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The Predictive Value and Influencing Factors of Craniocervical Flexion Test for Patients with Chronic Non-Specific Neck Pain: A Case Control Study

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Purpose: This study aims to examine the predictive value of Craniocervical Flexion Test (CCFT) scores in individuals with chronic non-specific neck pain (CNNP) and to identify factors that may affect CCFT scores.

Methods: This case-control study included 73 patients with CNNP and 127 healthy controls. We assessed baseline information such as demographics, duration and frequency of CNNP onset, Neck Disability Index (NDI), and Visual Analog Scale (VAS) scores. All subjects were evaluated by the same rater for CCFT, maximal muscle strength, and endurance of the deep cervical flexors. Head and neck posture was measured using two-dimensional videography, capturing sagittal head angle (SHA), forward head angle (FHA), and protracted shoulder angle (PSA). The predictive capacity of CCFT for CNNP was evaluated using the ROC curve and area under the curve (AUC). Univariate and multivariate ordered logistic regression models were employed to analyze factors influencing CCFT scores.

Results: The final analysis included 70 participants in the CNNP group and 123 in the control group. The CNNP group demonstrated lower CCFT scores, reduced maximal muscle strength, and decreased endurance of the deep cervical muscles ($P<0.05$). Among maximum muscle strength, endurance, and CCFT scores, the latter exhibited the highest AUC. Univariate and multivariate ordered logistic regression analyses revealed that maximal muscle strength, muscle endurance, FHA, and lower NDI scores significantly increased the likelihood of higher CCFT scores ($P<0.05$), while SHA significantly decreased this likelihood ($P<0.05$).

Conclusion: CCFT demonstrates good predictive value for CNNP, surpassing muscle strength and endurance. Maximal muscle strength, muscle endurance, FHA, and lower NDI scores were positive influencing factors for CCFT scores, whereas SHA was a negatively influencing factor.

Plain Language Summary: As the population of patients with chronic non-specific neck pain (CNNP) increases, there is a growing clinical need for an assessment tool to predict the occurrence of CNNP. The Craniocervical Flexion Test (CCFT) is a widely used assessment tool for this condition and may be instrumental in identifying affected patients. However, the predictive value of CCFT for CNNP remains unclear, and no research has yet examined the factors that may influence CCFT scores in this context. To address this gap, we conducted a case-control study to investigate the predictive ability of CCFT for CNNP, and explore the factors that may affect CCFT scores. Our results indicated that CCFT has good predictive value for CNNP, with influencing factors including maximal muscle strength, muscle endurance, sagittal head angle, forward head angle, and the Neck Disability Index. Therefore, we suggest that CCFT has a good application value in the diagnosis and management of CNNP.

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Introduction

Chronic non-specific neck pain (CNNP) is characterized by pain in the cervical region attributable to postural and/or mechanical factors, with symptoms persisting for more than three months.[1] The prevalence of non-specific neck pain is estimated to range from 30% to 50%, with approximately 20% of these cases advancing to CNNP, predominantly affecting younger individuals.[2] Therefore, identifying predictive factors for CNNP is a critical priority in clinical practice.

Patients with CNNP often exhibit hyperactivity in superficial muscles and hypoactivity in deep flexor muscles, leading to reduced muscle strength and endurance. This muscular imbalance can contribute to suboptimal head-neck alignment and compromised dynamic postural stability. Neck pain is a multifactorial condition, and existing literature identifies several predictive or prognostic factors, including pain intensity, work posture,[3] head and neck posture,[4] pain duration,[5] age, sex, and neck disability.[6] Maximal muscle strength[1,7] and muscle endurance[8] of the deep cervical flexor muscle group are frequently used to assess the severity of CNNP. However, these measures are insufficient for evaluating the presence of muscle imbalance between the superficial and deep neck flexors.

The craniocervical flexion test (CCFT), initially developed by Jull et al[9] is a low-load assessment tool extensively used to evaluate the recruitment capability of deep neck flexor muscles while maintaining low activation of superficial neck flexor muscles.[10] This test has been widely employed in both the assessment and treatment of neck pain[11,12] and cervicogenic headache,[13] demonstrating high reliability and validity in the assessment of CNNP.[1,10] Romeo et al[12] have suggested that the CCFT may be instrumental in identifying patients with CNNP and detecting impairments in the deep cervical flexor muscles. However, the predictive value of CCFT for patients with CNNP remains unknown. Furthermore, no research has yet examined the factors that may affect CCFT scores, which could assist in validating the predictive value of CCFT scores for CNNP. Consequently, this study aims to investigate the predictive value of CCFT for CNNP and explore the factors that may influence CCFT scores.

Materials and Methods

Study Design

This study employed a case-control design and adhered to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement for reporting. The research was conducted following the Declaration of Helsinki. Ethical approval was obtained from the hospital's research Ethics Committee (Approval No. KY-20220223001-01). Written consent was obtained from all participants involved in the study.

Participants

Inclusion criteria for CNNP group: (1) fulfillment of the diagnostic criteria of CNNP,[1] with clinical manifestations including pain between the occiput and the first thoracic vertebra region, lasting more than 3 months, possibly accompanied by limited cervical spine movement or stiffness; (2) to reduce the confounding effects of degenerative changes on test outcomes, subjects were selected within the age range of 18–40 years; (3) to mitigate the influence of pain on evaluations, the subjects were required to have a Visual Analog Scale (VAS) score of ≤5; (4) written informed consent was obtained from all participants prior to their inclusion in the study.

Exclusion criteria for CNNP group: (1) presence of specific neck pain conditions, including but not limited to cervical disc herniation, neck fracture, tumor; (2) a history of neck trauma or surgical intervention; (3) received neck and shoulder posture correction training or treatment for CNNP within the preceding 3 months; (4) inability to cooperate in the completion of assessments.

Inclusion criteria for control group: (1) Healthy volunteers with no prior history of CNNP; (2) matched in gender and age to the CNNP group; (3) written informed consent was obtained from all volunteers prior to their inclusion in the study.

Exclusion criteria for control group: (1) Pain in the head and neck region caused by various reasons; (2) individuals who have undergone head and neck posture correction or head and neck muscle strength training in the past three months; (4) inability to cooperate in the completion of assessments.

A cohort of 73 patients diagnosed with CNNP was recruited from the outpatient clinics of the Rehabilitation Medicine Department at both the First People's Hospital of Lianyungang City and the First Affiliated Hospital of Nanjing Medical University between March 2022 and December 2023, constituting the CNNP group. Concurrently, a control group comprising 127 healthy volunteers was established.

Measurements

A professionally trained clinician conducted an interview and assessment to gather and document essential information, including the duration (in days) and frequency (in days/months) of chronic non-specific neck pain (CNNP) onset. Patients diagnosed with CNNP were required to complete the Simplified Chinese Version of Neck Disability Index (NDI)[14] and Visual Analogue Scale (VAS) assessments. Subsequently, all participants underwent evaluations by the same examiner to assess deep cervical flexor function and head and neck posture, with assessments conducted each morning. The assessments were conducted in the following sequence: evaluation of head and neck posture, CCFT, assessment of maximal muscle strength and muscle endurance of the deep cervical flexor muscle group. A 20-minute interval was observed between each assessment. See Figure 1.

CCFT: The CCFT was evaluated following the methodology outlined by Rodrigues et al.[13] The subject was positioned in a supine posture with hips flexed and knees bent. A calibrated inflatable pressure transducer (China Fish Leap, YM100) was positioned posterior to the participant's neck. The pressure pump was inflated to 20 mmHg to ensure the airbag adequately occupied the space between the participant's neck and the bed surface. Subsequently, the examiner provided an explanation and demonstration of the head and neck flexion maneuver, which involved approximating the mandible towards the cervical spine. The CCFT test comprised a sequence of 5 pressure targets set at 22, 24, 26, 28, and 30 mmHg. Subjects were instructed to execute head and neck flexion to compress the airbag to the specified target pressure (eg, 22 mmHg) and sustain this pressure for a duration of 10 seconds, which was deemed successful. Following a 30-second rest interval, the subsequent target pressure (eg, 24 mmHg) was evaluated and maintained for 10 seconds. This process continued until the participant was unable to successfully achieve the required maneuver. Furthermore, subjects were deemed to have failed if compensatory maneuvers, including neck retraction, mouth opening, mandibular protraction, or sternocleidomastoid muscle augmentation, were observed during the test.

Muscle endurance: The endurance of the deep cervical flexor muscle group was evaluated following the methodology outlined Harris et al.[8] Subjects maintained the same initial position, with the mandible gently retracted to facilitate head and neck flexion, and elevated their head from the occipital tuberosity to a height of 2.5 cm above the bed surface, sustaining this position. The examiner positioned a hand beneath the occipital ridge, and the test was deemed concluded when the subject could no longer sustain the head and neck position, thereby contacting the examiner's hand. The duration for which the position was maintained was subsequently recorded in seconds.

Maximal muscle strength: The subject's posture and utilization of the pressure pump were in accordance with the CCFT protocol. The subject was directed to flex the head and neck, gradually compress the airbag, and incrementally elevate the pressure pump reading to its maximum value, indicative of the maximal muscle strength of the deep neck flexor muscle group (measured in mmHg). A failure was recorded if the subject exhibited compensatory movements or if the pressure reading decreased by more than 1 mmHg during the assessment.

Head and neck posture: Head and neck posture were evaluated utilizing the method developed by Letafatkar et al,[15] which includes the assessment of the sagittal head angle (SHA), forward head angle (FHA), and protracted shoulder angle (PSA). The reliability and validity of this assessment method have been previously established.[16] Prior to measurement, anatomical landmarks including the inferior edge of the tragus, the C7 spinous process, and the acromion

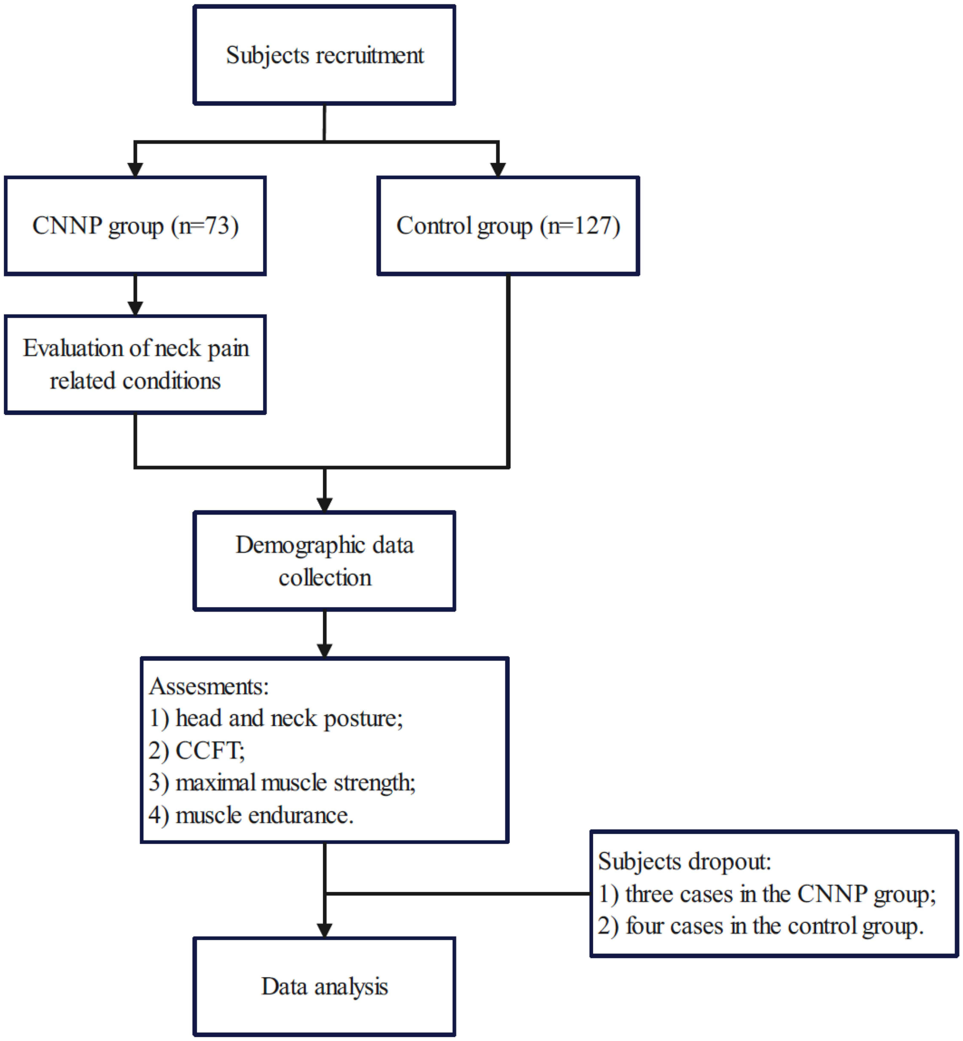

Figure 1 Research flowchart and measurement sequence.

were marked. Subjects were instructed to sit and perform repeated flexion, extension, lateral flexion, and rotation of the neck to achieve a comfortable head and neck position. Each subject's posture was assessed in three separate trials.

Measurements were conducted at a distance of 2 meters from the side of the seat using Photoshop CS6 software. The following parameters were assessed: (1) SHA: the angle formed between the line connecting the lower edge of the tragus to the lateral canthus and the horizontal line, which shows a positive correlation with the degree of atlantooccipital joint tilt;[17] (2) FHA: the angle between the line connecting the lower edge of the tragus to the C7 spinous process and the horizontal line, which is negatively correlated with the degree of head protraction. An FHA of less than 50°[18] is indicative of forward head posture. (3) PSA: The angle formed between the line connecting the C7 vertebra and the acromion and the horizontal plane, which exhibits a negative correlation with the degree of shoulder pronation.[19] See Figure 2.

Statistical Analysis

In this case-control study, statistical analyses were conducted using IBM SPSS software (version 26.0). The chi-squared test was employed to compare the distribution of categorical data. To assess differences between groups, either the independent *t*-test or the Mann–Whitney *U*-test was utilized, depending on the data distribution. Receiver Operating Characteristic (ROC) curves were constructed to evaluate the predictive efficacy of CCFT scores, maximal muscle strength, and muscle endurance for the occurrence of CNNP. The efficacy was evaluated using the area under the curve (AUC), and cut-off values were determined. Odds ratios (ORs) and their corresponding 95% confidence intervals (CIs) for the association between CCFT scores and selected

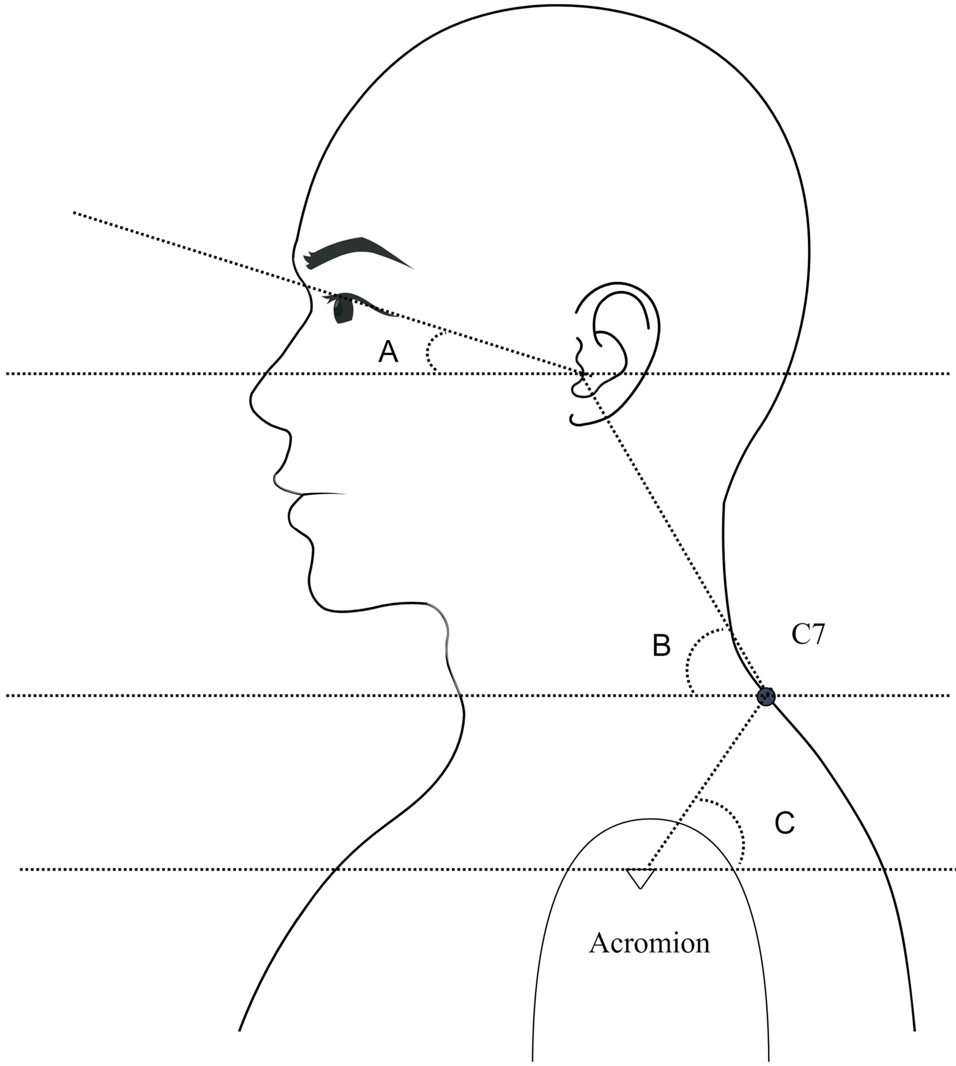

Figure 2 Schematic diagram of head and neck posture measurements. (**A**). sagittal head angle (SHA); (**B**). forward head angle (FHA); (**C**). protracted shoulder angle (PSA).

variables were estimated using ordered logistic regression models. Statistical significance was assessed at a two-tailed alpha level of 0.05.

Results

Demographics and Clinical Variables

A total of 200 subjects were initially included in this study, comprising 73 cases in the CNNP group (1 refused photography, 2 withdrew midway for personal reasons) and 127 cases in the control group (1 case failed to complete CCFT, 3 withdrew midway for personal reasons). Consequently, 193 subjects were ultimately included in the statistical analysis. There were no statistically significant differences between the two groups in terms of gender, age, height, weight, and BMI (P>0.05). However, the SHA levels in the CNNP group were significantly higher than those in the control group (P<0.05). Furthermore, the differences in FHA and PSA between the two groups were not statistically significant (P>0.05). Further details are presented in Table 1.

CCFT Scores, Maximal Muscle Strength, and Muscle Endurance of the Two Groups

The CCFT scores in the CCNP group [26 (24, 28) mmHg] were significantly lower than those in the control group [28 (26, 30) mmHg] (Z=−3.57, P<0.05). Additionally, the CCNP group showed significantly lower maximal muscle strength and muscle endurance in the deep neck flexors compared to the control group. For detailed data, refer to Table 2.

Table 1 Demographics of the Two Groups

Category	CNNP	Control	t/χ^2	P
Sample size	70	123		
Gender			1.75	0.19
Male	36	61		
Female	24	62		
Age (year)	26.06±6.31	25.12±4.86	1.07	0.29
Height (cm)	171.26±8.9	170.15±8.01	0.88	0.38
Weight (kg)	65.99±13.11	64.51±12.39	0.78	0.44
BMI				
<18.5	6	14	0.94	0.63
18.5~24.9	54	87		
≥25.0	10	22		
SHA(°)	22.76±8.71	20.26±7.31	2.13	0.04[a]
FHA(°)	44.64±10.44	47.14±7.99	−1.87	0.06
PSA(°)	59.68±12.08	57.63±11.77	1.52	0.25
VAS	2.47±0.86	–		
Duration of onset (months)	10.37±8.66	–		
Frequency of onset (days/month)	9.99±5.55	–		
NDI score	12.87±5.50	–		
Mild dysfunction	60			
Moderate dysfunction	10			

Notes: [a]P<0.05. Mild dysfunction: NDI score 0–20; moderate dysfunction: NDI score 21–40.

Table 2 CCFT Scores, Maximal Muscle Strength, and Muscle Endurance of the Two Groups

	CNNP (n=50)	Control (n=74)	t/χ^2	P
CCFT[n (%)]			13.32	0.01[a]
22	9 (12.86)	5 (4.07)		
24	19 (27.14)	21 (17.07)		
26	21 (30.00)	32 (26.02)		
28	15 (21,43)	38 (30.89)		
30	6 (8.57)	27 (21.95)		
Maximal muscle strength (mmHg)	33.03±4.48	35.07±5.21	−2.75	0.01[a]
Muscle endurance (s)	45.81±16.6	53.08±21.79	−2.42	0.02[a]

Note: [a]P<0.05.
Abbreviation: %, percentage of group.

Table 3 Efficacy of CCFT, Maximal Muscle Strength, and Muscle Endurance in Predicting CNNP

	AUC	P	95% CI	Youden Index	Sensitivity	Specificity	Cut-off Value
CCFT	0.65	<0.01	0.57~0.73	0.23	0.70	0.53	27.00
Maximal muscle strength	0.61	0.01	0.53~0.69	0.22	0.80	0.59	35.50
Muscle endurance	0.59	0.04	0.51~0.67	0.23	0.91	0.68	67.50

Efficacy of CCFT Scores, Maximal Muscle Strength, and Muscle Endurance in Predicting CNNP

The ROC curve analysis used CNNP as the outcome variable and CCFT scores, maximal muscle strength, and muscle endurance as test variables. CCFT scores had the highest AUC, with a Youden index of 0.23 and a cut-off value of 27. See Table 3 and Figure 3 for details.

Univariate Ordered Logistic Regression Analysis of CCFT Scores in Patients with CNNP

CCFT scores for CNNP patients were used as the outcome variable, with scores of 22, 24, 26, 28, and 30 assigned values of 1 to 5. Univariate ordered logistic regression models included gender (female=0, male=1), age, BMI, VAS, duration, frequency of onset, duration*frequency of onset, NDI scores (mild dysfunction=1, moderate dysfunction=2), maximal muscle strength, muscle endurance, SHA, FHA, and PSA as independent variables. The results indicated that muscle endurance, FHA, maximal muscle strength, and low NDI scores were favorable factors for CCFT scores, whereas SHA and duration*frequency of onset were unfavorable factors for CCFT scores (P<0.05). See Table 4 for details.

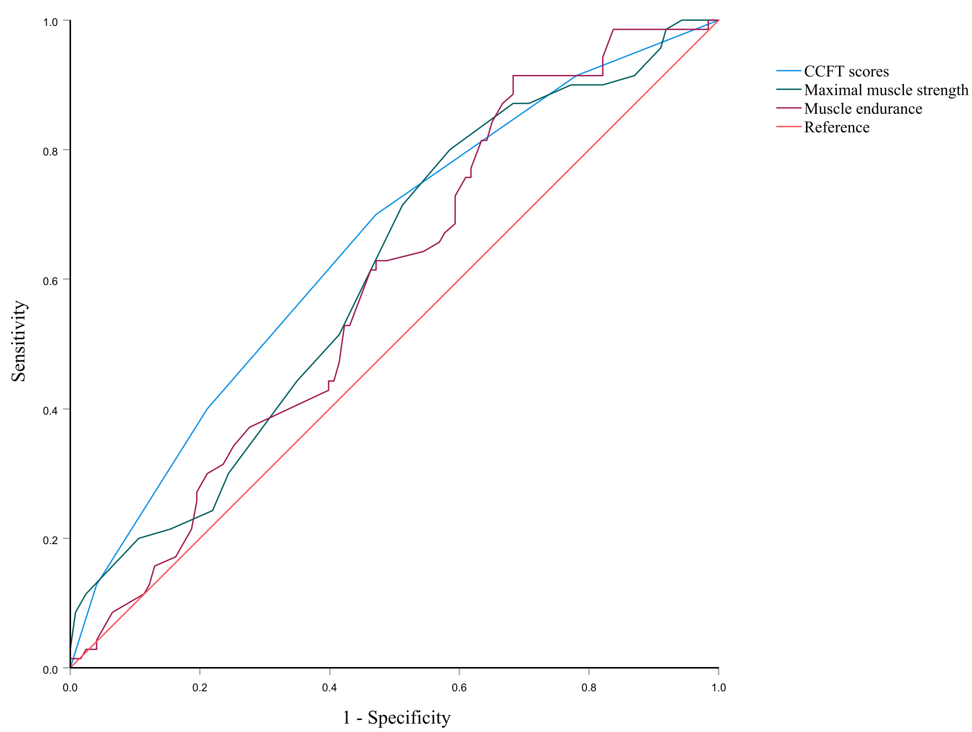

Figure 3 ROC curves of CCFT score, maximal muscle strength, and muscle endurance.

Table 4 Univariate Ordered Logistic Regression Analysis of CCFT Scores in Patients with CNNP

Factor	β	Wald	P	OR	95% CI
Gender	−0.27	0.41	0.52	0.76	0.33~1.76
Age	0.01	0.01	0.99	1.01	0.94~1.07
Weight	1.01	0.30	0.59	1.01	0.98~1.04
Height	0.02	0.39	0.53	1.02	0.97~1.06
BMI	0.02	0.10	0.75	1.02	0.89~1.17
Maximal muscle strength	0.11	4.75	0.03[a]	1.11	1.01~1.23
Muscle endurance	0.07	21.26	<0.01[a]	1.08	1.04~1.11
SHA	−0.07	7.31	0.01[a]	0.93	0.89~0.98
FHA	0.07	9.88	<0.01[a]	1.07	1.03~1.12
PSA	0.01	0.28	0.60	1.01	0.97~1.05
VAS	0.29	1.30	0.25	1.33	0.81~2.18
Duration	−0.05	3.52	0.06	0.95	0.91~1.01
Frequency	−0.01	0.01	0.93	0.99	0.92~1.08
Duration*frequency	−0.01	6.34	0.01[a]	0.99	0.98~0.99
NDI score =1	3.12	15.99	<0.01[a]	22.52	4.89~103.66
NDI score =2	–	–	–	–	–

Notes: [a]P<0.05, *multiplied by. NDI score =1: mild dysfunction, NDI score 0–20; NDI score =2: moderate dysfunction, NDI score 21–40.

Table 5 Multivariate Ordered Logistic Regression Analysis of CCFT Scores in Patients with CNNP

Factor	β	Wald	P	OR	95% CI
Maximal muscle strength	0.12	4.69	0.03[a]	1.12	1.01~1.25
Muscle endurance	006	13.42	<0.01[a]	1.07	1.03~1.10
SHA	−0.07	5.45	0.02[a]	0.93	0.88~0.99
FHA	0.06	5.36	0.02[a]	1.06	1.01~1.12
NDI score =1	2.18	6.97	0.01[a]	8.88	1.76~44.93
NDI score =2	–	–	–	–	

Notes: [a]P<0.05. NDI score =1: mild dysfunction, NDI score 0–20; NDI score =2: moderate dysfunction, NDI score 21–40.

Multivariate Ordered Logistic Regression Analysis of CCFT Scores in Patients with CNNP

Multivariate ordered logistic regression equations were constructed by including maximal muscle strength, muscle endurance, SHA and FHA, duration*frequency of onset, and NDI scores as independent variables. The results showed that maximal muscle strength, muscle endurance, FHA and lower NDI scores significantly increased the likelihood of higher CCFT scores ($P<0.05$). Conversely, SHA significantly decreased the likelihood of higher CCFT scores ($P<0.05$). See Table 5 for details.

Discussion

With the evolving lifestyle and work patterns, the prevalence of CNNP is escalating annually, imposing an increasing physiological and psychological burden on affected individuals. CCFT, along with assessments of maximal muscle strength and endurance of the deep cervical flexor muscle group, are recognized as effective tools for evaluating CNNP and are extensively utilized in clinical settings. However, their application and outcomes are infrequently documented within Asian populations.

The current study demonstrated that patients with CNNP exhibited lower CCFT scores compared to a healthy population, aligning with findings from previous research.[10,12] The CCFT specifically targets the activation of the longus capitis and colli muscles, which are deep flexors crucial for maintaining head and neck stability. Several studies have indicated that individuals with CNNP experience diminished recruitment efficiency of these deep head and neck flexor groups[19] and impaired sustained contraction,[20] contributing to their reduced CCFT scores.

However, the CCFT scores observed in patients with CNNP demonstrated geographical variability, with median or mean values ranging from 24 to 26 mmHg, as reported in previous studies.[13,21–23] In our study, the median CCFT score was 26 mmHg, aligning with the findings of Rodrigues et al,[13] and indicative of a relatively high level. The potential reasons for this observation are analyzed as follows: (1) Variations in the characteristics of the neck pain population. Previous research has indicated a negative correlation between CCFT scores and VAS scores in individuals experiencing neck pain.[12] To minimize the impact of pain and degenerative changes on the test outcomes, the study exclusively included young and middle-aged participants experiencing mild pain, as indicated by a VAS score of 5 or less. (2) Differences in the methodologies employed for CCFT are notable In the study conducted by Martins et al,[23] the difficulty level of the CCFT was augmented by necessitating three repetitions of 10-second isometric contractions for each level. Despite the inherently low-impact nature of the CCFT, this modification may still lead to reduced test scores. (3) Ethnic Variability: Substantial variations in muscle fiber composition and activity levels across different ethnic groups may influence the functional characteristics of the deep neck muscle groups.

The dysfunction of the deep neck flexor muscles is a significant contributing factor in the onset of CNNP.[24] Our research demonstrated that both the maximal muscle strength and endurance of the deep neck flexor muscle group were reduced in individuals with CNNP compared to the general population. The deep cervical muscle group is essential for maintaining proper head and neck posture, and prolonged overexertion can readily result in muscle fatigue.[25] Uhlig et al[26] identified impairments in the deep cervical flexor muscle group among patients experiencing neck pain, characterized by a shift in muscle fiber composition from type I to type IIb fibers, leading to diminished muscle endurance. This reduced endurance in the deep flexor group complicates the maintenance of proper posture and renders the muscle fibers more vulnerable to further impairment, thereby perpetuating a detrimental cycle. Furthermore, a study employing myoelectric recording devices demonstrated that individuals suffering from neck pain exhibit a diminished capacity for maximal voluntary contraction in the erector spinae, trapezius, and sternocleidomastoid muscles of the neck.[27] O'Riordan et al[28] found that enhancing active muscle strength in the neck is advantageous for alleviating pain, improving functional capabilities, and enhancing health-related quality of life. It is evident that patients with CNNP typically exhibit impairments in the neck flexor muscle group, characterized by reduced maximal muscle strength and endurance.

Although clinical evidence is limited, the adjustment of head and neck posture is widely acknowledged as crucial in managing CNNP.[29] Individuals with CNNP often exhibit "upper cross syndrome", which is marked by a forward head position, hyperextension of the upper cervical region, and rounded shoulders.[30] Rani et al[4] observed that patients experiencing neck pain displayed greater SHA compared to asymptomatic individuals. In contrast, Ruivo et al[31] proposed that suboptimal head and neck posture could be characterized by an SHA greater than 15° and a PSA less than 52°. Yip et al[18] proposed that a FHA of less than 50° should be classified as a postural abnormality. In the present study, the SHA among patients with CNNP was observed to be greater than that of the general population, thereby contributing to the clinical evidence base. Nonetheless, our findings did not reveal significant differences in FHA and PSA between the two cohorts. This lack of variance may be attributable to the relatively younger age and lesser severity of lesions in the CNNP patients included in our sample.

Few previous studies have examined the relative effectiveness of CCFT scores, maximal muscle strength, and muscle endurance of the deep neck flexor muscle group in predicting the occurrence of CNNP. The ROC curves generated in this study indicated that the AUC for CCFT scores surpassed that of both maximal muscle strength and muscle endurance, implying that CCFT scores possess the highest predictive efficacy. However, it is important to note that the AUC for CCFT scores was only 0.65, indicating that it is not yet the optimal indicator for diagnosing CNNP. Consequently, we conducted an in-depth examination of the factors potentially affecting CCFT scores. The findings indicated that maximal muscle strength, muscle endurance, FHA, and lower NDI scores were positively associated with CCFT scores, whereas SHA was negatively associated in patients with CNNP. The CCFT is a neuromuscular control training based on the concept of motor learning,[13] and the increased CCFT scores may be related to the improvement of function and posture of the deep neck flexor muscle group.

Florencio et al[30] demonstrated a moderate correlation between CCFT scores and the electromyographic (EMG) activity of neck muscle groups. Another study that recorded the EMG activity of the deep cervical muscle groups with built-in electrodes in the oropharyngeal wall found that the magnitude of the CCFT scores was linearly and positively correlated with the excitability of the deep cervical flexor muscle group, and the CCFT scores may be a sensitive response to the functional changes in the deep cervical flexor muscle group.[32] The aforementioned studies align with our conclusions. Conversely, inadequate posture is recognized as a significant contributor to muscle damage and dysfunction.[18] CCFT primarily engages the longus capitis and longus colli muscles, with the former facilitating flexion of the atlantooccipital joint and the latter contributing to the maintenance of a slight straightening of the cervical spine. When the deep cervical muscles are compromised, the strength of head and neck flexion diminishes, resulting in the collapse of cervical curvature, hyperextension of the atlantooccipital joint, and anterior head protraction.[33] Poor posture subsequently alters the positional relationship of the deep neck flexor muscles, potentially inhibiting their function.[34] NDI scores have demonstrated high reliability and validity in assessing the severity of CNNP. Lower NDI scores are indicative of better neck functional status,[35] suggesting a positive correlation between CCFT scores and neck functional status. Thus, we recommend the utilization of CCFT in the clinical prediction and assessment of CNNP. Although its predictive efficacy for CNNP may not be the highest among clinically known models, CCFT is straightforward and easy to implement, making it suitable for widespread use by clinicians and physiotherapists.

Study Limitations

This study also has limitations. CNNP is a multifaceted clinical issue influenced by various factors, potentially including culture, ethnicity, occupation, and psychological and behavioral elements.[3,5] One of the primary focuses of our investigation is cervical and neck posture. Since any interventions or treatments aimed at the cervical and neck region may affect both posture and the status of neck flexor muscles, we excluded patients who had undergone such interventions within the past three months. As a result, our final sample size was constrained, and the study population predominantly comprised Asian individuals with mild to moderate CNNP, which may restrict the generalizability of our findings to the broader CNNP population. Head and neck posture is closely related to individual lifestyle and work posture, and subgroup analysis could not be performed due to sample size limitations. In the future, we plan to expand the sample size and conduct subgroup analyses, carefully considering potential biases by stratifying variables such as work status and lifestyle. Additionally, we intend to further validate the findings of this study by incorporating electromyography and imaging assessments.

Conclusions

CCFT demonstrates good predictive value for CNNP, outperforming muscle strength and endurance. Factors positively influencing CCFT scores include maximal muscle strength, muscle endurance, FHA and lower NDI scores, while SHA negatively affects these scores. Therefore, we suggest that CCFT has a good application value in the diagnosis and management of CNNP.

Abbreviations

CNNP, Chronic non-specific neck pain; CCFT, Craniocervical flexion test; VAS, Visual analogue scale; NDI, Neck Disability Index; SHA, Sagittal head angle; FHA, Forward head angle; PSA, Protracted shoulder angle; ROC, Receiver operating characteristic; AUC, area under the curve.

Data Sharing Statement

The additional unpublished data from the study can be obtained from the corresponding authors.

Ethics Approval and Informed Consent

All participants provided informed consent for this study. This study was approved by the Ethics Committee of the First People's Hospital of Lianyungang City (KY-20220223001-01).

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Author Contributions

All authors made significant contributions to the work reported, whether in the conception, study design, execution, data acquisition, analysis and interpretation, or all of these areas. They took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no competing interests.

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