Acta of Bioengineering and Biomechanics
Vol. 26, No. 4, 2024

Original paper
DOI: 10.37190/ABB-02545-2024-02

The influence of core mechanics training on the body coordination of Wushu athletes during aerial rotations

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Purpose: This study aimed to enhance athletes' body coordination through mastering the optimal core mechanics training method. *Methods*: This article selected 20 Wushu athletes and randomly divided them into two groups: an experimental group that participated in core mechanics training and a control group that participated in normal waist and abdomen training. By comparing the data of core strength quality and completion degree of difficult movements before and after experiments, this study explored whether core mechanics training can improve the body coordination of Wushu athletes during aerial rotations. *Results*: Group A was one point higher than group B in the degree of contracted waist, and the improvement of core stability was also significantly higher than group B ($P < 0.05$). In terms of the improvement of core explosive power, the number of sit-ups per minute of both groups increased by more than 15. *Conclusions*: Core mechanics training can improve the quality of Wushu athletes' aerial rotations more effectively and enhance their body coordination.

Key words: *core strength, body coordination, aerial rotation*

1. Introduction

In order to meet the needs of civilian entertainment and military training, Wushu was greatly developed in the Song Dynasty [15]. Wushu is a difficult sport, and the movement skills are relatively difficult to master compared with other sports. Sports scientists are more interested in finding the most effective training methods to obtain optimal training benefits with minimum time and effort costs [5]. Good physical coordination helps athletes fully practice each move, making each move more beautiful and increasing the probability of winning in the actual competition environment. Various Wushu movements contain body movements such as turning, leaping and darting. Maintaining body balance in a flight state is a demonstration of good physical coordination. Research suggests that whole-body coordination is a unique characteristic, and strengthening upper limb coordination training can enhance the success rate of athletes in performing movements [8]. Seyfarth [11] proposed that different body parts, such as legs, arms, and trunk, can exhibit specific coordination patterns with each other. Nie [7] found that doing comprehensive exercises that can strengthen core strength and balance ability and involve all limbs could improve coordination. Throughout the Chinese and foreign research, it has been found that most of the current research on core strength from the perspective of sports training focuses on the concept of core strength and training methods [13]. Selvakumar et al. [10] conducted a controlled experiment on 32 people and found that core muscles played an important role in providing stability. Yao et al. [14] found through an agility test that core strength training could improve the core endurance of collegiate korfball players but not their flexibility. Vitale [12] conducted a randomized controlled experiment on 24 skiers and found that core strength training was an effective intervention for improving joint awareness and postural

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Received: November 5th, 2024
Accepted for publication: January 8th, 2025

control of lower limbs. Huang [4] proposed that the training and teaching of core strength footwork could contribute to the agility of limbs and play an important role in body coordination. Through core mechanics training, the control ability and core strength of athletes' muscle groups can be improved, which can enhance their body stability when they complete the jump, take-off, flight, rotation, and other movements, and promote the body coordination of the upper and lower limbs, making the movements look more relaxed and beautiful. In this paper, the interference of 12 weeks of core mechanics training was compared with normal waist and abdomen training to explore whether core mechanics training positively impacts the body coordination of Wushu athletes during aerial rotations. This paper aims to provide a theoretical basis for incorporating core mechanics training into aerial rotation training for Wushu athletes.

2. Materials and methods

2.1. Research subjects

In this study, 20 Wushu athletes were selected as experimental subjects and divided into groups randomly and evenly. Before the experiment, the experimental subjects were asked and investigated to collect relevant information and data, and SPSS software was employed to process and analyze the data. There was no remarkable difference in the measured data ($P > 0.05$), which provided a reliable reference for this experiment. The specific grouping and information data are presented in Table 1.

2.2. Research methods

2.2.1. Experimental design

A randomized cross-over experiment was designed using the selected 20 Wushu athletes. There were ten males and ten females among the 20 athletes. Each group included five males and five females. Group A was the experimental group and participated in core mechanics training; group B was the control group and participated in normal waist and abdomen training [3]. The experimentalists in the two groups were trained together for 12 weeks. Through the experiment, the impact of different training methods on the body coordination of Wushu athletes during aerial rotations was tested.

The duration of the experiment was 12 weeks, and the participants participated in the training on Monday, Thursday, Friday and Sunday, with each training lasting about one hour. In order to ensure that the external environment did not affect the training, the two groups received the training at the same time and the same training venue. The specific core mechanics training content [2] is presented in Table 2.

2.2.2. Analysis of the aerial rotation movement

The steps of an aerial rotation are as follows. After running up, the athlete stretched the right leg, swung the left arm forward, swung the left leg forward and upward, and hit the ground rapidly with the right foot to jump. In the air, the athlete continuously swung the left arm upward and swung the right arm forward and upward. The two arms were put together above the head. The body was kept vertically in the air like a straight line, and the angles were 360, 540 and 720°, respectively. The left and right feet landed one by one or at the same time. In order to facilitate the study, the above steps were divided into three parts: take-off (Fig. 1.1), the moment when the feet are off the ground; aerial rotation (Fig. 1.2), i.e., jump to the highest point to do the turn; land on the ground (Fig. 1.3), i.e., land and stand steadily in a horse stance or an upright posture.

Table 1. Information data of specific groups and subjects ($P > 0.05$ shows no significant difference)

	Age [years]	Height [cm]	Weight [kg]	Gender
Group A (10 people)	21.05 ± 2.18	173.11 ± 5.89	65.52 ± 8.21	1.33 ± 1.51
Group B (10 people)	21.35 ± 2.29	173.54 ± 5.27	63.83 ± 7.89	1.33 ± 1.51
P value	0.483	0.591	0.633	1.000

2.3. Research indicator selection

This study determined the primary research indicators by referring to the literature. According to the core strength training method and the characteristics of the aerial rotation movement in Wushu, the athletes' core strength quality and the completion degree of difficult movements were selected to assess whether core me-

Table 2. Specific content of core mechanics training in the experimental group

	Training content	Training intensity	Equipment required
Warm-up exercises	Shoulder and ankle joint activities; 800 m jog	Make the body active and warm slightly	–
Core mechanics training (90 seconds between each set of movements)	Lie on the side, support with one elbow, and open and close legs constantly	Three sets, one minute each	–
	Eight-level ventral bridge	Three sets, three minutes each	Yoga mat
	Abdominal curls	Three sets, one minute each	Yoga mat
	Lifting legs with a supine position and swing to lift legs	Three sets, one minute each	Yoga mat
	Resistance kicks with an elastic band	Three sets, 30 reps each group, alternate between legs	Elastic band
	Straight arm twist with a Swiss ball	Three sets, one minute each	Swiss ball
	Stand on a balance board and lift knees, then squat in a lunge position	Three sets, one minute each	Balance board
	Stand left and right and spin to throw a solid ball	Three sets, one minute each	Solid ball
	Jump in place and clap hands	Three sets, one minute each	–
Relaxation exercises	Stretch ligaments, massage	Require muscle relaxation	Fascia gun
	Mental relaxation and mental training	Relax both physically and mentally and keep the mood calm	–

1 2 3

Fig. 1. Three parts of the aerial rotation movement

chanics training has an impact on the body coordination of Wushu athletes during aerial rotations.

Core strength quality

The core area is the link power chain of the upper and lower limbs, so enhancing the core strength quality will also play a certain role in promoting the coordination of the upper and lower limbs. The research indicators of core strength quality were divided into core stability [6] and core explosive power [1]. In terms of core stability, the eight-level ventral bridge was used as the standard to detect the control ability of the trunk muscle group of the experimental subjects. The specific scoring criteria are shown in Table 3. Those who failed to complete the first level were given zero points. Those who completed the previous level continued to do the next level, and if they failed to complete this level, the score of the previous level was taken.

In terms of core explosive power, one-minute sit-ups, as well as left and right side throws of solid balls, were used as the criteria to test the rapid explosive power of an athlete's abdominal muscle group. In the sit-up test, athletes were required to lie on their backs on a mat with their hands at their ears and elbows touching their knees as they rose. The performance was evaluated by the number of successful sit-ups they performed in a minute. In the solid ball test, athletes were required to keep a gap of about 50 cm between the two feet, hold the solid ball in front of the chest with both hands, turn the body to the right (left) side, and throw the solid ball to the upper right (left) side.

Table 3. The scoring standards of the eight-level ventral bridge

	Test time [s]	Standard for the test movement	Test score
Level 1	60	A standard plank movement	10
Level 2	15	Based on level 1 movement, raise the right hand to keep the body stable.	20
Level 3	15	Based on the previous movement, raise the left hand to keep the body stable.	30
Level 4	15	Based on the previous movement, raise the right leg to keep the body stable.	40
Level 5	15	Based on the previous movement, raise the left leg to keep the body stable.	50
Level 6	15	Based on the previous movement, raise the right hand and left leg to keep the body stable.	65
Level 7	15	Based on the previous movement, lift the left hand and right leg to maintain the body stable.	80
Level 8	30	Return to Level 1 movement.	100

The completion degree of difficult movements

The two groups of Wushu athletes completed the movement of aerial rotation before and after the 12-week training. During the testing process, each athlete needs to complete the rotation angle of their aerial rotations as much as possible. Therefore, they performed the same movement three times, and the best score was taken. The completion degree of difficult movements of the Wushu athletes before and after the training was scored. The scoring was done by three coaches. During the scoring process, each coach observed the athlete's movements from a different angle and scored according to the scoring criteria. The average score was taken as the final score. The specific scoring standards are shown in Table 4.

Table 4. Specific scoring standards of the difficulty movements in aerial rotations

	Scoring standards	Score
Vacating phase (a total score of 50 points)	Head height	10 points
	The degree of contracted waist	10 points
	The degree of leg bending	10 points
	The completion degree of turn	20 points

2.4. Statistical analysis of data

In this study, Excel was used to set up the experimental indicator database, and SPSS statistical software was used to process and analyze the data of each indicator. The test results before and after the experiment were respectively analyzed by paired sample *T*-test, and the results of the two groups were analyzed by independent sample *T*-test [9]. The significance level of the difference was $P < 0.05$, while the significance level was $P < 0.01$.

2.5. Experimental results

Core stability test results

As can be seen from Fig. 2, before the experiment, the test scores of groups A and B on the eight-level ventral bridge were all at the same level (64.69 points and 65.08 points), and there was no remarkable difference between the two groups ($P > 0.05$). After the experiment, the test level of the eight-level ventral bridge in both groups gradually increased; 87.46 and 82.67 points were obtained, and the test result showed a very obvious difference compared with that before the experiment ($P < 0.01$). The comparison between the two groups showed that the test score of group A was significantly higher than that of group B after the experiment ($P < 0.05$), indicating that the core mechanics training method was more effective than normal waist and abdomen training in enhancing the control stability ability of trunk muscle group. Moreover, it showed that core mechanics training could effectively improve the quality of core strength and enhance the control stability of the core trunk muscle group of Wushu ath-

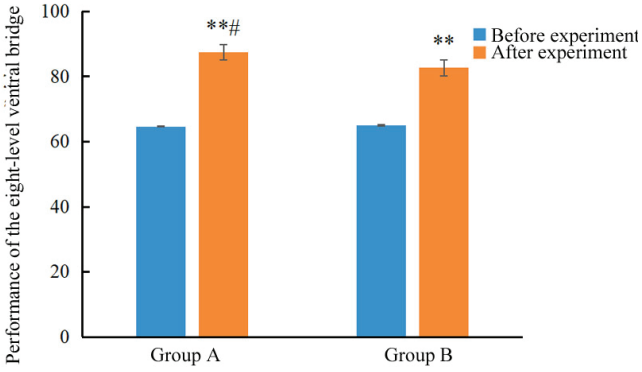

Fig. 2. The test results statistics of the eight-level ventral bridge in two groups of Wushu athletes
** – $P < 0.01$ compared with before the experiment, showing a very significant difference, # – $P < 0.05$ compared to the control group, showing a significant difference

letes, improving their body coordination and making contributions to the completion of excellent aerial rotation movements.

The core explosive power test results

As can be seen from Table 5, the data of the two groups before the experiment was not much different ($P > 0.05$), which showed that the core explosive power of the athletes in the two groups was homogeneous before the experiment. After the experiment, the athletes who underwent two kinds of training were tested again, and it was found that the data was improved. The number of sit-ups per minute increased by more than 15 compared with before the experiment ($P < 0.01$). The distances of the left- and right-side throws of the solid ball in group A were very significantly different from that before the experiment ($P < 0.01$) and also very significantly different from that after the experiment in group B ($P < 0.01$). Compared with before the experiment, the distance of the left-side throw of the solid ball in group B showed a remarkable difference ($P < 0.05$), but the distance of the right-side throw of the solid ball increased from 9.10 ± 1.03 to 9.26 ± 1.78, showing an insignificant difference. These results indicated that core mechanics training, compared with normal waist and abdomen training, had a very obvious positive impact on the rapid explosive power of the abdominal muscle group of Wushu athletes.

The score of the flight stage

As can be seen from the score data in Table 6, there was no remarkable difference between group A and group B in the flying stage before training ($P > 0.05$). Compared to before the experiment, the head height and rotation completion scores of groups A and B both increased by about one point after the experiment, showing significant differences ($P < 0.05$). The scores of the contracted waist degree increased by about three points, showing a great obvious difference ($P < 0.01$). In the degree of leg bending, the scores of the two groups were improved, respectively, but group A showed a very significant difference ($P < 0.01$) and group B showed a significant difference ($P < 0.05$). However, the comparison between the two groups showed that the scores of the two groups were basically the same in terms of head height and the degree of rotation completion. The contracted waist degree of group A was significantly different from that of group B ($P < 0.05$). In terms of the degree of leg bending, the difference between the two groups was quite obvious ($P < 0.01$). Therefore, it can be seen that there was no remarkable difference between core mechanics training and normal waist and abdomen training in terms of head height and rotation completion degree scores, but in terms of the contracted waist degree and leg bending degree, core mechanics training achieved higher scores. The results verified that core mechanics training could enhance the body coordination of the athletes during aerial rota-

Table 5. Core explosive test data statistics in two groups of Wushu athletes

	The number of sit-ups per minute [n]	The distance of the left-side throw of a solid ball [m]	The distance of the right-side throw of a solid ball [m]
Group A before the experiment	51.35 ± 2.36	8.25 ± 1.09	9.04 ± 1.28
Group A after the experiment	67.04 ± 3.19**	9.66 ± 1.63**##	10.17 ± 1.92**##
Group B before experiment	51.67 ± 2.06	8.11 ± 1.18	9.10 ± 1.03
Group B after experiment	67.27 ± 2.91**	8.96 ± 1.94*	9.26 ± 1.78

* – $P < 0.05$ compared with the pre-experiment, showing a significant difference, ** – $P < 0.01$ compared with the pre-experiment, showing a very significant difference, ## – $P < 0.01$ compared with the control group, showing a very significant difference.

Table 6. The score statistics of the two groups of Wushu athletes in the flight stage of the aerial rotation

	The score for the head height	The score for the contracted waist degree	The score for the leg bending degree	The score for the rotation completion degree
Group A before experiment	7.92 ± 1.47	5.67 ± 1.22	5.09 ± 0.67	16.28 ± 2.09
Group A after experiment	9.24 ± 0.56*	8.95 ± 0.73**#	8.44 ± 0.58**##	17.46 ± 1.60*
Group B before experiment	8.36 ± 1.53	5.51 ± 1.51	5.31 ± 1.01	15.99 ± 2.30
Group B after experiment	9.50 ± 0.33*	7.86 ± 0.56**	6.47 ± 0.83*	17.16 ± 1.36*

* – $P < 0.05$ compared to that before the experiment, indicating a significant difference, ** – $P < 0.01$ compared to that before the experiment, showing a very significant difference, # – $P < 0.05$ compared to the control group, showing a significant difference, ## – $P < 0.01$ compared to the control group, showing a very significant difference.

tions more effectively than normal waist and abdomen training.

3. Discussion

Wushu, a traditional sport that combines strength, skill, and aesthetics, demands high physical fitness from athletes. Especially in complex movements like aerial rotations, Wushu athletes not only need to demonstrate explosive power and flexibility but also require a high level of body coordination to ensure smooth and precise execution. Core mechanics training, as an integral part of modern fitness and sports training, significantly influences the body coordination of Wushu in aerial rotation movements. The core muscle group of the human body, including the muscles in the waist, abdomen, and back, plays a crucial role in supporting and maintaining body balance. When Wushu athletes perform complex movements such as aerial rotations, the core muscle group plays a vital role by providing necessary stability and helping athletes maintain body balance and coordination during these movements. Through core strength training, Wushu athletes can enhance the strength and endurance of these muscles, thereby improving their performance in aerial rotation movements.

In order to verify the effectiveness of core strength training, this study conducted a case analysis on 20 Wushu athletes. The subjects were randomly divided into group A and group B. Group A underwent core mechanical training, while group B underwent conventional waist and abdominal training. The training lasted for 12 weeks. Before and after the training, both groups of athletes were tested for core stability, core explosive power, and completion rate of aerial movements. The athletes in group A who underwent core mechanical training showed significant improvements in both core stability and explosive power after the training, as well as an improvement in completion rate of aerial movements. The reasons were analyzed. When Wushu athletes perform aerial rotations, they require a high level of body balance and stability. Core mechanics training enhances the strength of the core muscles, enabling athletes to better control their center of gravity and reduce the risk of instability during movements. Additionally, Wushu rotations and other techniques involve the coordinated effort of multiple muscle groups. Core mechanics training not only strengthens the core muscles but also promotes synergy among different muscle groups. This ability to work in synergy is crucial for Wushu athletes. Excellent muscle coordination allows athletes to surpass the limitations of their bodies and attempt more challenging movements. For example, during the process of performing a lotus kick after an aerial rotation, athletes need to utilize the strength in their legs and waist to generate rotational and striking power while maintaining balance. Core mechanics training enhances muscle coordination, making these complex movements easier to achieve.

In summary, core mechanics training has a significant impact on the body coordination of Wushu athletes during movements such as aerial rotations. Through enhancing the strength and stability of the core muscle group, improving coordinated work between muscles, preventing and reducing sports injuries, and increasing explosive power and strength output, core mechanics training enables Wushu athletes to better perform complex movements such as aerial rotations.

4. Conclusions

This paper took 20 Wushu athletes as the experimental subjects for case analysis. The experimental subjects were randomly divided into two groups, group A receiving core mechanics training and group B receiving normal waist and abdomen training. The core strength quality and the completion degree of difficult movements of the two groups before and after training were analyzed. It was found that the data of the two groups improved after training, but the improvement in body coordination after core mechanics training was higher than that after normal waist and abdomen training. Group A was significantly higher than group B in the scores of contracted waist degree, leg bending degree, eight-level ventral bridge, and the distance of the left- and right-side solid ball throws. Therefore, the following conclusions were drawn:

(1) Core mechanics training can promote the core strength quality required by completing the difficult movements of aerial rotations and the completion quality and has a positive impact on the body coordination of athletes during aerobatic rotations, i.e., core mechanics training can improve the body coordination to make aerial rotations movement more standard and beautiful and help Wushu athletes to get higher scores;
(2) Both core mechanics training and normal waist and abdomen training can significantly improve the completion degree of martial arts athletes' air turn movements, but comparatively, the improvement range of core mechanics training is significantly higher than that of normal waist and abdomen

training, and can effectively enhance the body coordination of Wushu athletes when doing air turn.

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