and lower trapezius using a hand-held dynamometer (HHD). A correlation analysis was conducted between the outcome measures using the Spearman Rho coefficient.

Results: A significant positive correlation between pain and the neck disability index was found, while right serratus anterior strength was negatively correlated with pain and the neck disability index. Right upper trapezius strength was negatively correlated with the neck disability index. strength of the right middle trapezius was positively correlated with joint position error of flexion ($p\leq 0.05$). No significant relationships were found between pain and proprioception ($p>0.05$).

Conclusion: The functional disability of patients with CMNP is correlated with the degree of pain and strength of the upper trapezius and serratus anterior and should be considered in the assessment, while cervical proprioception does not seem to be correlated with the measured outcome variables.

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Key Words: *Chronic mechanical neck pain — Functional disability — Proprioception — Scapular muscles.*

Introduction

Neck pain, along with back pain, is one of the most prevalent musculoskeletal conditions. Many individuals seek treatment at medical centers at least once in their lives [1]. It has been estimated that around 22% to 70% of the population may have neck pain at some point in their life. Furthermore, it has been indicated that the prevalence of neck pain is expanding. At any given moment, 10% to 20% of the general population reports neck issues, with 54% of people experiencing neck discomfort in the previous 6 months. The prevalence of neck pain rises with age and is highest in women in their fifth decade of life [2].

Chronic mechanical neck pain (CMNP) is defined as persistent neck and/or shoulder discomfort that lasts more than 3 months and is triggered by neck movement, neck postures, or cervical muscle palpation [2,3]. It has become a growing issue [4]. Causing functional impairment in huge populations [5].

Although the fundamental causes of CMNP are unknown, biomechanical factors and psychosocial stress may play a role in neck pain [6]. Functional conditions, activity levels, and work performance may deteriorate with time, and psychological disorders such as anxiety and depression may emerge, all of which have a detrimental impact on quality of life [4].

Material and Methods

Study design:

Data were obtained for pain, disability, proprioception, and muscular strength from twenty-three subjects diagnosed with CMNP. The design for this study was cross-sectional and observational. This study was conducted at the outpatient clinic of the Talla Central Hospital, Elmonofia, Egypt between September 2022 and July 2023.

Patients:

Twenty-three male and female patients with a mean age of 34.93±7.93. There were 7 (30.4%) males and 16 (69.6%) females referred by an orthopedic surgeon with a diagnosis of CMNP. Patients were included if they had complained of CMNP for more than three months with an age range between 18 and 45 years, a body mass index between 17 and 27.1, a baseline NDI score of at least 20% (10 points), and at least 3/10 pain intensity on NPRS M.

Exclusion criteria:

Patients were excluded if they had any of the following conditions: **[6].**

- Spinal canal stenosis.

1- Traumatic injury to the cervical spine.

2- Beforevious surgery in cervical spine.

3- Hypermobility of the cervical spine.

4- Any red flags e.g., cervical instability, history of cancer, long use of corticosteroids.

5- Beforesence of an inflammatory rheumatologic disease.

Assessment procedure:

At baseline, the study purpose was explained to eligible participants, and the principal investigator (PI) clearly explained all the items in the informed consent form and addressed any question or concern. The subjects were then asked to sign the informed consent form. After assignment, patients' demographics were collected, and assessments of pain, disability, proprioception, and muscle strength were performed.

1- Pain Assessment (NPRS):

Subjects were assessed for pain using the Arabic version of the Numeric Pain Rating Scale (ANPRS), which is a pain rating questionnaire This self-report measure uses an 11-point numeric scale, ranging from 0 ("no pain") to 10 ("worst pain imaginable") **[8].** The NPRS exhibited moderate reliability (ICC = 0.67). The MCID for the NPRS was 1.5 in patients with mechanical neck pain **[9].**

2- Function and disability assessment (NDI):

The NDI is a self-reported questionnaire that consists of 10 questions: Pain intensity, personal care, lifting, reading, headaches, concentration, work, driving, sleeping, and recreation. Each item is scored from 0 (no disability) to 5 (total disability). The maximum possible score is 50. However, the NDI is frequently normalized to 100 and reported as a percent [10]. Because the questionnaire is straight-forward, the majority of the patients need approximately 5 minutes to complete it [11]. The NDI exhibited excellent reliability (ICC=0.88). The MCID for the NDI ranges from 5 to 9.5 in patients with mechanical neck pain **[9].**

3- Proprioception assessment:

Proprioception of cervical range of motion Has been assessed by the bubble inclinometer (Baseline@ Bubble Inclinometer, Fabrication Enterprises Inc., White Plains, New York 10602, USA) which is a highly reliable measuring instrument. The infratester and intertester reliabilities (intraclass correlation coefficient [ICC] 2,1=0.99 and 0.99, respectively).

4- Muscle strength assessment:

Muscle strength of the lower trapezius, middle trapezius, upper trapezius, and serratus anterior were assessed by a handheld dynamometer, also known as a manual muscle tester (Model 01165, Lafayette Instrument Company, Indiana, USA). The **HHD** has been shown to be highly reliable for both inter-rater and intra-rater testing and has been determined to be a valid method for strength assessment [12,13]. Intra-rater reliability coefficients for scapulothoracic strength across all muscles were substantial to almost perfect, with intra-class correlation coefficients (ICC) values ranging from 0.80 to 0.95 and 0.71 to 0.92 in the healthy and neck pain groups, respectively [14].

Ethical consideration:

The study has been approved by the ethical committee of the Faculty of Physical Therapy, Cairo University, approval number: PT.REC/012/004039. The participants signed an informed consent form before data collection. The study was registered on ClinicalTrials.gov with the registration number NCT05845853.

Data analysis:

Data were analysed using the statistical package for social sciences (SPSS) computer program version 27 software for Windows (IBM SPSS Inc., Chicago, IL, USA). Descriptive statistics were expressed as the mean ± standard deviation for continuous variables and the frequency distribution (%) for categorical variables. The normality of the data was examined using the Shapiro-Wilk statistical test. A correlation between the studied variables was performed using Spearman correlation coefficient. Spearman correlation coefficient values were estimated as follows: 0-0.19 very weak, 0.2-0.39 weak, 0.4-0.69 moderate, 0.7-0.89 strong, and 0.9-1.00 very strong correlation. The alpha level was set at $p=0.05$. The level of significance for all statistical tests was set at $p<0.05$.

(A) (B) (C) (D)

Fig. (1): Assessment of scapulothorathic muscle strength.
(A): Upper trapezius **(B):** Serratus anterior. (C): Middle trapezius. (D): Lower trapezius

Results

A total of 23 participants with chronic mechanical neck pain completed the study. Their mean age was 34.93±7.93. There were 7 (30.4%) males and 16 (69.6%) in total. The Shapiro-Wilk test revealed a mixture of normal and non-normally distributed variables, but after visual examination of the histograms and QQ plots, non-parametric tests were more appropriate to conduct. Spearman Rho coefficient was used to investigate the correlation between the tested variables and showed the following:

A correlation between cervical pain, functional disability, and scaplothorathic muscle strength:

The results showed a significant positive correlation between pain and neck disability index while right serratus anterior strength was negatively correlated with pain and neck disability index and right upper trapezius strength was negatively correlated with neck disability index.

The results also showed a significant positive correlation between the strength of each tested muscle with all other tested muscles except between (left serratus anterior and bilateral lower trapezius) strength, (left upper trapezius and left lower trapezius) strength, no significant correlation was found between the other tested variables Table (1).

B- Correlation between cervical pain, cervical proprioception:

The result showed a significant positive correlation between (right side bending with bilateral rotation) joint position error sense (p<_0.05), no significant correlation between the other tested variables (p>0.05). Table (2).

C- Correlation between scaplothorathic muscle strength, cervical proprioception:

The result showed significant positive correlation between joint position error of flexion and strength of right middle trapezius (p<_0.05), no significant correlation between the other tested variables (p>0.05). Table (3).

Table (1): Correlation between cervical pain, functional disability, and scaplothorathic muscle strength.

	Pain	NDI *(%)*	RT SA (N)	LT SA (N)	RT UT (N)	LT UT (N)	RT MT (N)	LT MT (N)	RT LT (N)	LT LT (N)
Pain	–	.61*	.51*	-.41	-.25	-.11	-.21	-.25	-.17	-.13
NDI (%)	.61*	–	-.53*	-.37	-.50*	-.39	-.29	-.37	-.34	-.23
RT SA (N)	-.51*	-.53**	–	.84**	.75**	.71**	.56**	.65**	.55**	.48*
LT SA (N)	-.41	-.37	.84**	–	.73**	.70**	.69**	.70**	.36	.39
RT UT (N)	-.25	-.50*	.75**	.73**	–	.90**	.82**	.80**	.53*	.48*
LT UT (N)	-.11	-.40	.71**	.70**	.90**	–	.75**	.68**	.48*	.41
RT MT (N)	-.5	-.29	.56**	.69**	.82**	.75**	–	.90**	.60**	.63**
LT MT (N)	-.248	-.37	.65**	.70**	.80**	.68**	.90**	–	.66**	.74**
RT LT (N)	-.17	-.34	.55**	.36	.53*	.48*	.60**	.66**	–	.91**
LT LT (N)	-.13	-.23	.48*	.39	.48*	.41	.63**	.74**	.91**	

*Correlation is Significance at p-value s0.05. ** Correlation is significance at p-value s0.01.

Abbreviations: NDI: Neck disability index, RT SA: Right serratus anterior, RT UT: Right upper trapezius, RT MT: Right middle trapezius, LT: Right lower trapezius, LT SA: Serratus anterior, LT UT: Upper trapezius, LT MT: Middle trapezius, LT: Lower trapezius.

Table (2): Correlation between cervical pain, cervical proprioception.

	Pain level	JPE Flexion (degree)	JPE extention (degree)	JPE right side bending (degree)	JPE left side bending (degree)	JPE right rotation (degree)	JPE left rotation (degree)
Pain level	–	-.04	.17	-.21	-.11	.01	-.01
JPE Flexion (degree)	-.04	–	.16	.36	-.05	.38	.02
JPE extention (degree)	.17	.16	–	-.41	.22	-.21	-.36
JPE right side bending (degree)	-.21	.36	-.41	–	-.16	.58**	.52*
JPE left side bending (degree)	-.11	-.05	.22	-.16	–	-.38	-.19
JPE right rotation (degree)	.01	.38	-.21	.58**	-.38	–	.23
JPE left rotation (degree)	-.01	.02	-.36	.52*	-.19	.23	

*Correlation is Significance at p-value s0.05. ** Correlation is significance at p-value s0.01.

Abbreviations: JPE: Joint position error.

Table (3): Correlation between scaplothorathic muscle strength, cervical proprioception.

	JPE Flexion (degree)	JPE extention (degree)	JPE right side bending (degree)	JPE left side bending (degree)	JPE right rotation (degree)	JPE left rotation (degree)
RT SA (N)	-.01	-.33	.13	.020	.002	.069
LT SA (N)	.10	-.11	.13	.06	.020	.08
RT UT (N)	.28	-.23	.21	-.28	.26	.11
LT UT (N)	.20	-.33	.19	-.25	.29	.11
RT MT (N)	.44*	-.06	.16	-.06	.16	-.01
LT MT (N)	.36	.08	.05	.12	.03	-.07
RT LT (N)	.08	-.09	-.29	.03	-.22	-.27
LT LT (N)	.14	.12	-.32	.15	-.26	-.31

*Correlation is Significance at p-value s0.05.

Abbreviations: RT SA: Right serratus anterior, RT UT: Right upper trapezius, RT MT: Right middle trapezius LT: Right lower trapezius, LT SA: Serratus anterior, LT UT: Upper trapezius, LT MT: Middle trapezius LT: Lower trapezius, JPE: Joint position error.

Discussion

This study investigated the relationship between pain, disability, proprioception, and scapular muscle strength in subjects with CMNP. The results showed a positive correlation between pain and functional disability in patients with CMNP. This result appears reasonable because pain intensity is one of the items on the neck disability index. Clinically, a higher pain level is a direct influence of disability. Our findings were in line with another study, in which Resnick et al., 2005 **[15]** revealed a moderate correlation between pain intensity and the NDI score, despite his conclusion that developing a gold standard subjective outcome measure for neck pain would be difficult since the wide range of biopsychological influences acting on each patient are so individual [15].

The results of the current study showed a significant negative correlation between serratus anterior strength, pain, and functional disability. This result was in agreement with the Javdaneh study, which reported that improvement in serratus anterior muscle strength was associated with improvement in pain in CMNP patients. According to Javdaneh et al. (2021), **[7]** our explanation for this correlation is that the serratus anterior (SA) muscle is a strong upward rotator, which in turn improves scapular alignment and decreases the compressive load on the posterior cervical structure, which in turn reduces pain and function disability.

The results of the current study also found that upper trapezius strength was negatively correlated with the neck disability index. In agreement with our study other studies have found that increasing the strength of the upper trapezius, serratus anterior, and lower trapezius muscles is associated with a decrease in functional impairment **[16,17].**

theories for explaining decreased muscle strength in chronic musculoskeletal pain cases have been frequently utilized. These theories assume that pain prevents complete muscle activation via spinal and supraspinal processes **[18].** This theory might explain the negative correlation between pain and upper trapezius and serratus anterior muscle strength.

Reddy et al., 2019 **[19]** found a significant positive association between the degree of neck pain and position sense error in subjects with neck pain. Contrary to our study, we could not find any correlation between neck pain and cervical proprioception. In agreement with our study, Lee et al., 2008 **[20]** study did not reveal any correlation between neck pain severity and cervical proprioceptive sense in chronic neck pain subjects.

The lack of correlation between most of the variables may be due to the small sample size investigated in our current study. Considering the inclinometer application, there were limitations to this instrument. The inclinometer had a fixed vertical reference point realized by gravity and is thus stable, provided the zero point is accurately calibrated and established. Therefore, understanding the placement of the instrument is essential when performing various measurements to prevent the screen from rotating at 45° **[21].**

Clinical implementation:

As scaplothorathic muscle strength specially serratus anterior had been negatively correlated with each of cervical pain and functional disability, management of patient with chronic mechanical neck pain shouldn't be limited to cervical exercises but also include exercises for scaplothorathic muscle.

Limitations:

1- The small sample size may limit the generalizability of the findings of this study.
2- Since we only kept in touch with the participants at the time of assessment only, we were unable to assess the long-term results.
3- The method used for assessment of proprioception using an inclinometer may have been subjected to examiner's bias.

Conclusion:

The functional disability of patients with CMNP is correlated with the degree of pain and strength of the upper trapezius and serratus anterior and should be considered in the assessment, while cervical proprioception does not seem to be correlated with the other measured outcome variables.

Source of funding:

The study was not funded by any organization or entity.

Conflict of interests:

Authors declare no potential conflicts of interests.

Author contribution:

The authors contributed equally to the study.

Acknowledgement:

We are grateful to all the individuals who participated in this work, we appreciate their help.

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دراسه العلاقه بين الالم والاعاقة الوظيفية والاحساس العميقة وقوة عضلات لوح الكتف للمرضى الذين يعانون من الم الرقبة الميكانيكى المزمن

الهدف من البحث: اكتشاف اذا كان هناك علاقه ترابطيه بين الالم والاعاقه والاحساس العميق وقوه عضلات لوح الكتف للمرضى الذين يعانون من الم الرقبه الميكانيكى المزمن.

طريقة البحث: تم إجراء هذا البحث على ثلاثه وعشرين شخصا متوسط اعمارهم ٣٤,٩٣ ± ٧,٩٣. مما يعانون من الام الرقبه الميكانيكيه المزمن. تمت إحالتهم من قبل جراحى العظام . تم تقييم جميع المرضي من حيث شدة الألم باستخدام النسخة العربية من مقياس تصنيف الألم الرقمى والإعاقة الوظيفة باستخدام النسخة العربية من مؤشر إعاقة الرقبة، واستقبال الحس العميق العنقي باستخدام مقياس الميل لحساب إحساس خطأ موضع المفصل، وقوة العضلات الكتفية للشبه المنحرف الأمامى والعلوى والوسطى والسفلى باستخدام مقياس القوة المحمول باليد. تم إجراء تحليل الارتباط بين مقاييس النتائج باستخدام معامل سبيرمان رو.

نتائج البحث: ابرزت نتائج هذا البحث وجود علاقه ترابطيه موجبه بين الالم والاعاقه الوظيفيه للرقبه وكذلك علاقه ترابطيه سالبه بين بين الالم والاعاقه الوظيفيه للرقبه وقوه العضله المسننه الاماميه بينما لم توجد اى علاقه بين الالم والاحساس العميق.

الاستنتاجات: قوه عضلات لوح الكتف وخاصه العضله الاماميه المسننه لها دور اساسى فى التاثير على الالم والاعاقه فى المرضى الذين يعانون من الام الرقبه الميكانيكيه المزمن.