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Relationship Between Changes in Cranio-Cervical Extensor Muscles and Quality of Life: A Single-Center Study of 15 Patients with Chronic Tension-Type Headache

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ABCDEF G 1 **Xiaoman Min**
B 2 **Yongjun Huo**
BCEF 3 **Ning Sun**
B 4 **Hongwei Zhi**
F 4 **Haitao Li**
B 4 **Sishuo Zhang**
ABCEFG 4 **Wenqiang Cui**
B 5 **Yanlin Guo**
ABEG 4 **Hongyun Wu**

1 College of Traditional Chinese Medicine, Shandong University of Traditional Chinese Medicine, Jinan, Shandong, PR China
2 Department of Medical Imaging, Affiliated Hospital of Shandong University of Traditional Chinese Medicine, Jinan, Shandong, PR China
3 First Clinical Medical College, Shandong University of Traditional Chinese Medicine, Jinan, Shandong, PR China
4 Department of Neurology, Affiliated Hospital of Shandong University of Traditional Chinese Medicine, Jinan, Shandong, PR China
5 Department of Neurology, Tai'an Hospital of Traditional Chinese Medicine, Tai'an, Shandong, PR China

Corresponding Author: Hongyun Wu, e-mail: whyhzhongonly@126.com

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Background: This single-center study of 15 patients with chronic tension-type headache aimed to compare the cranio-cervical extensor muscles between patients with chronic tension-type headache and healthy individuals and to explore the relationship between changes in cranio-cervical extensor muscles and quality of life (QoL).

Material/Methods: We recruited 15 patients with chronic tension-type headache and 15 healthy individuals. Patients with chronic tension-type headache were diagnosed by 2 neurologists according to the diagnostic criteria in the International Classification of Headache Disorders, 3rd edition (ICHD-3). Morphological changes in the cranio-cervical extensor muscle were detected using magnetic resonance imaging (MRI). QoL and the degree of neck dysfunction were assessed using the Headache Impact Test-6 (HIT-6) and Neck Disability Index (NDI), respectively.

Results: The relative cross-sectional areas (rCSAs) of the rectus capitis posterior minor (RCPmin) were lower in patients with chronic tension-type headache than in healthy individuals. The HIT-6 scores ($r=-0.93$, $P<0.001$ and $r=-0.85$, $P<0.001$ for RCPmin right side and left side, respectively) and NDI scores ($r=-0.75$, $P<0.001$ and $r=-0.70$, $P<0.001$ for RCPmin right side and left side, respectively) were negatively associated with the rCSA of RCPmin in the chronic tension-type headache group.

Conclusions: Most patients with chronic tension-type headache experience RCPmin atrophy. The more evident the RCPmin atrophy, the worse the QoL of the patients with chronic tension-type headache.

Keywords: **Cross-Sectional Studies • Magnetic Resonance Imaging • Muscular Atrophy • Quality of Life • Tension-Type Headache**

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Background

Tension-type headache is the most common type of headache [1,2]. Among all the diseases registered by the Global Burden of Diseases, Injuries, and Risk Factors studies in 2016, tension-type headache has the highest prevalence [3], ranging from 36% to 78% [4]. Tension-type headache is more common in men than women and is more common in people aged 30-39 years [5]. Chronic tension-type headache is a disease that evolves from episodic tension-type headache, and its incidence rate is 2.2% [6]. Patients with chronic tension-type headache may experience anxiety, depression, or sleep disorders under the continuous influence of headaches, and the pain of patients with chronic tension-type headache has various negative effects on their daily activities, work, and family [7-9]. Tension-type headache can be treated with analgesics, preventive therapy, and antidepressants [10,11].

McPartland et al found that, compared with healthy subjects, subjects with chronic neck pain had atrophy of the rectus capitis muscle, which may indicate a relationship between chronic pain and muscle atrophy [12]. In a study on tension-type headache, Fernández-de-las-Peñas et al found that the rectus capitis posterior minor (RCPmin) and rectus capitis posterior major (RCPmaj) of patients with chronic tension-type headache were atrophied compared to healthy individuals [13]. The splenius capitis is atrophied in adolescents with tension-type headache [14]. Eunsang Lee et al found that after 2 weeks of biofeedback treatment, tension-type headache patients' headache symptoms improved and their Headache Impact Test-6 (HIT-6) scores decreased significantly [15]. Wonho Choi found that the tension of suboccipital muscles, headache, and Neck Disability Index (NDI) scores of patients with tension-type headache decreased after performing cervical deep-muscle flexion exercises [16]. Therefore, we speculated that the neck muscles of patients with chronic tension-type headache may be atrophied, which may also be related to decreased quality of life (QoL) of patients with chronic tension-type headache.

With the continuous development of medicine, magnetic resonance imaging (MRI) has gradually become an important tool for detecting muscle atrophy [17]. Fernández-de-Las-Peñas et al used MRI to measure the cross-sectional areas (CSAs) of neck muscles, and the CSAs measured using this method are considered to be accurate [13]. We used MRI to detect the CSAs of the crano-cervical extensor muscles of patients with chronic tension-type headache, including the RCPmin, semispinalis capitis, and splenius capitis. Therefore, this single-center study of 15 patients with chronic tension-type headache aimed to investigate the relationship between changes in crano-cervical extensor muscles and QoL.

Material and Methods

Ethics Statement

This study was approved by the Ethics Committee of the Affiliated Hospital of Shandong University of Traditional Chinese Medicine (registration number: ChiCTR2200058447, ethics approval number: 2020-018) and was performed in accordance with the Declaration of Helsinki. All participants reported that the MRI examination and other tests were acceptable and completed all tests. All participants signed an informed consent form prior to participation.

Study Population

Recruitment of Subjects

We recruited 22 subjects with chronic headache and 15 healthy subjects between November 2021 and April 2022. All subjects were recruited from the Affiliated Hospital of Shandong University of Traditional Chinese Medicine and were right-handed. All our subjects were formally recruited through registration and screening, excluding outpatients and inpatients. According to the diagnostic criteria of the chronic tension-type headache in the International Classification of Headache Disorders, 3rd edition (ICHD-3: Code 1.1, 2013) [18], patients with chronic tension-type headache were diagnosed by neurologists Professor Wu and Professor Li.

Inclusion Criteria

For inclusion in this study, all patients had to meet the ICHD-3 diagnostic criteria of chronic tension-type headache [18]: mild or moderate nonpulsatile pain on both sides of the head, without photophobia, fear of sound, nausea, or vomiting. All cases evolved from episodic tension-type headache, but headache must last for at least 15 days per month for more than 3 months before it can be considered chronic headache. In addition, the severity of headache should not be affected by daily physical activity, and there should be no signs of secondary headache or medication-overuse headache.

Patients with chronic tension-type headache who were included in the examination could receive preventive or therapeutic treatment with pain-killing drugs with the doctors' consent or when they have a headache.

Subjects in the healthy control group were required to be in a healthy state and have no headache within the last year, no medication in 1 month, and no family history of headache. The subjects did not consume alcohol, caffeine, or other substances for at least 3 days before MRI.

Exclusion Criteria

The exclusion criteria for all subjects included the following: (1) subjects taking opioid analgesics, antipsychotics, or ergotamine, consuming alcohol, or abusing other drugs; (2) subjects complicated with serious primary or mental diseases, such as heart, brain, liver, kidney, and hematopoietic system diseases; (3) pregnant or lactating women; (4) subjects contraindicated to undergo MRI or unwilling to cooperate; (5) the body mass index (BMI) of the subjects was not within the normal range, or they were too weak to exercise normally.

After screening, 15 patients with chronic tension-type headache and 15 healthy individuals were recruited for this study. An MRI scan was performed during the interictal stage in the chronic tension-type headache group, at least 3 days after the chronic tension-type headache attack. MRI was performed on 1 healthy individual on the same day.

Data Collection

Clinical evaluation

In addition to recording the subjects' sex, age, and preferred hand, the height (m) and weight (kg) of each subject were also recorded to calculate their BMI, which was used to explore whether the BMI of the subjects had an effect on the changes in their muscles. The data of all subjects were obtained using the same measuring ruler and scale.

MRI-Related Data

In this study, we used MRI to detect morphological changes in muscles [13]. All images were acquired using a SIGMA Pioneer 3.0T MRI scanner. The region of interest of the muscle was manually delineated using the area measurement function of the MRI machine.

The suboccipital muscles, including the RCPmaj, RCPmin, obliquus capitis superior, and obliquus capitis inferior, are considered to be closely related to chronic tension-type headache [19]. The obliquus capitis inferior is involved in ipsilateral neck rotation. The RCPmin, RCPmaj, and obliquus capitis superior can help extend the head, and unilateral contraction contributes to ipsilateral rotation and side bending of the head [20]. Similar to the RCPmin and RCPmaj, the semispinalis capitis and splenius capitis also participate in head extension. The semispinalis capitis can maintain the neck forward-bending posture. The splenius capitis helps with ipsilateral rotation of the head and leaning the head backward. After combining the previous research and careful consideration, we analyzed the following neck muscles: the RCPmin, semispinalis capitis, and splenius capitis [13,14].

The measurement parameters were as follows: 28 slices, 4-mm slice thickness, 200 mm field of view read, 520 ms repetition time, 20.0 ms echo time, 256×256 matrix size, and 15:00 acquisition time.

Calculation of Neck Muscles' Relative Cross-Sectional Areas (rCSAs)

Because the measured neck muscles can be observed on at least 2 cervical planes, to minimize the error between the chronic tension-type headache and control groups, we used the rCSA to standardize the data. Our method was optimized using Elliott's method [21]. After the MRI examination, we obtained sagittal and axial slices of head and neck of each subject. Through their sagittal slices, we could locate specific levels of each cervical vertebra, then we chose the slices corresponding to the cervical vertebra we desired. Finally, we used axial images to measure the rCSAs of the neck extensor muscles at specific cervical levels. The rCSAs of both RCPmin muscles were measured using axial scans at the C1 and C2 levels (Figure 1A). The rCSAs of the semispinalis capitis and splenius capitis were measured once each in the C3 and C4 segments (Figure 1B, 1C). To ensure the accuracy of data, at least 2 professionals (Professor Cui, Professor Huo, or Professor Zhi) were present when measuring each group of data, none of them knew the subject's diagnosis, and they all stated that they had no objection to the measured data values.

The HIT-6 Score

The HIT-6 can be used to evaluate the effect of various types of headaches on QoL [22], so we used the HIT-6 to evaluate the effect of chronic tension-type headache on QoL. These 6 questions of the HIT-6 originate from the Internet-based Headache Impact Questionnaires, Migraine Disability Assessment Scale, and migraine-specific QoL questionnaires. These 6 questions are related to the degree of pain, social activities, daily activities, cognitive function, psychological state, and concentration of patients. The total score of the HIT-6 should be between 36 and 78, and the corresponding scores of each option are as follows: never, 6 points; rarely, 8 points; sometimes, 10 points; often, 11 points; and always, 13 points. The higher the score of the subjects, the greater the effect of headaches on QoL. The criteria for determining the effect of different total QoL scores are shown in Table 1 [23].

The NDI Score

The NDI can be used to evaluate neck dysfunction in patients with neck pain and is widely used as a self-reported questionnaire for assessment of disability in patients with neck pain [24]. The NDI consists of 10 questions, including the intensity of neck pain, headache, attention loss, and other related symptoms

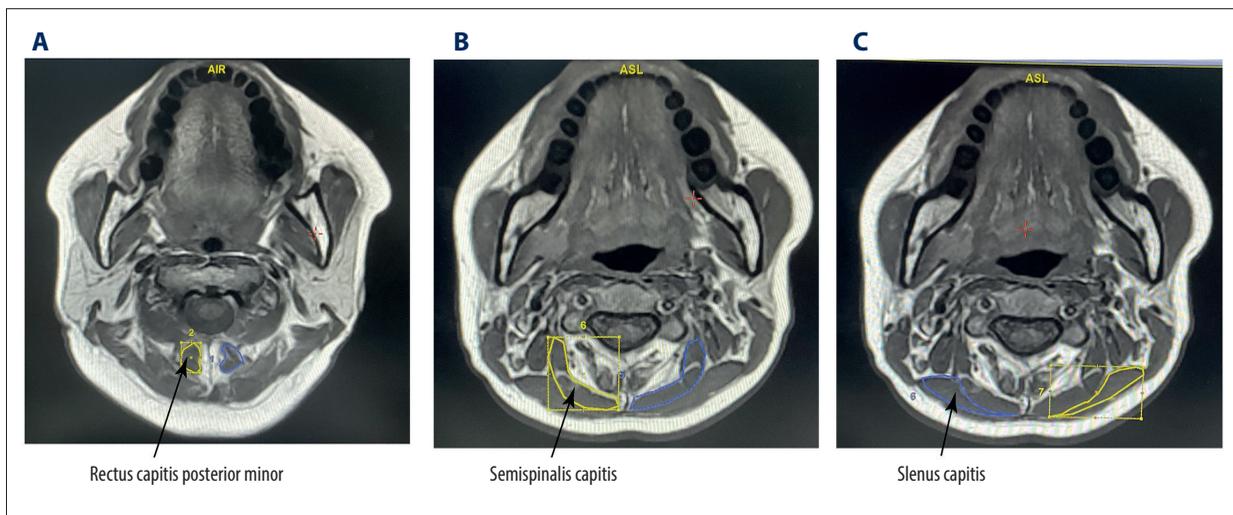


Figure 1. (A-C) Posterior cervical extensor muscles on magnetic resonance imaging. In this study we tested 3 muscles: the rectus capitis posterior minor, semispinalis capitis, and splenius capitis. The blue and yellow parts in the picture are the cross-sectional areas of the muscles we tested. This figure was created using Adobe Illustrator CC 2018 (Adobe).

Table 1. Criteria for determining the effect of the different Headache Impact Test-6 (HIT-6) scores on quality of life (QoL). The total score of the HIT-6 should be between 36 and 78. The higher the score of the subjects, the greater the effect of headaches on QoL.

Total score	Degree of impact on QoL
36-49	No impact
50-55	Slight affect
56-60	Significant affect
61-78	Serious affect

and the impact of neck pain on daily life, such as lifting heavy objects, reading, work, driving, entertainment, and sleep. The corresponding scores for each option are as follows: 0 points, no effect, 1 point, occasionally affected; 2 points, slightly affected; 3 points, moderately affected; 4 points, severely affected; and 5 points, continuously affected. The neck function impairment index was calculated after obtaining the corresponding score for each subject. The calculation formula is as follows: neck function impairment index (%)=(total score of each item/ number of items completed by the subject×5)×100%. The higher the neck function impairment index, the greater the effect of neck pain on QoL [25], so we used the NDI score to explore the influence of neck dysfunction on QoL of chronic tension-type headache patients.

Statistical Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) statistical package (version 26.0; SPSS Inc.).

Anthropometric data are expressed as the mean±standard deviation. The normal distribution of quantitative data was evaluated using the Kolmogorov-Smirnov test ($P>0.05$). The data without normal distribution were analyzed using a nonparametric test, and the data with normal distribution were analyzed using a parametric test. The Kruskal-Wallis H test was used to analyze the side-to-side rCSA differences in all muscles (patient and control groups, left and right). Differences in rCSAs between the patients and controls were assessed using the Wilcoxon rank-sum test. Spearman’s rho (rS) test was used to analyze whether there was a correlation between neck muscle rCSA and BMI. Finally, Spearman’s rho (rS) test was used to explore the association between rCSAs of scanned muscles and headache-related variables (HIT-6 score, NDI score) in patients with chronic tension-type headache. Statistical analyses were performed at a 95% confidence level. Statistical significance was set at $P<0.05$.

Results

Participants and Baseline Characteristics

Fifteen patients were included in this study, with a disease duration of more than 3 (7.60±2.41) months and an average attack duration of more than or equal to 15 (19.07±4.22) days. All patients with chronic tension-type headache in this study had symptoms of tension headache within 1 month before the test and lasted for more than 15 days. Fifteen age-, sex-, and dominant-hand-matched healthy controls were included in this study. The demographic characteristics, including sex, age, and dominant hand, are shown in Table 2. No significant differences were observed between the groups ($P=1.00, 0.98, \text{ and } 1.00$, respectively).

Table 2. Baseline characteristics of subjects. Fifteen age-, sex-, and dominant-hand-matched healthy controls were included in this study. The demographic characteristics included sex, age, and dominant hand.

Items		CTTH	Controls	P-value
Sex	Male	7	7	1.00
	Female	8	8	
Age (mean±SD)		35.53±12.31	35.67±12.23	0.98
Dominant hand	Right	15	15	1.00
	Left	0	0	

Table 3. Difference in relative cross-sectional area of the left and right muscles. No significant difference was found in the left and right muscles of each subject in all patients with chronic tension-type headache and healthy individuals ($P>0.05$).

Items	P-value
RCPmin (CTTH)	1.000
RCPmin (Controls)	1.000
Semispinalis capitis C3	0.877
Semispinalis capitis C4	0.924
Splenius capitis C3	0.878
Splenius capitis C4	0.746

MRI Outcomes

Comparison of Left and Right Craniocervical Extensor Muscles

After the Kolmogorov-Smirnov test, the rCSA data did not have normal distribution range; thus, nonparametric analysis was selected. No significant difference was found in the left and right muscles of each subject in all patients with chronic tension-type headache and healthy individuals ($P>0.05$). In all our subjects, the 4 pairs of muscles we tested were symmetrical. The result of the comparison of left and right muscles of subjects are displayed in **Table 3**.

Comparison of Craniocervical Extensor Muscles Between Chronic Tension-Type Headache Patients and Healthy Controls

Compared with healthy controls, the rCSAs of the RCPmin in patients with chronic tension-type headache were lower ($P<0.001$ and $P<0.001$ for RCPmin right side and RCPmin left side, respectively, **Table 4, Figure 2**), indicating that the RCPmin in chronic tension-type headache patients are atrophic. However, at C3 and C4 levels, there were no significant differences in

Table 4. Differences in relative cross-sectional areas (rCSAs) between patients with chronic tension-type headache and healthy controls. Compared with healthy controls, the rCSAs of the RCPmin in patients with chronic tension-type headache were lower ($P<0.001$ and $P<0.001$ for RCPmin right side and RCPmin left side, respectively). At C3 and C4 levels, there was no significant difference in the rCSAs of the semispinalis capitis and splenius capitis between patients with chronic tension-type headache and controls ($P>0.4$).

Items	P-value
RCPmin (CTTH)	1.000*
RCPmin (Controls)	1.000*
Semispinalis capitis C3	0.877
Semispinalis capitis C4	0.924
Splenius capitis C3	0.878
Splenius capitis C4	0.746

Values are expressed as mean±standard deviation. * Significant differences between CTTH and controls (Wilcoxon rank-sum test).

the rCSAs of the semispinalis capitis and splenius capitis between patients with chronic tension-type headache and controls ($P>0.4$, **Table 4**). We did not find any significant difference between the semispinalis capitis and splenius capitis of patients with chronic tension-type headache and healthy individuals. Moreover, we did not find a direct correlation between BMI and rCSA values ($P=0.244 >0.05$). The rCSA values of subjects had no relationship with their height and weight.

HIT-6 Outcomes

The HIT-6 scores of patients with chronic tension-type headache ($55.07±4.83$) were significantly higher than those of healthy volunteers ($39.73±3.56$) (Wilcoxon rank-sum test, $P<0.001$, **Figure 3A**), indicating that chronic tension-type headache had a significant negative effect on QoL. The proportion of patients whose QoL was affected was 87% ($n=13$), of whom 39% ($n=5$)

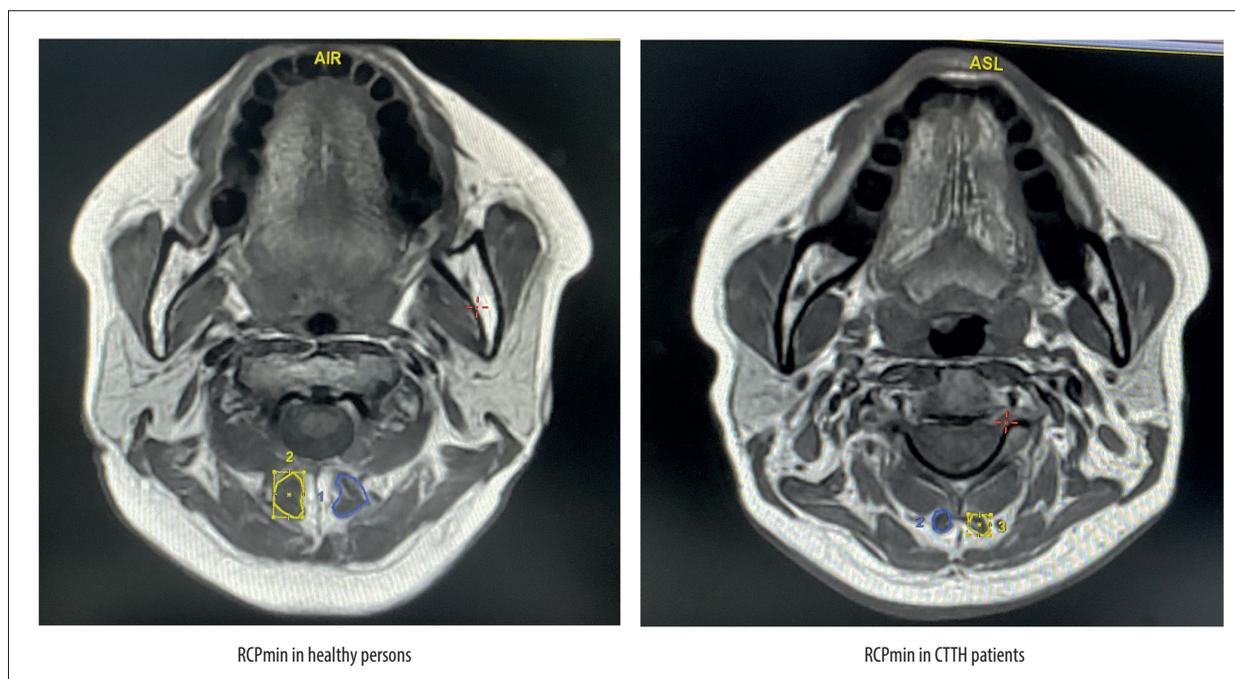


Figure 2. The rectus capitis posterior minor (RCPmin) in patients with chronic tension-type headache and healthy controls. The blue and yellow parts in the picture are the cross-sectional areas of the RCPmin. Compared with the healthy controls, the RCPmin of CCHH patients was atrophic. This figure was created using Adobe Illustrator CC 2018 (Adobe).

were slightly affected, 46% (n=6) were moderately affected, and 15% (n=2) were seriously affected.

NDI Outcomes

The neck function impairment index of patients with chronic tension-type headache ($16.2 \pm 10.96\%$) was significantly higher than that of healthy volunteers ($5.01 \pm 2.60\%$) (Wilcoxon rank-sum test, $P < 0.001$, **Figure 3B**). The proportion of chronic tension-type headache patients with neck dysfunction was 27% (n=4), and the proportion of healthy individuals was 0%. This indicates that patients with chronic tension-type headache are more likely to have neck disability than healthy individuals, and that abnormal neck muscle function has a greater effect on their QoL.

Correlation Analysis Results

Correlation Between the HIT-6 Score and the rCSA of RCPmin in the Chronic Tension-Type Headache Group

The results of Spearman correlation analysis showed that there was a significant negative correlation between the HIT-6 score and the rCSA of the RCPmin in the chronic tension-type headache group ($r = -0.93$ and $P < 0.001$ and $r = -0.85$ and $P < 0.001$ for RCPmin right side and RCPmin left side, respectively). The higher the HIT-6 scores, the smaller the rCSA value in the RCPmin. This result suggests that atrophy of the RCPmin affects the

activities of daily living in patients with chronic tension-type headache and reduces their QoL.

Correlation Between the NDI Score and the rCSA of RCPmin in the Chronic Tension-Type Headache Group

The NDI score and rCSA of the RCPmin in the chronic tension-type headache group were also negatively correlated ($r = -0.75$, $P < 0.001$ and $r = -0.70$ and $P < 0.001$ for RCPmin right side and RCPmin left side, respectively). With the decrease in rCSAs of the RCPmin in patients with chronic tension-type headache, their NDI scores increased. The more evident the RCPmin atrophy, the worse the neck function of the patients with chronic tension-type headache.

Discussion

In our study, we measured the rCSAs of patients with chronic tension-type headache and healthy individuals and analyzed the relationship between the rCSAs and QoL in patients with chronic tension-type headache. According to our results, compared with the healthy control group, the rCSAs of the RCPmin in patients with chronic tension-type headache were lower, suggesting muscle atrophy, whereas the rCSAs of the semispinalis capital and splenius capital did not differ significantly between patients with chronic tension-type headache and healthy individuals. We did not find a clear correlation

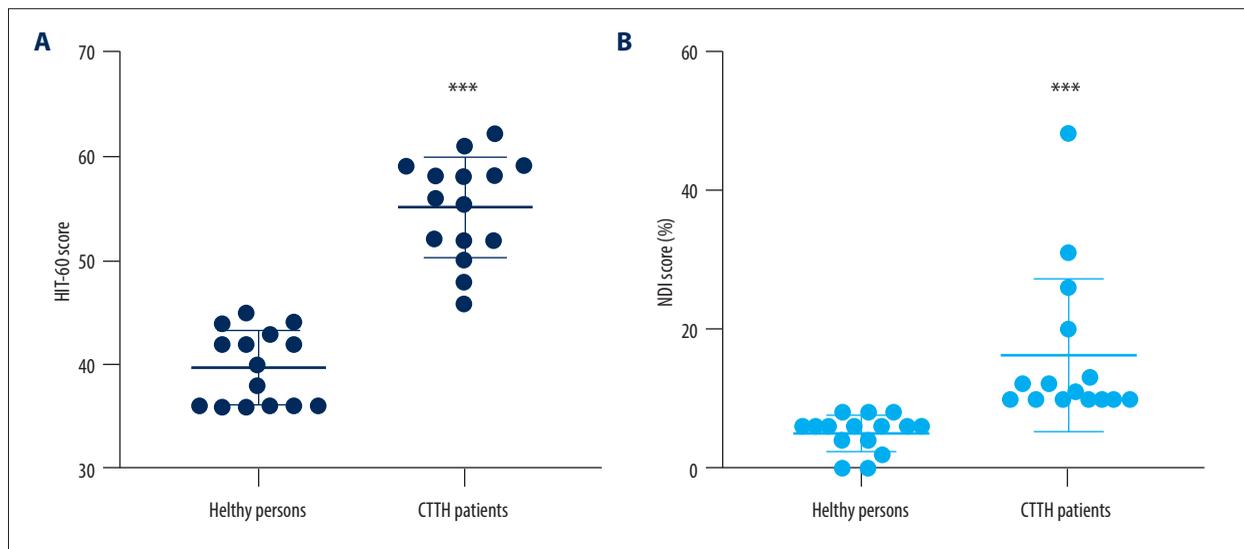


Figure 3. Comparison of Headache Impact Test-6 (HIT-6) and Neck Disability Index (NDI) scores between patients with chronic tension-type headache and healthy controls. The scatter diagram of HIT-6 (A) and NDI (B) scores in the 2 groups. The HIT-6 scores of patients with chronic tension-type headache (55.07 ± 4.83) were significantly higher than those of healthy volunteers (39.73 ± 3.56). The neck function impairment index of patients with chronic tension-type headache ($16.2 \pm 10.96\%$) was significantly higher than that of healthy volunteers ($5.01 \pm 2.60\%$). This figure was created using GraphPad Prism version 6 (GraphPad Software). *** $P < 0.0001$ compared with healthy controls (Wilcoxon rank-sum test).

between the rCSA values of the subjects and their BMI index. Some patients with chronic tension-type headache had small rCSAs' RCPmin values, not because of their low BMI index, but because their RCPmin had atrophied.

Our results suggest that chronic tension-type headache is closely associated with RCPmin atrophy. Deep-muscle atrophy in patients with musculoskeletal diseases has been reported in previous studies. The symptomatic side of patients with unilateral back pain shows spinal muscle atrophy [26]. The degree of pain in patients with chronic low back pain is negatively correlated with the degree of atrophy of the paraspinal muscle [27]. Furthermore, in a prior study related to tension-type headache, the RCPmin and RCPmaj of patients with chronic tension-type headache were more atrophied compared with those of healthy individuals [13]. In our study, consistent with previous findings, the RCPmin in patients with chronic tension-type headache also showed atrophy. The area around the RCPmaj is surrounded by the superior oblique muscle of the head, RCPmin, semispinalis capitis, and splenius capitis. The RCPmaj is at risk of unclear boundary, resulting in inaccurate data, and thus is not measured. This suggests that patients with chronic tension-type headache have experienced atrophy of the rectus capitis muscle, which may be an important factor leading to chronic pain. The splenius capitis also atrophies in adolescents with tension-type headache [14]. However, there was no significant difference in the rCSAs of the semispinalis capitis and splenius capitis between patients with chronic tension-type headache and healthy controls in our study. We

will recruit more subjects in the future and further observe the changes in these 2 muscles.

The current explanation for the decrease in rCSAs in the cervical muscles of patients with tension-type headache is mostly hypothetical. The RCPmin is connected to the cervical dura mater through a myodural bridge [28-30]. During normal head movement, it can prevent or limit inflection of the dura mater, which is sensitive to pain [29,31]. The RCPmin of patients with chronic headache tend to have a fatty infection (FI) [32]. FI can cause atrophy of the RCPmin, reduce its strength, and cause the RCPmin to be unable to maintain normal tension levels within the myodural bridge [33]. Therefore, FI is likely to lead to infolding of the dura mater in daily life and further cause headache and neck pain, which may also explain why osteopathic manipulative treatment techniques can alleviate some cranio-cervical disorders [30,31]. Headache can limit neck movement, and insufficient effective use of the neck may change the state of the neck muscles and lead to muscle atrophy [34,35], but the RCPmin may not substantially contribute to gross movements of the head [36]. Therefore, the restriction of neck movement by headache of chronic tension-type headache patients may not be closely related to the changes in RCPmin status.

In our study, as also reported by Eunsang Lee et al [15], we found that the degree of atrophy of the RCPmin in patients with chronic tension-type headache was negatively correlated with their HIT-6 scores. Moreover, the NDI scores of patients with chronic tension-type headache were negatively correlated

with the degree of atrophy of their RCPmin, which was consistent with the findings of Wonho Choi [16]. The degree of atrophy of the RCPmin in patients with chronic tension-type headache affected their QoL. We hope that we can improve the QoL of patients with chronic tension-type headache by changing the state of the crano-cervical extensor muscles.

The strength of our study is that the age of the patients we selected covered a relatively wide range. Our study has shown that the RCPmin in patients with chronic tension-type headache tend to be atrophied compared with healthy individuals. If we continue to recruit more subjects, the change trend of the RCPmin we found may help clarify the diagnosis of chronic tension-type headache in more patients of various ages with chronic tension-type headache. Each patient with chronic tension-type headache was accurately diagnosed by experts with high reliability. All rCSAs were measured by the same examiner, which reduces the data error as much as possible.

However, our study has some limitations. First, we only selected patients with chronic tension-type headache to participate in this study, rather than patients with other types of headaches. Therefore, our study results can only be applied to patients with chronic tension-type headache and not to those with other types of headache. Future studies should further explore whether other types of headaches are associated with neck muscle atrophy. Second, the sample size of the present study was relatively small, as only 15 patients with chronic tension-type headache and 15 healthy individuals were included. In the future, we can further expand the number of subjects to conduct multicenter observations with a large sample size to reduce the influence of regional factors on the experimental results and further clarify the relationship between muscle atrophy and chronic tension-type headache. Third, although our participants were systematically educated before the MRI examination, some subjects still have a short period of activity during MRI scanning, which may have had a slight impact on the results. We hope we can find a way to shorten the test time in the future. Fourth, the rCSA of muscle was manually delineated using the area measurement function of the MRI machine. Although our drawing process was very careful, there were still inevitable small errors. Finally, the muscle tissue around the RCPmaj is quite dense, which can easily produce large errors in measurement. We did not measure this muscle tissue. Efforts should be made to determine a measurement method suitable for the RCPmaj. In this way,

we can have a more comprehensive understanding of the effect of changes in cranial neurological extension muscles in patients with chronic tension-type headache.

Conclusions

In our study, compared with healthy controls, the rCSAs of the RCPmin in patients with chronic tension-type headache were lower. Our results show a change in the crano-cervical extensor muscles in patients with chronic tension-type headache. With the decrease in rCSAs of the RCPmin in patients with chronic tension-type headache, their HIT-6 scores and NDI scores increased. The more evident the RCPmin atrophy, the worse the QoL of the patients with chronic tension-type headache. However, it remains unclear whether atrophy of the neck muscles leads to the occurrence of chronic tension-type headache or whether chronic tension-type headache leads to changes in the neck muscles. More experiments are required to explore the pathophysiology related to changes in the cervical extensor muscles to provide a basis for the clinical diagnosis and treatment of chronic tension-type headache.

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Ethics statement

Each one of our coauthors has conformed to the Helsinki Declaration concerning human rights and informed consent, and has followed correct procedures concerning treatment of humans in research.

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Board of the Affiliated Hospital of Shandong University of Traditional Chinese Medicine (2020-018).

Declaration of Figures' Authenticity

All figures submitted have been created by the authors, who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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