Int J Clin Exp Med 2020;13(9):6687-6694
www.ijcem.com /ISSN:1940-5901/IJCEM0114689

Original Article

Cervical exercises improves cervical spondylotic localization: effects observation and mechanism analysis

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Received May 20, 2020; Accepted July 7, 2020; Epub September 15, 2020; Published September 30, 2020

Abstract: Objective: This study aimed to analyze the role of cervical exercises in the treatment of patients with cervical spondylotic localization (CSL). Methods: 63 CSL patients in Wonkwang University were divided into Group A (GA, n=32, drug treatment + cervical exercises) and Group B (GB, n=31, drug treatment) according to the diagnosis time. The curative effects were compared at 1 month after treatment. Results: (1) Compared to GB at 1 month after treatment, GA had lower scores in the 4 items of symptoms and signs and the 10 items of neck disability as well as greater mild disability to severe disability ratio ($P<0.05$). No statistical difference was observed in the moderate disability to extremely severe disability ratio between the two groups ($P>0.05$). At 1 week and 2-4 weeks after treatment, the VAS scores in GA were lower than those in GB ($P<0.05$); the total response rate (TRR) and recurrence rate (RR) was 90.62% and 6.25% in GA, 70.97% and 25.81% in GB, respectively ($P<0.05$). Conclusion: Cervical exercises helped relieve the pains, facilitate the recovery of cervical function, reduce the RR and improve the TRR in CSL patients.

Keywords: Cervical exercises, CSL, pain, dysfunction, recurrence, mechanism

Introduction

Cervical spondylosis is a multiple chronic orthopedic disease. Due to aging, social development, the increase in the number of white-collar workers and the progress of electronic information technology, the incidence of cervical spondylosis is rising, not only in the elderly but also in the young population [1]. Clinically, cervical spondylosis can be categorized as cervical root syndrome, cervical osteoarthritis, hyperplastic cervical spondylitis and cervical intervertebral disc herniation. It is mainly caused by mechanical compression of vertebral artery, spine and nerve root, showing various manifestations [2, 3].

Cervical spondylotic localization (CSL) is the early-middle stage of cervical spondylosis, which is less severe and accounts for about 2/5 of the cervical spondylosis cases. Patients may suffer from distending pains, limpness and numbness at neck, shoulders and occipitalia, stiff cervical muscles and local tenderness. Some may be affected during movement [4]. Regardless of its low severity, CSL may develop into other severe types of cervical spondylosis with rising difficulties in the treatment and intensifying pains [5], if not addressed specially. After assessment of patients' conditions, conservative treatments, including physical therapy, drugs, traction, acupuncture and moxibustion, massage and acupotomy, may be selected. These methods have demonstrated marked effects, but the recurrence rate after treatment is high due to improper posture in daily life and excessively frequent cervical movement [6, 7].

To ensure long-term effectiveness, efforts should be made to find alternative treatments. This study considers the important role of strengthening the muscles and ligament tension around the cervical vertebra as they may strain. Cervical exercises under guidance of CSL patients could effectively reduce the recurrence rate after treatment [8]. Therefore, 63 CSL patients were studied to provide more options for their treatment and healthcare.

Materials and methods

Materials

A medical examination was conducted on all students in the Department of Sports Science of Wonkwang University from July 2019 to February 2020, and a total of 63 patients diagnosed with CSL were included in the study and divided into Group A (GA, n=32) and Group B (GB, n=31) according to the order of diagnosis. Inclusion criteria: in line with the CSL diagnosis criteria of western medicine [9]; stagnation of vital energy and blood stasis according to the syndrome differentiation of traditional Chinese medicine [10]; age between 18 and 80; cervical curvature straightening or disappearing as displayed on the X-ray machine for cervical vertebra; good treatment adherence. Written informed consent was signed and provided by patients or their family members. This study was conducted with the approval of the ethics committee of our university. Exclusion criteria: complications such as diseases in heart, brain, liver and kidneys, mental disability, neck and shoulder pains due to other reasons; allergic to the drugs used in this study; osteoarticular tuberculosis; severe osteoporosis.

Methods

Patients in GB were treated by ibuprofen sustained release capsules (Specification: 0.3 g×10 capsules, GYZZ No.: H10900089, producer: SK&F). One capsule was taken half an hour after the breakfast and the supper every day. Health guidance was also provided to correct faulty postures in study and daily life. An appropriate pillow was selected to maintain correct sleeping position. Both drug treatment and health guidance lasted for 1 month.

Compared to GB, GA was required to take cervical exercises additionally as follows: (1) Leftward-rightward swagging: patients stood still with legs-shoulder width apart and looked at the front horizontally with arms on the waist. The head inclined leftward slowly until the left ear was in close contact with the left shoulder. After 15 s, the head returned to the middle position and inclined to the other side in the same degree. After maintaining the posture for 15 s, the head returned to the middle position again. The cycle repeated 15 times. (2) Forward-backward bending: patients stood as in step (1) and then slowly leaned the head back as far as possible while breathing in. Then the head slowly returned to the normal position and lowered till the lower jaw was in maximal contact with the chest. During this process, patients breathed out. The head was maintained in this position for 15 s. The whole movement repeated 15 times. (3) Head shaking: patients stood as in step (1). After completely relaxing their necks, they slowly rotated their heads substantially for 10 times clockwise and 10 times counterclockwise. For each movement, the back neck was pressed with one palm and rubbed against it, either longitudinally or horizontally, until heat was generated. Cervical exercises lasted for 1 month. (4) Shrugging and necking down: patients stood as in step (1) except for both arms which hanged down in this exercise and then were slowly raised to the shoulder, with the neck down maximally. After maintaining for 15 s, shoulders were relaxed and the neck stuck out. Next, both shoulders dropped down while the neck extended upward maximally. The posture was maintained for 15 s, during which, breath was held. Then patients relaxed shoulders and breathed slowly and naturally. During shrugging, the neck and shoulders should be relaxed as much as possible. (5) Looking right and left: patients stood as in step (1). While breathing in, they slowly turned their heads to the left until their necks were fully stretched. After 15 s, the head returned to the normal position and then slowly turned rightward in the same degree for 15 s. In this process, patients breathed out. The whole exercise repeated for 15 times.

Observation indicators

Symptoms and signs: before and at 1 month after treatment, typical symptoms and signs of CSL were scored as 0 for nil, 2 for occasional and 4 for always. These symptoms and signs included neck or shoulder pain, stiff neck, tenderness in occipito-cervical part or shoulders, and limited neck movement.

Pain intensity: the visual analogue scale (VAS) [11] (**Figure 1**), a scale plate with 11 numbers from 0 to 10, was used to evaluate the pain intensity before, at 1 week, and 2-4 weeks after treatment. Patients were guided to select a number to indicate their pain intensity, including 0 for no pain, 1-3 for mild pain, 4-6 for mod-

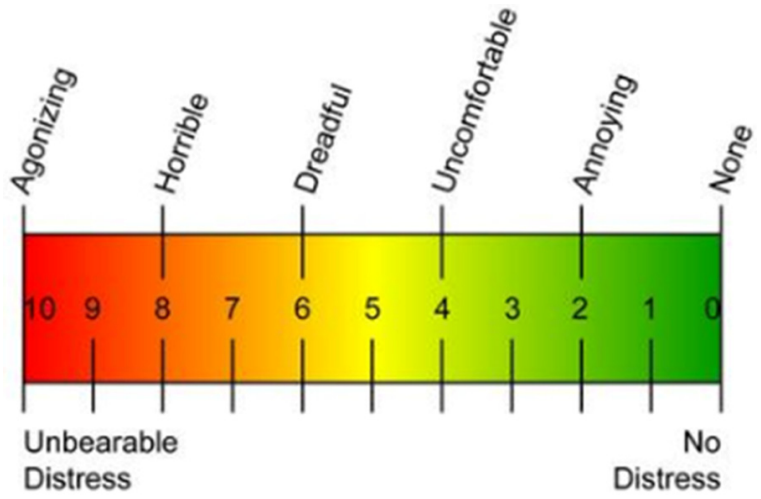

Figure 1. VAS for pain intensity. On a scale of 0 to 10 scores, pain intensity increased when approaching the red zone and decreased when moving toward the green zone.

erate pain, 7-9 for severe pain and 10 for extremely severe pain.

Degree of neck disability: the Neck Disability Index (NDI) [12] was used for assessment before and at 1 month after treatment. 10 items, including working, sleeping, driving, pain intensity, reading, headache, entertainment, concentration, personal care and lifting objects were scored on a scale of 0 to 5. The results were positively correlated with the degree of disability. NDI was expressed as the score/50×100%, corresponding to mild disability for 0-20%, moderate disability for 21-40%, severe disability for 41-60% and extremely severe disability for 61-80%.

Efficacy: efficacy criteria were established according to the improvements in symptoms and NDI before and after treatment. Patients were cured if all symptoms disappeared at 1 month after treatment, signs returned to the normal level and NDI reduced by 90% or more; the efficacy was regarded as marked effective if at 1 month after treatment, the symptoms basically disappeared, signs were close to the normal level and NDI reduced by 70-89%. Upturn was defined as a partial improvement in all symptoms and signs and a reduction of 50-69% in NDI. The treatment was ineffective if at 1 month after treatment, symptoms and signs remained the same and the decrease in NDI was less than 50%. Total response rate (TRR) = Cure rate + Markedly effective rate + Upturn rate.

Recurrence rate (RR): all patients were followed up for 6 months. The recurrence rate was recorded and compared. Recurrence criteria: typical CSL symptoms appeared again after the patient was cured at the discretion of the doctor, and a definite diagnosis was made.

Statistical analysis

Statistical analysis was performed with SPSS23.0. In case of nominal data expressed as [n (%)], comparison studies were carried out through X^2 test; in case of numerical data expressed as mean ± standard deviation (mean ± SD), comparison studies were carried out through T test; in case of intragroup comparison at multiple points, ANVOA analysis and F test were adopted. Drawings were made with Graphpad Prism 8. For all statistical comparisons, significance was defined as $P<0.05$.

Results

General materials

The proportions of male (53.13% vs 58.06%) and female patients (46.87% vs 41.94%), average age, body mass index (BMI), course of disease (70.13±13.62 d vs 72.65±14.18 d), VAS and NDI expressed no statistically significant difference between GA and GB upon admission ($P>0.05$) (**Table 1**).

Improvement of symptoms and signs by cervical exercises

There was no significant difference in scores of pain in neck or shoulders, stiff neck, tenderness in occipito-cervical part or shoulders, and limited neck movement between the two groups before treatment ($P>0.05$). The scores were sharply reduced in both groups at 1 month after treatment ($P<0.05$), which were far lower in GA than in GB ($P<0.05$) (**Figure 2**).

Relief of pain intensity by cervical exercises

The VAS score expressed no statistical significance between the two groups before treatment ($P>0.05$). After treatment, VAS score in

Table 1. Intergroup comparison of general materials ($\bar{x} \pm sd$)/[n (%)]

Materials		GA (n=32)	GB (n=31)	t/X^2	*P*
Gender	Male	17 (53.13)	18 (58.06)	0.156	0.693
	Female	15 (46.87)	13 (41.94)		
Age (y)		22.13±2.19	23.37±2.42	1.962	0.054
BMI (kg/m^2)		24.61±2.38	23.95±2.41	1.094	0.278
Course of disease (d)		70.13±13.62	72.65±14.18	0.719	0.475
VAS upon admission (score)		6.25±2.37	6.19±2.42	0.010	0.921
NDI upon admission (score)		37.15±5.42	35.96±5.17	0.891	0.376

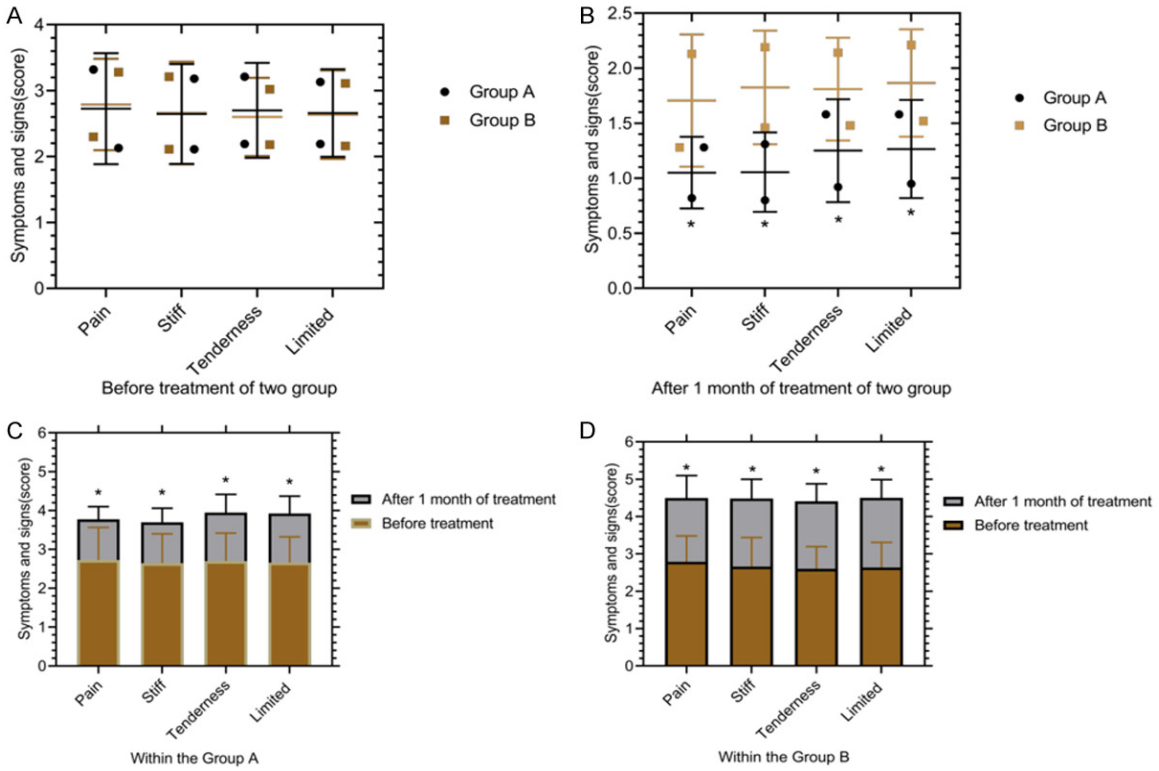

Figure 2. Intergroup comparison of symptoms and Signs. For neck or shoulder pain, stiff neck, tenderness in occipito-cervical part or shoulders, and limited neck movement, the two groups were not statically different before treatment (*P*>0.05) (A). At 1 month after treatment, these scores reduced in both groups but were far lower in the GA (*P*<0.05) (B-D). **P*<0.05 vs GB.

GA reduced steadily and significantly from week 1 to week 4 (*P*<0.05), while in GB, there was no statistical difference in VAS score at week 1 (P>0.05), but a significant and steady decrease showed up from week 2 to week 4 (*P*<0.05). At 1 week and 2-4 weeks after treatment, the VAS scores in GA were markedly lower than those in GB (*P*<0.05) (**Figure 3**).

Reduction of NDI by cervical exercises

For the 10 items, i.e., working, sleeping, driving, pain intensity, reading, headache, entertainment, concentration, personal care and lifting objects, there was no statistically significant difference between the two groups before treatment (*P*>0.05). At 1 month after treatment, both groups achieved a marked intragroup reduction (*P*<0.05), and the scores in GA were much lower than those in GB (*P*<0.05) (**Figure 4**).

Alleviation of disability level by cervical exercises

For the ratios of mild, moderate, severe and extremely severe disability, there was no statistical difference between the two groups before

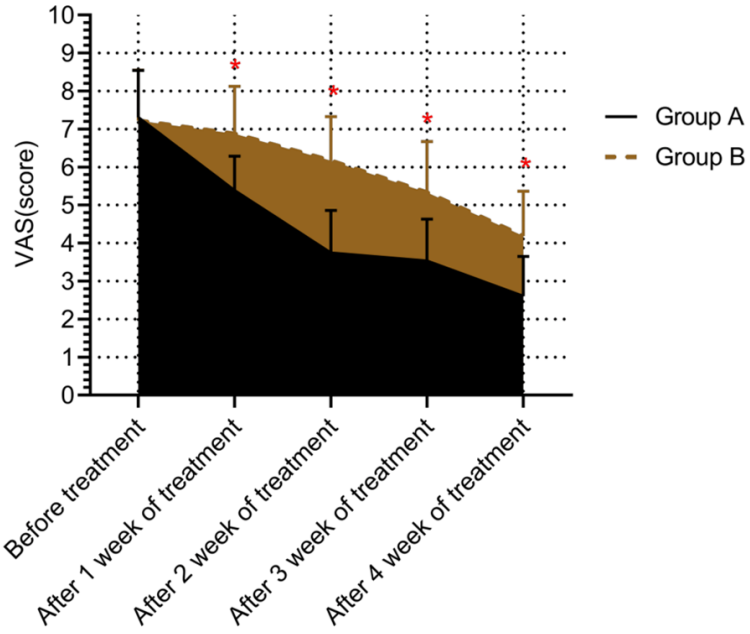

Figure 3. Intergroup comparison of pain intensity. Before treatment, the VAS scores were not significantly different between the two groups (P>0.05). After treatment, the VAS scores were far lower in GA at 1 week and 2-4 weeks after treatment (P<0.05). *P<0.05 vs GB.

treatment (P>0.05). At 1 month after treatment, the ratio of mild disability increased (P<0.05), the ratios of severe and extremely severe disability reduced (P<0.05), and the ratio of moderate disability showed no difference in GA (P>0.05). In GB, only the ratio of severe disability decreased (P<0.05), while the other three ratios remained insignificantly different (P>0.05). Intergroup comparison suggested that GA had higher ratio of mild disability and lower ratio of severe disability than GB at 1 month after treatment (P<0.05), while the other two ratios were not statistically different (P>0.05) (**Table 2**).

Increase of TRR by cervical exercises

Numbers of patients regarded as cured, markedly effective, upturned or ineffective were 7 (21.88%), 12 (37.50%), 10 (31.25%) and 3 (9.38%) in GA, 4 (12.90%), 9 (29.03%), 9 (29.03%) and 9 (29.03%) in GB. The TRR was 90.62% in GA and 70.97% in GB (X^2=3.946, P=0.047) (**Table 3**).

Reduction of RR by cervical exercises

During the 6-month follow-up, there were 2 recurrence cases in GA (6.25%) and 8 in GB (25.81%) (P<0.05) (**Table 4**).

Discussion

Western medicine believes that CSL is a pathological state in which cervical spine instability is insufficient to form compression. The causes include long-term working with head lowered, internal and external imbalance, trauma, excessive neck movement and incorrect neck posture [13, 14]. There are more than 30 muscles adjacent to the cervical vertebra in human body. These small and thin muscles cross, overlap or parallel to each other, and contain short tendons and long bellies, which ensures that the cervical muscle can contract flexibly and comfortably, and accurately assist the head and neck to form a 3D space movement [15]. However, the cervical muscle is prone to injury and fatigue due to poor endurance and small strength. Therefore, long-term working with head lowered or frequent neck movements are likely to cause CSL [16].

Previous studies have found that the cervical muscles in patients with cervical spondylosis were less resistant to fatigue than those in healthy populations [17], and in patients with neck pain, the muscle strength of anterior flexion, backward extension and muscle group rotation decreased significantly, especially the extensor muscle group [18]. CSL is treated conservatively by drugs, traction and physical therapy given its low severity [19]. In this study, drug therapy and functional exercise were selected. By actively exercising the cervical spine, patients enhanced the conjugate movement of cervical vertebra, the movement of six degrees of freedom in the 3D space and the movement of the instantaneous rotation axis. As a result, ligament elasticity and cervical muscle strength were further improved to maintain the stability of the centrum at a high level. Continuous active movement of the cervical spine is helpful to relieve local pressure, debond the soft tissues and smooth the joints [20]. Some studies have confirmed that the combination of drugs and functional exercises can restore the function of regulating cervical

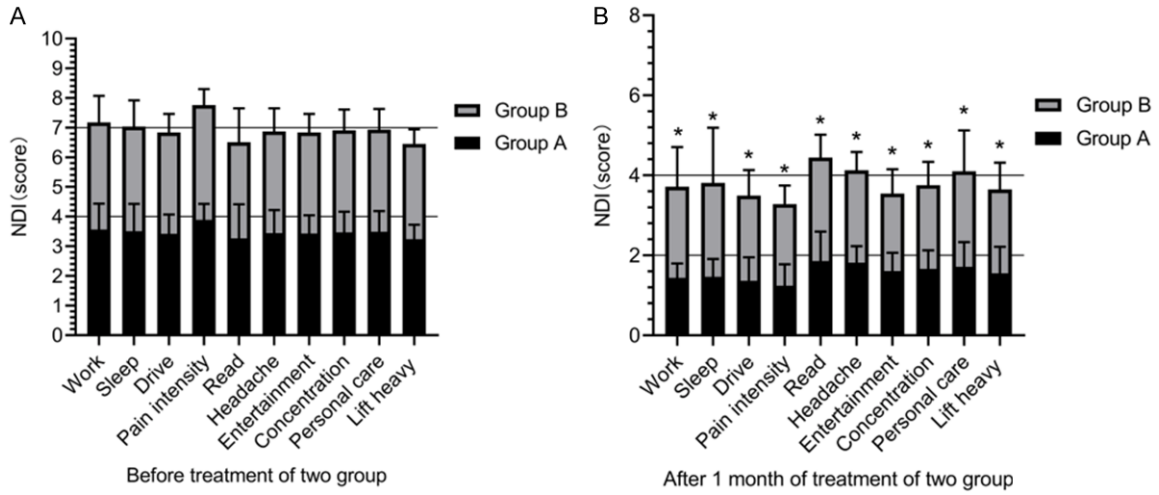

Figure 4. Intergroup comparison of NDI. Before treatment, the NDI scores were not significantly different between the two groups (P>0.05) (A). After treatment, the NDI scores were far lower in GA at 1 week and 2-4 weeks after treatment (P<0.05) (B). *P<0.05 vs GB.

Table 2. Intergroup comparison of neck disability level before and at 1 month after treatment [n (%)]

Group	Time	Mild disability	Moderate disability	Severe disability	Extremely severe disability
GA (n=32)	Before treatment	2 (6.25)	12 (37.50)	13 (40.63)	5 (15.63)
	At 1 month after treatment	13 (40.63)	17 (53.13)	2 (6.25)	0 (0.00)
GB (n=31)	Before treatment	4 (12.90)	11 (35.48)	12 (38.71)	4 (12.90)
	At 1 month after treatment	5 (16.13)	16 (51.61)	8 (25.81)	2 (6.45)
X^2		4.630	0.014	4.510	2.132
P		0.031	0.904	0.034	0.144

Table 3. Intergroup comparison of TRR [n (%)]

Group	Get well	Marked effect	Getting better	Invalid	TRR
Group A (n=32)	7 (21.88)	12 (37.50)	10 (31.25)	3 (9.38)	29 (90.62)
Group B (n=31)	4 (12.90)	9 (29.03)	9 (29.03)	9 (29.03)	22 (70.97)
X^2					3.946
P					0.047

Table 4. Intergroup comparison of recurrence rate in 6 months [n (%)]

Group	n	Recurrent	Non-recurrent
GA	32	2 (6.25)	30 (93.75)
GB	31	8 (25.81)	23 (74.19)
X^2		4.510	
P		0.034	

spine movement and maintain the dynamic and static equilibrium of cervical spine [21]. In the present study, patients in GA had lower scores of neck or shoulder pain, stiff neck, tenderness in occipito-cervical part or shoulders, and limited neck movement than GB at 1 month after treatment (P<0.05), suggesting that the combination with cervical exercises could alleviate the symptoms and signs of CSL patients more quickly and maximally, and effectively control their conditions. After treatment, the TRR was 90.62% in GA and 70.97% in GB (P<0.05), which was consistent with the findings in similar studies (96.77% vs 70.79%) [22], indicating that cervical exercises contributed to better efficacy in the treatment of CSL. This should be attributed to the fact that since the continued practice exercises can improve bone metabolism of cervical vertebra, regular functional exercises can accelerate the bone metabolism, increase bone organic composition and bone

mineral density, improve the toughness and strength of bone, and slow down the degeneration of bone, so as to improve the symptoms of cervical spondylosis and help patients obtain better curative effect [23].

The specific mechanisms of cervical exercises were to improve the metabolisms of muscle cells and bones. According to studies, strenuous exercises lead to the increase of free radicals while endurance training administers to the antioxidation of muscles [24]. When muscles are contracted persistently, the oxygen free radicals in the cells will exceed the limit and cannot be cleared away timely. Metabolites accumulate gradually and finally weaken the contractility. In animal experiments, it was found that the soft tissue of rabbit was prone to ischemia when the cervical muscle contracted over time. In this study, GA had lower VAS and NDI scores as compared to GB at 1 week and 2-4 weeks after treatment ($P<0.05$). At 1 month after treatment, GA had higher ratio of mild stability and lower ratio of severe disability ($P<0.05$), indicating the role of cervical exercises in alleviating neck disability and pains related to cervical spondylosis. Similar findings were also reported in other study that after 2-month cervical exercises, the cervical function was improved by more than 70% in cervical spondylosis patients [25]. In addition, the 6-month recurrence rate was 6.25% in GA and 25.81% in GB ($P<0.05$). Similar studies have shown that the recurrence rate of cervical spondylosis was reduced by at least 20% during the cervical exercises [26], indicating that cervical exercises were helpful to improve the long-term effects and prognosis of patients with cervical spondylosis. Through analysis, it is found that continuous cervical exercises can alleviate or eliminate these adverse conditions and improve the state of the cervical muscles. In addition, normal spinal movements and functions are balanced and maintained by the dynamic-static system of the cervical vertebra. Cervical exercises can play a role in biomechanics, enhance the strength of neck muscles and ligaments, improve the stability of the cervical vertebra, decelerate the degeneration of cervical vertebrae and restore the imbalance of the static system of cervical spine, thus the patients can obtain better prognosis [27].

In conclusion, cervical exercises reduced pain intensity and disability in the treatment of CSL, achieving good short-term and long-term effects. However, this study was disadvantaged for limited and less representative samples who were students from the sports science department. The results were also biased. In the future, in-depth studies with a larger sample size and a wider scope should be designed to gain more information for the treatment of CSL patients.

Acknowledgements

This work was supported by Humanities and Social Sciences Research Project of Jiangxi Province, China (No: TY19219) and Basic Education Research of Jiangxi Province, China (No: SZUSYTY2019-986).

Disclosure of conflict of interest

None.

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