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Original Article

Clinical effect of "Tai Chi spinal exercise" on spinal motor function in patients with axial spondyloarthritis

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Abstract: Objective: To investigate the effect of "Tai Chi spinal exercise" on spinal motor function in patients with axial spondyloarthritis (ax-SpA). Methods: Eighty-four patients with ax-SpA were collected and randomly divided into the observation group and the control group, with 42 patients in each group. On the basis of non-steroidal anti-inflammatory drugs (NSAIDs) treatment, the control group received standard exercise therapy (including bridge-style movement, crouching movement and other conventional exercise methods), and the observation group practiced "Tai Chi spinal exercise" (which is modified and developed from the Tai Chi Chuan). After 12 weeks of intervention, the bath ankylosing spondylitis disease activity index (BASDAI) score, the bath ankylosing spondylitis functional index (BASFI) score, the C-reactive protein (CRP)-based ankylosing spondylitis disease activity score (ASDAS-CRP), visual analog scale (VAS) score of low back pain, and the spondyloarthritis research consortium of Canada (SPARCC) score in two groups were compared. In addition, the fingertip-to-ground distance, ear-to-wall distance, and the erythrocyte sedimentation rate (ESR), CRP, Dickopff-related protein 1 (DKK-1) levels were measured. Results: After 12 weeks of intervention, the BASDAI score, BASFI score, ASDAS-CRP score, VAS score of low back pain and SPARCC score of the observation group were all lower than those of the control group (all $P<0.05$). The fingertip-to-ground distance and the ear-to-wall distance of the observation group were also lower than those of the control group (both $P<0.05$). Besides, the serum ESR, CRP and DKK-1 levels in the observation group were lower than those in the control group (all $P<0.05$). Conclusion: Compared with the standard exercise therapy, "Tai Chi spinal exercise" has an ideal effect in patients with ax-SpA, which could more effectively relieve the low back pain and improve the spinal motor function, with shorter training time and better compliance.

Keywords: Tai Chi spinal exercise, axial spondyloarthritis, spinal motor function, pain degree

Introduction

Axial spondyloarthritis (ax-SpA) is a chronic inflammatory rheumatic disease that can invade the sacroiliac joints and spinal column. Ax-SpA can be divided into ankylosing spondylitis and radiologically negative spinal arthritis, and the prevalence rate in China is about 0.60%-2% [1]. In the early stages of inflammation, patients will feel pain when the spine rotates, side bends, flexes and extends. Without timely and effective intervention, osteosclerosis and fat deposition would occur, thereby affecting the spinal mobility and leading to ossification of the attachment site over time, which is the most common cause of disability in adolescents [2]. Therefore, it is of great significance to take effective measures to actively intervene the disease process.

Ax-SpA lacks radical drugs or methods, the clinical treatment of which aims to control inflammation, relieve pain, and improve spinal mobility. C-reactive protein (CRP) can be used as an effective indicator to evaluate the disease activity of ax-SpA and predict structural damage and therapeutic response [3]. The erythrocyte sedimentation rate (ESR) is a non-specific indicator for the evaluation of inflammatory activity and is generally used to reflect changes in plasma composition, which is significantly accelerated in ax-SpA patients [4]. In addition, studies have shown that serum Dickopff-related protein 1 (DKK-1) is abnormally expressed in ax-SpA patients and involved in the process of bone damage [5]. Therefore, the disease progression and therapeutic effect of ax-SpA can be grasped to a certain extent by monitoring CRP, DKK-1 and ESR levels. Non-steroidal anti-

inflammatory drugs (NSAIDs), as anti-inflammatory drugs and analgesics, could improve joint function, delay the progress of joint erosion, and prevent the formation of osteophytes, which have been widely used in the treatment of ankylosing spondylitis patients [6]. However, when NSAIDs are given alone to treat a more complicated ax-SpA, its efficacy cannot reach the clinical expectation, so it is necessary to supplement with exercise therapy to further improve the spinal motor function of patients. “Tai Chi spinal exercise” is a set of effective clinical rehabilitation treatment method modified and developed from the representative traditional Chinese fitness exercise “Tai Chi Chuan”, which has a good effect on relieving pain and improving spinal stability, mobility, and patient’s quality of life [7]. However, there are few reports on the effects of this intervention in ax-SpA patients. Therefore, this study adopted the method of randomized controlled experiment to explore the effect of “Tai Chi spinal exercise” on spinal motor function in patients with ax-SpA.

Materials and methods

The general information

Eighty-four ax-SpA patients admitted to Beijing Hospital of Traditional Chinese Medicine from October 2016 to November 2018 were collected as observation subjects, and they were randomly divided into the observation group and the control group, with 42 patients in each group. This study was approved by the Ethics Committee of Beijing Hospital of Traditional Chinese Medicine.

Inclusion criteria: All patients met the ax-SpA classification diagnostic criteria recommended by the 2009 International Spinal Arthritis Assessment Working Group [8, 9]; patients aged from 18 to 60 years old; patients who did not use NSAIDs within half a year, and there were no contraindication signs of NSAIDs; all patients signed the informed consent.

Exclusion criteria: Patients with Sjogren’s syndrome, polymyalgia rheumatica and other rheumatic diseases; patients who had a past history of spinal tumor or spinal surgery; patients who had cardiovascular disease, coronary artery bypass grafting surgery and heart failure within the past six months; patients with uncontrolled hypertension, malignant tumor, active upper gastrointestinal ulcer, severe liver and kidney dysfunction, and blood diseases; patients who had mental illness or those who cannot cooperate in the treatment.

Methods

Both groups were orally given celecoxib capsules (Pfizer Pharmaceutical Co., Ltd.) at 0.2 g/time twice daily for 12 weeks. Meanwhile, the control group received standard exercise therapy, including bridge-style movement, single-legged bridge-style movement, crouching movement, superman type prone movement, hip-leg support exercise, side-lying hip abduction, reverse support exercise, upper back tensioning exercise and training ball-ground bridge movement. The total duration of each training is 30-40 minutes, and the training frequency is 3 times/week for a total of 12 weeks.

The observation group was supplemented with “Tai Chi spinal exercise”. Before training, we explained the role, training methods, treatment courses, etc. of “Tai Chi spinal exercise” to patients and used video to show the action essentials. Then, the professionals personally demonstrated and guided the patients with various actions in the side. After all patients mastered the “Tai Chi spinal exercise”, they were trained intensively. The action essentials of “Tai Chi spinal exercise” were as follows: breathe evenly, put right leg in front and left leg in back, and place weight on the right leg into a controlled lunge position. Then lower the head and shoulders, lift up the hands to the top right of the head through the chest, presenting the posture of holding a ball. At the same time, slowly raise the head and torso, and the body naturally turned right to the limit and maintained the motion for 2 seconds. After that, shift the weight to left leg and lower hands slowly to the left knee level while bending forward slightly for 2 seconds. Then shift the weight to right leg and repeat the above actions as a loop. Then again, breathe evenly, put left leg in front and right leg in back, and place weight on the left leg into a controlled lunge position. Then lower the head and shoulders, lift up the hands to the top left of the head through the chest, presenting the posture of holding a ball. At the same time, slowly raise the head and torso, and the body naturally

turned left to the limit and maintained the motion for 2 seconds. After that, shift the weight to right leg and lower hands slowly to the right knee level while bending forward slightly. Then shift the weight to left leg and repeat the above actions as a loop. Each loop was alternated, and each training period was 15-20 minutes. During the training process, the movements were required to be carried out slowly, with smooth actions, focused attention and peace of mind.

Reverse abdominal breathing training: place legs shoulder-width apart, stand straight, keep center of gravity stable, look straight ahead, and maintain standing posture. When breathe evenly, the legs naturally flex and squat, the knees were slightly buckled inside, presenting a horse stance, and hands kept naturally akimbo. Inhale slowly and deeply and cooperate with the abdomen. Then exhale slowly and distend the abdomen. Each inhalation and exhalation was considered as a cycle. Performed 15-18 cycles per minute for a total duration of 15-20 minutes each time. The total duration of “Tai Chi spinal exercise” was 30-40 minutes each time with the frequency of 3 times per week for a total of 12 weeks. During the training process, the training intensity was determined according to the actual situation of patients. After the end of each training, the patients needed to rest for 10 min before the next action to avoid excessive fatigue. Besides, in order to avoid accidents, the operator was standing by to observe the patients’ complexion, breathing, etc.

Outcome measurement

Assessment of disease activity and functional status: the BASDAI, BASFI, and ASDAS-CRP scores in two groups were calculated. BASFI was evaluated by the “ankylosing spondylitis BASFI functional scale” [10], which mainly assessed the functional problems of the body within the past one week, with 0 score indicating easy to finish and 10 scores indicating unable to finish. The BASDAI indicators include the total degrees of the following six symptoms in the past one week (0-10 points): BASDAI1 is the degree of fatigue, BASDAI2 is the degree of neck or back pain, BASDAI3 is the degree of peripheral joint pain and swelling, and BASDAI4 is the degree of discomfort caused by haphalgesia and tenderness, BASDAI5 is the degree of morning stiffness, and BASDAI6 is the duration of morning stiffness [10]. BASDAI was calculated according to the formula: 0.2 × (BASDAI1 + BASDAI2 + BASDAI3 + BASDAI4 + 0.5 × BASDAI5 + BASDAI6), wherein the BASDAI scores <4 indicated the disease remission period and scores ≥4 indicated the active period [11]. ASDAS-CRP was calculated according to the formula: 0.12 × BASDAI2 + 0.06 × BASDAI6 + 0.11 × VAS (low back pain) + 0.07 × BASDAI3 + 0.58 × ln (CRP + 1). Among them, ASDAS-CRP scores <1.3 were classified as the disease remission period; 1.3≤ ASDAS-CRP scores <2.1 were classified as the low-to-moderate active period; 2.1≤ ASDAS-CRP scores <3.5 were classified as the high activity period; ASDAS-CRP scores ≥3.5 were classified as the extremely high activity period [12].

Assessment of pain degree: low back pain was evaluated by 0-10 linear VAS before and after intervention. The higher the score was, the more severe the pain was [10].

Comparison of SPARCC scores: MRI was used to check patient’s sacroiliac joints before and after intervention, and SPARCC scores were graded according to the scoring system of the spondyloarthritis research consortium of Canada. The assessment included lesion scope, edema intensity and edema depth, and the total score was 72, which was positively correlated with the disease activity degree [13].

Measurement of spinal mobility: before and after the intervention, the fingertip-to-ground distance and the ear-to-wall distance were measured. The smaller the value, the better the improvement effect on spinal mobility.

Laboratory test: before and after the intervention, 5 mL fasting venous blood was collected from the patient, and the serum was separated by centrifugation at 3,000 r/min for 10 min. The serum CRP and DKK-1 levels were determined by enzyme-linked immunosorbent assay kit (R&D systems, USA). The 1.28 mL venous blood was extracted, and the ESR level was detected by NF-9905 automatic dynamic blood sedimentation instrument (Chongqing Southern Numerical Control Equipment Co., Ltd, China).

Statistical analysis

The data were analyzed with the SPSS19.0 statistical software. Measurement data conform-

Table 1. Comparison of general information between the two groups

	Observation group (n=42)	Control group (n=42)	χ^2/t	P
Gender (n, %)			0.057	0.811
Male	29 (69.05)	30 (71.43)		
Female	13 (30.95)	12 (28.57)		
Age (year)	35.67±5.2	36.58±5.2	0.800	0.426
Disease course (year)	6.25±0.89	6.14±0.86	0.576	0.566
Family history (n, %)	10 (23.81)	9 (21.43)	0.068	0.794

Table 2. Comparison of disease activity and functional status between the two groups ($\bar{x}$ ± sd)

	Observation group (n=42)	Control group (n=42)	t	P
BASDAI score				
Before intervention	4.23±2.86	4.35±2.90	0.191	0.849
After intervention	2.30±1.58***	3.05±1.71***	2.088	0.040
BASFI score				
Before intervention	2.44±1.57	2.50±1.60	0.174	0.863
After intervention	1.30±1.06***	1.84±1.27***	2.116	0.037
ASDAS-CRP score				
Before intervention	3.48±2.38	3.42±2.37	0.116	0.908
After intervention	1.24±1.04***	1.78±1.29***	2.112	0.038

Note: BASDAI: the bath ankylosing spondylitis disease activity index; BASFI: the bath ankylosing spondylitis functional index; ASDAS-CRP: the C-reactive protein (CRP)-based ankylosing spondylitis disease activity score. Compared with the group before intervention, ***P<0.001.

ing to the normal distribution were expressed as mean ± standard deviation ($\bar{x}$ ± sd) and compared by the group t test. The count data were expressed as cases/percentage (n/%) and evaluated by the χ^2 test. The VAS scores between the two groups were compared using the Mann-Whitney U test. The data were considered statistically significant at P<0.05.

Results

Comparison of general information between the two groups

There were no statistically significant differences in gender, age, disease course and family history between the two groups (P>0.05), with comparability, as shown in **Table 1**.

Comparison of disease activity and functional status between the two groups

Before the intervention, there were no significant differences in BASDAI score, BASFI score and ASDAS-CRP score between the two groups (P>0.05). After intervention, the BASDAI score, BASFI score and ASDAS-CRP score decreased in both groups, and these scores in the observation group were lower than those in the control group (P<0.05). See **Table 2** and **Figure 1**.

Comparison of pain degree between the two groups

Before the intervention, the VAS scores of low back pain in the two groups were not significantly different (P>0.05). The VAS scores of low back pain decreased after intervention in both groups, and the scores in the observation group were lower than those in the control group (P<0.05). See **Table 3** and **Figure 2**.

Comparison of SPARCC scores between the two groups

Before the intervention, there were no significant differences in the SPARCC scores between the two groups (P>0.05). After intervention, SPARCC scores decreased in both groups, and the decrease was more significant in the observation group (P<0.05), as shown in **Table 4**.

Comparison of spinal mobility between the two groups

Before the intervention, there were no significant differences in the finger-to-ground distance and the ear-to-wall distance between the two groups (P>0.05). After intervention, the finger-to-ground distance and the ear-to-wall distance decreased in both groups, and the above two indicators in the observation group were lower than those in the control group (P<0.05), as shown in **Table 5**.

Comparison of serum ESR, CRP and DKK-1 levels between the two groups

Before the intervention, there were no significant differences in the serum ESR, CRP and DKK-1 levels between the two groups (P>0.05).

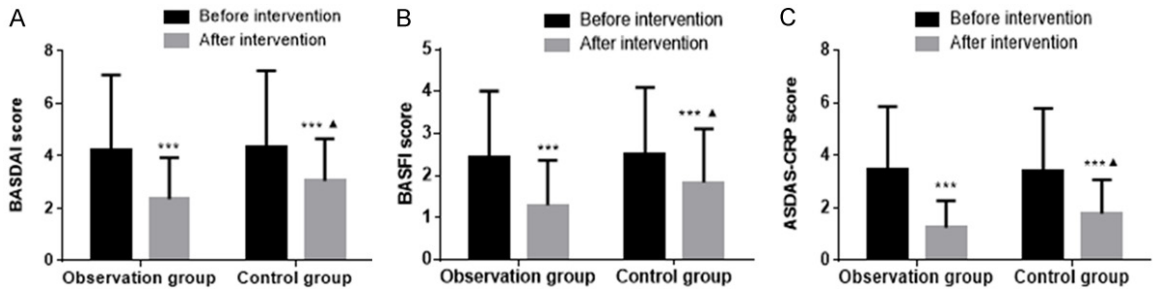

Figure 1. Comparison of disease activity and functional status before and after intervention between the two groups. A: BASDAI scores; B: BASFI scores; C: ASDAS-CRP scores. BASDAI: the bath ankylosing spondylitis disease activity index; BASFI: the bath ankylosing spondylitis functional index; ASDAS-CRP: the C-reactive protein (CRP)-based ankylosing spondylitis disease activity score. Compared with the group before intervention, ***P<0.001; compared with the control group, ▲P<0.01.

Table 3. Comparison of pain degree between the two groups ($\bar{x}$ ± sd)

	Observation group (n=42)	Control group (n=42)	t	P
Before intervention	5.13±2.47	4.98±2.21	1.662	0.100
After intervention	2.01±1.60	3.47±1.96	3.740	0.000
t	6.871	3.313		
P	0.000	0.001		

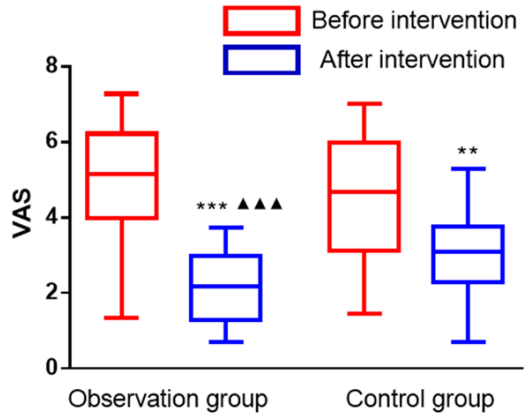

Figure 2. Comparison of pain degree before and after intervention between the two groups. VAS: visual analog scale score. Compared with before intervention, **P<0.01, ***P<0.001; compared with the control group, ▲▲▲P<0.001.

After intervention, the serum levels of ESR, CRP and DKK-1 reduced in both groups, and these serum indicators in the observation group were lower than those in the control group (P<0.05). See **Table 6** and **Figure 3**.

Discussion

The pathogenesis of ax-SpA is mainly related to gene, bacterial infection, immune and endocrine dysfunction [14-16]. Ax-SpA is an autoimmune disease, and abnormal activation of autoreactive T and B cells is involved in the occurrence and progression of ax-SpA. The autoreactivity causes the disorder of self-control and non-self-recognition, and induces the immune response and inflammatory response, leading to tissue damage [17, 18]. At present, the clinical treatment of ax-SpA is mainly based on non-pharmacological measures, drugs and surgery. In the drug therapy, NSAIDs are used as the first-line drugs, which can quickly relieve local swelling and pain, and improve joint function. Besides, continuous medication can prevent new bone formation and slow down disease progression [19, 20]. However, drug therapy can not cure or completely control the disease, and can cause adverse reactions, which are not easy for patients to accept. In clinical practice, drug therapy is often supplemented by exercise therapy to improve the effect of disease control and reduce the disability rate.

“Tai Chi spinal exercise” comes from Tai Chi Chuan, which is a traditional Chinese fitness exercise. In the training process of “Tai Chi spinal exercise”, the waist is mainly used as a hub, so its activity is large, which is conducive to increasing the blood flow. Besides, the exercise intensity of “Tai Chi spinal exercise” is medium and suitable for those with mobility difficulties and weak constitution. Moreover, it is an aerobic exercise, which can increase the patient’s vital capacity and reduce their weight and waist load, and can also regulate emotions, improve pain tolerance and reduce the patient’s pain

Table 4. Comparison of SPARCC scores between the two groups ($\bar{x}$ ± sd)

	Observation group (n=42)	Control group (n=42)	t	P
Before intervention	19.86±13.90	20.64±14.50	0.252	0.802
After intervention	10.74±7.52	15.00±10.51	2.136	0.036
t	3.740	2.041		
P	<0.001	0.044		

Note: SPARCC: the spondyloarthritis research consortium of Canada.

Table 5. Comparison of spinal mobility between the two groups ($\bar{x}$ ± sd, cm)

	Observation group (n=42)	Control group (n=42)	t	P
Fingertip-to-ground distance				
Before intervention	18.42±6.05	18.38±6.07	0.030	0.976
After intervention	15.40±5.01***	17.94±5.81***	2.146	0.035
Ear-to-wall distance				
Before intervention	14.25±4.30	14.27±4.32	0.021	0.983
After intervention	12.02±3.60***	13.77±4.05***	2.093	0.039

Note: compared with the group before intervention, ***P<0.001.

sensation in the low back [21, 22]. Burks et al. showed that Tai Chi Chuan can alleviate the symptoms of osteoarthritis, and the osteoarthritis index (WOMAC) total score, WOMAC pain score, WOMAC stiffness score and WOMAC function score of patients with knee arthritis were significantly improved after practicing Tai Chi Chuan [23]. Wolf et al. found that after 12 months of Tai Chi Chuan training, the pain symptoms of arthritis patients were obviously relieved, and the balance control ability was markedly improved [24]. The above findings all indicate that Tai Chi Chuan can effectively improve the prognosis of arthritis patients, but the intervention effect on the more complicated and more special ax-SpA is rarely reported. In this study, after intervention, the effect on improving disease activity, spinal motor function, pain degree, SPARCC score and spinal mobility degree in the observation group was significantly better than that in the control group, suggesting that “Tai Chi spinal exercise” can effectively improve the spinal motor function, relieve pain, delay the disease progression and improve the life quality of patients. The reason is that Tai Chi exercise can also expand the movement range of the low back joints, enhance the strength of core muscle groups, augment the muscle loading capacity, improve the clearance effect of lumbar pain factors, and ease local pain. At the same time, “Tai Chi spinal exercise” can also improve microcirculation, promote bone blood supply, increase bone calcium deposition, increase bone density, and maintain the stability of various segments of spine column. Besides, “Tai Chi spinal exercise” is a whole-body exercise that can comprehensively exercise the skeletal system, help maintain the normal shape of the spine and improve the movement range of the joints.

CRP is a human acute reactive protein, and systemic inflammation can lead to a sharp increase in plasma CRP levels. Currently, CRP is clinically regarded as a reliable indicator to evaluate ax-SpA disease activity, and it plays a certain role in predicting joint structural damage [25]. ESR, the erythrocyte sedimentation rate, is one of the indicators reflecting inflammatory response. In the early stage of ax-SpA, the increase of ESR was correlated with the radiological progression of the spine [26]. It was reported that Wnt signaling pathway was involved in the pathogenesis of ax-SpA and the process of bone damage. DKK-1 is a substance in the Wnt signaling pathway and belongs to a negative regulator, playing an important role in the process of bone damage [27]. In this study, after intervention, the serum ESR, CRP and DKK-1 levels decreased in the observation group, and SPARCC score in the observation group was also significantly improved compared with the control group, suggesting that “Tai Chi spinal exercise” can be helpful to alleviate the degree of inflammatory response, reduce bone damage, control the disease progression of ax-SpA, and improve the activity and function of patient’s diseased joints. However, due to the current lack of clinical reports on reducing serum ESR, CRP, and DKK-1 levels in ax-SpA patients by exercise therapy, it is necessary to expand the sample size for further verification.

Table 6. Comparison of serum ESR, CRP and DKK-1 levels between the two groups ($\bar{x}$ ± sd)

	Observation group (n=42)	Control group (n=42)	t	P
ESR (mm/h)				
Before intervention	21.05±16.84	20.69±16.40	0.099	0.921
After intervention	8.25±6.87***	14.58±11.66***	3.031	0.003
CRP (mg/L)				
Before intervention	14.54±10.83	14.38±10.70	0.068	0.946
After intervention	6.54±6.03***	10.23±8.18***	2.353	0.021
DKK-1 (pg/mL)				
Before intervention	3257.54±425.54	3250.42±423.57	0.077	0.939
After intervention	2815.21±344.30***	3018.54±378.49***	2.575	0.012

Note: ESR: the erythrocyte sedimentation rate; CRP: C-reactive protein; DKK-1: Dickopff-related protein 1. Compared with the group before intervention, ***P<0.001.

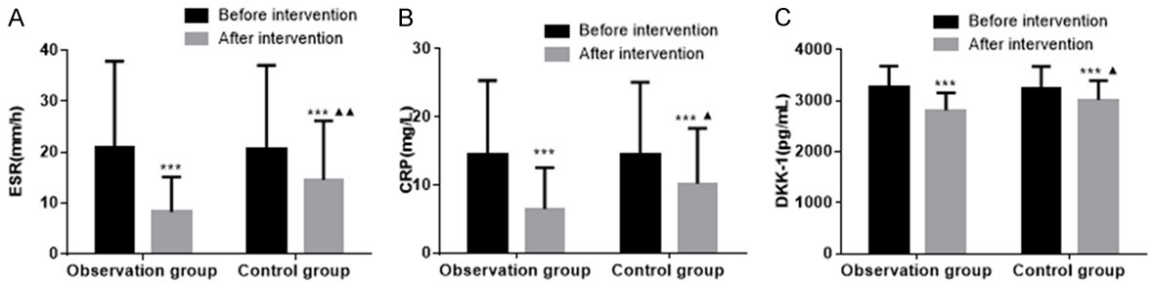

Figure 3. Comparison of serum ESR, CRP and DKK-1 levels before and after intervention between the two groups. A: ESR levels; B: CRP levels; C: DKK-1 levels. ESR: the erythrocyte sedimentation rate; CRP: C-reactive protein; DKK-1: Dickopff-related protein 1. Compared with before intervention, ***P<0.001; compared with the control group, ▲P<0.05, ▲▲P<0.01.

In addition, although “Tai Chi spinal exercise” is a suitable rehabilitation treatment method worthy of promotion, excessive or non-standard exercises may increase the joint torque and load and cause spinal joint damage. Therefore, in the future application, individualized treatment plans should be designed according to different groups of people, and the existing problems should be continuously improved, which will contribute to the promotion of “Tai Chi spinal exercise”.

In summary, compared with standard exercise therapy, “Tai Chi spinal exercise” has an ideal effect in patients with ax-SpA, which can more effectively relieve patient’s low back pain and improve spinal motor function, with shorter training time and better compliance.

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Disclosure of conflict of interest

None.

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