

Study on Electromyographic Characteristics of Neck Muscles in College Students with Chronic Neck Pain

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Abstract: *Objective:* To provide new insights for the evaluation and diagnosis of chronic neck pain (CNP). *Methods:* 22 patients with CNP and 22 healthy individuals were recruited from South China Normal University, who were all college students. The subjects' neck extensor muscle strength in the head neutral position, the natural anteversion position, and the maximum forward flexion position were measured by an isometric muscle strength tester respectively. The neck extensor strength of CNP patients and healthy subjects were compared. *Results:* In the neutral position, the maximum isometric muscle strength of neck extensor muscles was 12.31 kg for CNP patients and 15.16 kg for healthy individuals, resulting in a ratio of 81% strength in patients compared to healthy subjects. This difference was highly significant ($P < 0.000$). In the natural anteversion position, the respective values were 12.6 kg for CNP patients and 15.05 kg for healthy individuals, with a ratio of 83%, and a significant difference between groups ($P < 0.001$). In the maximum forward flexion position of the head, the values were 13.36 kg for CNP patients and 16.15 kg for healthy individuals, with a ratio of 82%, and a highly significant difference ($P < 0.000$). *Conclusion:* The neck extensor muscle strength levels in college students with CNP were significantly lower compared to healthy college students across all measured positions.

Keywords: Chronic neck pain; Muscle strength characteristics

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1. Introduction

Chronic neck pain (CNP) is a soft tissue disease in the neck caused by the injury of neck muscles and tendons [1]. It is also known as cervical fibrositis and cervical myofascial pain syndrome. The prevalence of pain in necks and shoulders is high, characterized by multiple pains and accompanied by numbness. Besides, there are also such symptoms as local muscle contraction, tension, and stiffness, producing nodules and certain tender points. The symptoms get worse when a certain posture is maintained for too long, but they are relieved immediately after the activity [2].

With the widespread use of mobile phones and other electronic devices due to improved living conditions, the onset age of CNP has become increasingly younger. CNP not only causes physical and psychological distress to patients but also leads to a range of associated issues. Neck pain is notably common during adolescence [3], and data over recent decades indicate a steady rise in neck pain prevalence among adolescents [4]. A survey of 140 college students revealed that 98% spend more than 3.5 hours daily on mobile phones, significantly heightening the risk of neck-related disorders [5]. The lifetime prevalence of neck pain among adults aged 20 to 69 is 66.7% [6].

The pathogenesis of muscle pain is very complex and has not been fully clarified. It is generally believed that it may be the result of energy depletion due to the continuous contraction of the muscles. When the fast muscle motor units are depleted, muscle fatigue occurs, and the rise of intramuscular pressure leads to the obstruction of blood circulation, the low excitability of the muscle cell membrane, and the delay of conduction velocity [7]. Muscle fatigue is a natural physiological response following sustained muscle contraction, influenced by factors such as age, type of contraction, and other variables [8]. Neck muscles, categorized into anterior and posterior groups as well as deep and superficial layers, play a crucial role in coordinating, relaxing, and stabilizing the cervical spine during movement [9]. Prolonged isometric contraction of weaker muscles to maintain neck position and posture under load can lead to excessive pain due to sustained contraction [10]. Among the neck's muscle groups involved in each direction of movement, agonist muscles fatigue first, with the splenius capitis muscle particularly prone to fatigue during neck flexion. Individuals with CNP experience an earlier onset of neck muscle fatigue compared to those without CNP, independent of duration or pain intensity [11]. The decline in muscle endurance and neuromuscular efficiency is considered a primary factor contributing to CNP.

The prevalence of CNP increases year by year, affecting the daily lives of its patients. This study explored the characteristics of neck extensor muscle strength in college students with CNP and healthy college students to facilitate the diagnosis, treatment, and patient outcome evaluation of this condition.

2. Research subjects

2.1. Participants

22 college students with CNP and 22 healthy college students, aged between 20 and 27, were recruited in South China Normal University, College Town Campus. This study was conducted following the principles of the Declaration of Helsinki and approved by the Ethics Commission of the South China Normal University. The participants' basic information is shown in **Table 1**. All subjects signed an informed consent before the experiment.

Table 1. Basic information of the CNP patients and healthy individuals

Index	CNP group (<i>n</i> = 22)	Healthy group (<i>n</i> = 22)
Age (years)	23.2 ± 1.07	23.6 ± 1.86
Height (cm)	169.0 ± 8.05	169.2 ± 8.01
Weight (kg)	60.3 ± 10.6	61.0 ± 10.9
Gender (male/female)	10/12	10/12

2.2. Inclusion criteria for CNP patients

Patients with CNP met the following criteria [12]:

- (1) Recurrent neck pain, stiffness, and discomfort.
- (2) Restriction of head and neck movement, and local tenderness in the muscles at the back of the neck.
- (3) Duration of pain > 3 months.

- (4) Voluntary participation and signing of informed consent.

2.3. Inclusion criteria for healthy subjects

Healthy subjects met the following criteria:

- (1) No neck pain.
- (2) Similar proportion of male and female, major, age, height, and weight as the CNP patients.

2.4. Exclusion criteria

- (1) Accompanied by spinal cord and nerve root compression, hand numbness, dizziness, and other pathological phenomena.
- (2) Neck pain caused by neck tumor, infection, and other reasons.
- (3) History of neck surgery or trauma, or congenital spinal abnormalities
- (4) Accompanied by severe cardiovascular and cerebrovascular disease, hypertension, diabetes, etc.

3. Test indicators and methods

3.1. Maximum isometric strength of neck extensor muscles

A wireless handheld digital muscle strength tester was used (microFET3, HOGGAN, USA) to test the maximum isometric strength of neck extensor muscles.

In this study, the muscle strength of the subjects' neck extensor muscles was measured using kilogram-force (kgf) as the unit. Maximum Voluntary Contraction (MVC) assessments were conducted in three positions: head neutral, natural anteversion, and maximum forward flexion. After each test, the peak force and duration of the contraction were recorded, and the testing apparatus was reset for subsequent measurements. The procedure for the MVC test for different head positions is described below:

- (1) Neutral position: Each subject sat upright in a chair with their back against the backrest and slightly retracted lower jaw. The subject gazed straight ahead with ankle joints flexed at 90° and feet flat on the ground. The experimenter positioned a hand-held muscle strength tester on the back of the subject's head with one hand while stabilizing it with the other. The subject was instructed to resist the resistance applied by the experimenter for 5 seconds during the MVC test. Following each test, the subject maintained the head in the neutral position with a 30-second interval before the next test. Three tests were conducted in total. The maximum reading from the tester was recorded for each test, and the average value was calculated from these readings.
- (2) Natural anteversion position: Each subject sat in a chair with arms naturally hanging and feet together. Horizontal alignment was ensured based on the grid's horizontal line on a posture assessment form. Using the height of each subject's canthus from the ground, a mark was made on the wall to maintain a horizontal eye level. The experimenter positioned a hand-held muscle strength tester on the back of the subject's head with one hand while stabilizing it with the other. During the MVC test, the subject resisted the resistance applied by the experimenter for 5 seconds. Subsequently, the subject returned their head to the neutral position, and after a 30-second interval, the next test commenced. The maximum reading on the tester was recorded. Three readings were taken and the average value was calculated.
- (3) Maximum forward flexion position: Each subject sat upright in a chair with their back against the backrest, maintaining slight retraction of the lower jaw, and ensuring their ankle joints were flexed at 90° with feet flat on the ground. The experimenter positioned a hand-held muscle strength tester on the back of the subject's head with one hand, stabilizing it with the other hand. During the MVC test, the

subject resisted the resistance provided by the experimenter for 5 seconds. Following each test, the subject returned their head to the neutral position, and after a 30-second interval, the next test commenced. A total of 3 tests were conducted. For each test, the maximum reading from the tester was recorded, and the average value was calculated based on these readings.

3.2. Data processing

The experimental data were statistically analyzed by SPSS 22.0 and expressed as mean \pm standard deviation (SD). The data of patients and healthy subjects were compared and analyzed using an independent *t*-test. $P < 0.05$ indicated a significant difference while $P < 0.01$ indicated a very significant difference.

4. Results

Table 2 and **Figure 1** present the average values of isometric strength in the neck extensor muscles of patients with CNP and healthy subjects across three different head positions. In the head neutral position, patients exhibited an average maximum isometric strength of 12.31 kg compared to 15.16 kg in healthy subjects, with a patient-to-healthy ratio of 81%. This difference was highly significant ($P < 0.001$). Similarly, in the natural anteversion position, the average strengths were 12.6 kg for CNP patients and 15.05 kg for healthy subjects, resulting in an 83% patient-to-healthy ratio, also significantly different ($P < 0.001$). In the maximum forward flexion position, patients showed average strengths of 13.36 kg compared to 16.15 kg in healthy subjects, with an 82% patient-to-healthy ratio, and again, a highly significant difference ($P < 0.001$). These findings indicate that overall, patients with CNP have lower isometric strength in their neck extensor muscles compared to healthy individuals.

Table 2. Isometric strength of neck extensor muscles in patients and healthy subjects (mean \pm SD)

Head position	CNP group (kg)	Healthy group (kg)	CNP group/healthy group ratio (%)	<i>P</i>
Neutral position	12.31 \pm 1.99	15.16 \pm 2.50	81	0.001
Natural anteversion position	12.60 \pm 2.15	15.05 \pm 2.36	83	0.001
Maximum forward flexion position	13.36 \pm 1.96	16.15 \pm 2.66	82	0.001

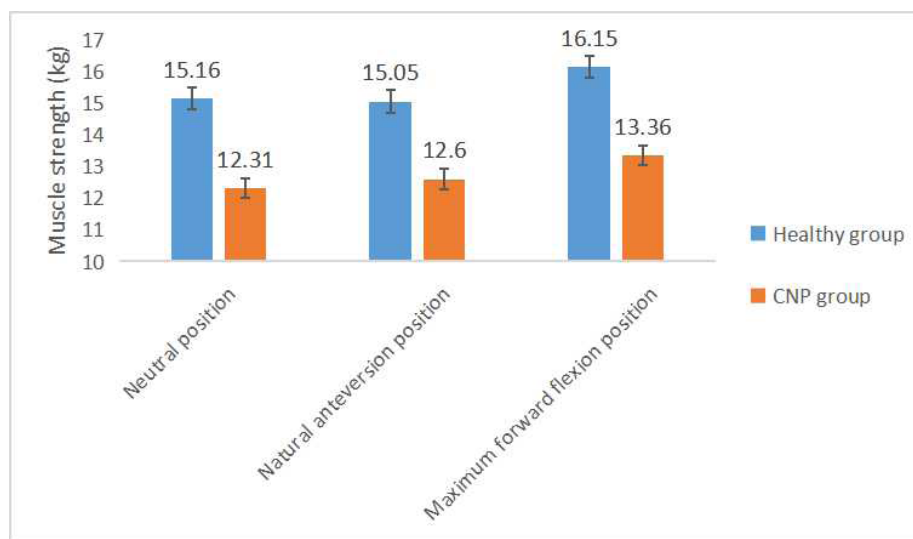


Figure 1. Isometric strength of neck extensor muscles in patients and healthy subjects

5. Discussion

Muscle strength plays a pivotal role in biomechanical research, offering insights into rehabilitation progress and movement function evaluation. Human movement relies on muscle strength, making it a quantitative measure of functional capability. Therefore, studying muscle strength holds significant value for assessing motor function and biomechanical dynamics. Exercise therapies targeting the neck, such as traditional practices like Baduanjin and yoga, as well as modern techniques including neck-specific exercises, three-dimensional static resistance training, and isokinetic exercises, aim to enhance neck muscle strength. These therapies also alleviate spasms, improve blood circulation, and expedite inflammation resolution. They effectively enhance muscle strength and coordination in college students with CNP, restoring mechanical properties of neck muscle groups, delaying fatigue, and promoting neck stability with promising outcomes^[13].

The etiology of CNP is closely tied to factors involving neck muscles. Research utilizing soft tissue tension testing systems has indicated that patients with CNP often experience increased neck muscle tension and decreased endurance, correlating with physical signs and neck function changes. Understanding the influence of neck muscle strength and endurance on neck biomechanics is crucial in preventing and managing CNP. Instability in the neck is a primary source of CNP discomfort. Core muscle and overall body strength training can alleviate pain and reduce the incidence of CNP while enhancing joint flexibility and stability^[14]. Normally, neck muscles coordinate to maintain mechanical balance, but they are prone to weaknesses in endurance, low strength, imbalance, and poor coordination. Dysfunction often arises from weakened flexion and extension capabilities of neck muscles, leading to biomechanical imbalances in surrounding muscles, ligaments, tendons, and joint capsules^[15].

CNP often arises from frequent activities that involve looking down for extended periods. This repetitive behavior disrupts the neck's natural biomechanical functions, leading to a breakdown in its ability to stabilize itself. This instability causes physical changes in the cervical spine's structure, such as narrowing of the intervertebral foramen. The primary cause is the lack of consideration for biomechanics in daily life and work routines. Despite its flexibility, the neck is structurally less stable compared to other joints in the body. It relies heavily on coordinated efforts among muscles, bones, and ligaments to maintain stability while facilitating complex and dynamic three-dimensional movements. When CNP develops, these normal movement patterns are disrupted, often resulting in prolonged muscle contractions as the body tries to compensate, ultimately leading to chronic pain in the neck^[16].

6. Conclusion

Through comparative analysis of neck muscle strength in college students with CNP and healthy peers, it was observed that the neck extensor muscle strength levels in CNP-afflicted students were significantly lower compared to those in their healthy counterparts.

Disclosure statement

The authors declare no conflict of interest.

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