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ARTICLE

A Study on the Importance of Core Strength and Coordination Balance during Basketball Based on Biomechanics

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ABSTRACT

When basketball players play against each other in a game, better coordinated balance can give them a better advantage. This paper briefly introduces the coordination balance and core strength of basketball players. Twenty basketball varsity members were selected from Chengdu College of University of Electronic Science and Technology of China as subjects for the test. The athletes were randomly divided into a control group and an experimental group. The control group received regular strength training, and the experimental group received core strength training in addition to regular training. Both groups underwent isometric muscle strength test, coordination and balance test and shooting percentage test before and after training. The results demonstrated that muscle group strength increased in the control group after conventional training, but the experimental group showed more significant improvement in muscle group strength after additional core strength training; the experimental group had better coordination and balance ability after core strength training; the experimental group had a significantly higher shooting percentage after core strength training due to the improvement of coordination and balance ability.

KEYWORDS

Isometric muscle strength test; basketball; core strength; coordinated balance

1 Introduction

As a ball game with strong confrontation, basketball has comprehensive requirements on the strength, speed, endurance and skills of the players [1]. With the development of modern basketball, confrontation techniques between players also show diversified development, and the rhythm between the offensive and defensive sides is changing faster and faster. In the process of more and more intense confrontation, the good physical quality of athletes can better achieve the confrontation advantage [2]. Good physical quality not only refers to more durable endurance and more powerful explosive power, but also includes the body's coordinated balance ability. In the course of basketball confrontation, there will be a variety of different movement skills and conflicts between the body; in this process, the player's body center of gravity and the distribution of body strength will change rapidly, and once these changes are out of range, they will greatly affect the stability of the player and eventually lead to failure of the confrontation or a decrease in the hit rate of the shot [3]. Athletes' coordinated balance can greatly affect their endurance and explosive power when performing basketball confrontation. Park et al. [4] explored differences of maximum muscle strength and isokinetic knee and core muscle functions according to pedal power of racing cyclist candidate. They found that athletes with greater peak and average muscle power had significantly lower body fat and significantly higher free fat. Taveira et al. [5] compared trunk muscle strength and postural control of older running athletes *vs.* older physically active adults. They found that older adults who performed running exercise had higher isokinetic torque of extensor trunk muscles and better postural control than those who performed regular physical activity. The main purpose of this study is to provide a reference for the training of basketball players through analyzing the effectiveness of core strength training. This paper briefly introduces the coordinated balance and core strength of basketball players. Twenty basketball varsity members from Chengdu College of University of Electronic Science and Technology of China were selected as subjects for the test. The novelty of this paper is applying core strength training to strengthen the coordination and balance of athletes and verifying the effectiveness of core strength training on muscle strength and coordination and balance enhancement using a controlled approach.

2 Core Strength-Based Coordinated Balance Training

2.1 Coordinated Balance

Muscle tissue directly coordinates body movements [6]. In the entire closed-loop of motor coordination, each part of the process, from sensory incoordination to transmission of nerve impulses to the movement of muscle tissue, takes a certain amount of time [7]. If the time is shortened, the athlete can more quickly achieve a coordinated balance of the body during the confrontation and thus gain an advantage in the confrontation [8]. The strength of muscle tissue, as the structure that directly coordinates and balances the movement, is crucial, and sufficient muscle strength allows for faster adjustments to the movement.

Since the sensory organs and the nervous system are involved in the coordination and balance of movements by the muscle tissue, the training of the muscle tissue will also have a training effect on the senses and the nervous system.

2.2 Core Strength

The main role of the core region of the human body is the transmission of upper and lower limb forces, the maintenance of human stability and the control of the body's center of gravity, while core strength is the strength quality of the core region to achieve the above role [9].

Targeted training of the core region can effectively maintain the stability of the spine and pelvis, guarantee the balance of the center of gravity, and better achieve the coordinated balance of the upper and lower limbs [10].

Core strength training is targeted to muscle groups in the core region. The regulation of muscle groups by the nervous system is promoted through the unstable environment created during training to maintain correct body posture, and the sensory perception of inconsistencies is enhanced to exercise the control of core muscles, thus improving the body's coordinated balance [11]. Basketball players face fierce confrontation in the actual game and need to complete various technical movements in the rhythmical and variable confrontation [12]. If athletes want to accomplish reasonable technical movements in the confrontation, they need to maintain their balance of the center of gravity as much as possible. Core strength training can strengthen the athletes' coordination ability, keep themselves stable during the confrontation, reduce the influence on technical movements, and improve the shooting percentage [13].

3 Example Analysis

3.1 Experimental Subjects

In this paper, basketball varsity members from Chengdu College of University of Electronic Science and Technology of China were selected as subjects for the test. They were male athletes with an average age of 20 ± 1 years and an average height of 175 ± 2 cm. All 20 members had received training for three years and had no history of injury, as well as no physical injuries in the last three months.

3.2 Experimental Equipment

Training equipment included leather ruler, stopwatch, basketball, barbell and yoga mat.

Testing equipment included Biodex dynamic and static balance instrument (Beijing Goaltouch Technology and Trade Co., Ltd., China) and Biodex isometric muscle strength tester (Hanfei Medical Instrument Co., Ltd., China).

3.3 Training Program

In this study, 20 male varsity basketball volunteers were randomly and equally divided into a control group and an experimental group. The control group received conventional strength training, while the experimental group received the targeted core strength training in addition to conventional training [14]. The training programs are shown in Table 1.

Table 1: Regular strength training and core strength training programs

Type of training	Training program	Training load	Single group training volume	Break time between groups	Number of groups
Regular strength training	Push-ups	Self-weight, no additional load	20	60 s	6
	Chin-ups		10		6
	Double-bar flexion arm support		15		6
	Back jerk		10		6
	Hard pull	5 RM	5		3
	Bench press	10 RM	10		3
	Barbell squat	10 RM	10		3
	Jerk (weightlifting technique)	5 RM	5		3
Core strength training	Plank support	Self-weight, no additional load	Last 60 s		3
	T-support				
	Straight-legged side support				
	Lie on one's back and lift his legs				
	Lie on one's back and point the ground left and right				
	Lie on one's back, straighten his legs, and touch the feet				
	Lie on one's back, bend his knees, and curl the stomach				

3.4 Test Methods

Both the control and experimental groups underwent isometric muscle strength test, balance test, and shooting percentage prior to training and again after a six-week training period.

The content of the isometric muscle strength test is as follows. The muscle strength of the ankle, knee, hip and low back muscle groups was tested according to the manual of the isometric muscle strength test system [15]. The angular velocity was set as 180°/s.

The content of the balance ability test [16] is as follows. The subject stood in the center of the balance tester as required by the dynamic and static balance test procedure and maintained a stable balance. After starting the balance tester and related test procedures, the room was kept quiet. The subjects performed balance movements with both feet, left foot and right foot in two states (static with eyes open and dynamic with eyes open). The subjects did the balance movement test in such a way that the torso was not disturbed by the outside world, and each movement lasted for 20 s and repeated five times. Judgment indicators of dynamic and static balance ability were overall stability index (SI), anterior and posterior stability (APSI) and medial and lateral stability (MLSI).

The content of the shooting percentage test is as follows. The first item was fixed-point shooting [17]. The subject stood on the arc of a circle with the center of the basket as the circle point and a radius of 4.3 m and shot at an angle of 0°, 45°, 90°, 135° and 180°, respectively. Each person shot ten times at each spot and finished within two minutes. Every subject repeated the test twice, and the better performance was taken as the final performance. The second item was a dribble jump shot with a sharp stop. Firstly, obstacles were set at the sites on the arc of a circle with the center of the basket as the circle point and a radius of 6.03 m, whose angles with the rim were 45° and 135°. Then, the subject was provided with a ball at the three-point line. After receiving the ball, the subject dribbled to the obstacle for a change of direction in front of the body and stopped sharply for a jump shot. He repeated the movement ten times. Every subject repeated the test twice, and the better one was taken as the final performance.

3.5 Mathematical Statistics

The collected data were statistically processed using SPSS software [18] and Excel software. The numerical results were presented in the form of $x \pm d$. *T*-test was carried out on the data in the same group before and after training and data in different groups. A P value smaller than 0.05 indicated a significant difference.

3.6 Test Results

As shown in Table 2, there was no significant difference in muscle strength of the low back, ankle, knee and hip muscle groups between the control and experimental groups before the training; after six weeks of training, the total extension work and peak flexion-extension moment of the low back muscle strength, the total flexion-extension work and peak flexion-extension moment of the ankle and hip muscle strength, and the total extension work and peak flexion-extension moment of the knee muscle strength were significantly improved in the control group; the total extension work and peak extension moment of the low back muscle strength and the total flexion-extension work and peak flexion-extension moment of the ankle, knee and hip muscle strength were significantly improved in the experimental group. In addition, the total extension work and peak extension moment of the low back and ankle muscle strength in the experimental group were significantly higher than those in the control group, and the total flexion and extension work and peak flexion and extension moments of the knee and hip muscle strength in the experimental group were significantly higher than those in the control group.

Table 3 shows the results of balance tests performed before and after a six-week training period for the control and experimental groups. The first is the balance characteristics of the static double-foot posture. The SI, APSI and MLSI were significantly lower in both groups after training. In addition, the experimental group had significantly lower SI, APSI and MLSI compared to the control group after training. The second is the static left-foot posture. The SI, APSI and MLSI were significantly lower in both groups after training, and the APSI and MLSI of the experimental group were significantly lower than that of the control group.

In the static right-foot posture, there was a significant reduction in APSI in the control group after training, there was a significant reduction in SI, APSI and MLSI in the experimental group, and the APSI of the experimental group was significantly lower than the control group.

Table 2: Isometric muscle strength values at 180°/s for the control and experimental groups before and after training

Test site	Group	Test time	Total work of flexion/J	Total work of extension/J	Peak flexion moment/NM	Peak extension moment/NM
Low back muscle strength	Control group	Before training	391.4 ± 18.2	398.4 ± 20.5	140.4 ± 7.5	117.4 ± 5.8
		After training	411.6 ± 37.1	477.5 ± 21.5*	153.7 ± 7.4*	151.4 ± 9.5*
	Experimental group	Before training	422.5 ± 17.1	401.1 ± 44.7	138.4 ± 9.5	116.0 ± 9.7
		After training	422.5 ± 29.6	592.8 ± 43.0*+	147.8 ± 20.8	177.5 ± 15.0*+
Ankle joint muscle strength	Control group	Before training	67.6 ± 3.5	79.5 ± 8.8	24.6 ± 4.8	33.5 ± 3.5
		After training	155.8 ± 14.9*	102.0 ± 11.3*	70.6 ± 14.7*	52.9 ± 7.7*
	Experimental group	Before training	70.7 ± 8.6	73.7 ± 9.9	26.1 ± 4.1	31.4 ± 0.9
		After training	170.1 ± 19.5*	127.5 ± 18.8*+	75.0 ± 7.1*	61.3 ± 4.8*+
Knee joint muscle strength	Control group	Before training	287.2 ± 27.2	443.8 ± 50.7	56.6 ± 4.7	102.5 ± 9.6
		After training	320.1 ± 22.7	495.0 ± 50.7*	73.5 ± 6.4*	138.0 ± 14.4*
	Experimental group	Before training	291.5 ± 23.9	451.8 ± 60.2	58.4 ± 5.1	105.5 ± 10.3
		After training	359.9 ± 20.1*+	589.0 ± 60.2*+	82.3 ± 8.9*+	160.1 ± 18.1*+
Hip joint muscle strength	Control group	Before training	241.7 ± 23.7	237.3 ± 15.0	79.8 ± 4.2	74.5 ± 2.9
		After training	417.5 ± 76.6*	420.1 ± 66.9*	115.1 ± 18.0*	117.8 ± 15.9*
	Experimental group	Before training	244.1 ± 28.2	257.5 ± 29.8	80.3 ± 5.7	77.8 ± 5.0
		After training	619.5 ± 48.9*+	527.6 ± 87.8*+	145.1 ± 21.5*+	145.3 ± 20.0*+

Note: * indicates significant difference before and after training within the same group and + indicates significant difference between different groups.

Table 3: Balance ability characteristics of the control and experimental groups before and after training

Balance posture	Group	Test time	SI	APSI	MLSI
Double-foot	Control group	Before training	1.22 ± 0.41	0.74 ± 0.29	0.85 ± 0.25
		After training	1.72 ± 0.25	$0.71 \pm 0.17^{*}$	$0.75 \pm 0.12^{*}$
	Experimental group	Before training	1.19 ± 0.25	0.75 ± 0.21	0.83 ± 0.15
		After training	$1.04 \pm 0.28^{*+}$	$0.58 \pm 0.13^{*+}$	$0.83 \pm 0.12^{*+}$
Left-foot	Control group	Before training	2.77 ± 0.31	1.71 ± 0.24	1.88 ± 0.22
		After training	2.58 ± 0.27	$1.44 \pm 0.18^{*}$	$1.48 \pm 0.25^{*}$
	Experimental group	Before training	2.68 ± 0.24	1.67 ± 0.63	1.94 ± 0.35
		After training	$2.03 \pm 0.25^{*+}$	$1.32 \pm 0.14^{*+}$	$1.27 \pm 0.12^{*+}$
Right-foot	Control group	Before training	2.18 ± 0.36	1.35 ± 0.36	1.53 ± 0.44
		After training	$1.71 \pm 0.36^{*}$	$0.98 \pm 0.25^{*}$	$1.25 \pm 0.22^{*}$
	Experimental group	Before training	2.24 ± 0.44	1.37 ± 0.35	1.51 ± 0.36
		After training	$1.37 \pm 0.24^{*+}$	$0.83 \pm 0.14^{*+}$	$0.95 \pm 0.15^{*+}$

Note: * indicates significant difference before and after training within the same group and + indicates significant difference between different groups.

Fig. 1 shows the shooting percentages of the control and experimental groups tested before and after the training. The comparison in Fig. 1 demonstrated that the shooting percentages of the control group and the experimental group were similar before the training was conducted, whether it was a fixed-point shot or a dribble jump shot. After the training, both the control group and the experimental group had improved shooting percentages, especially the experimental group.

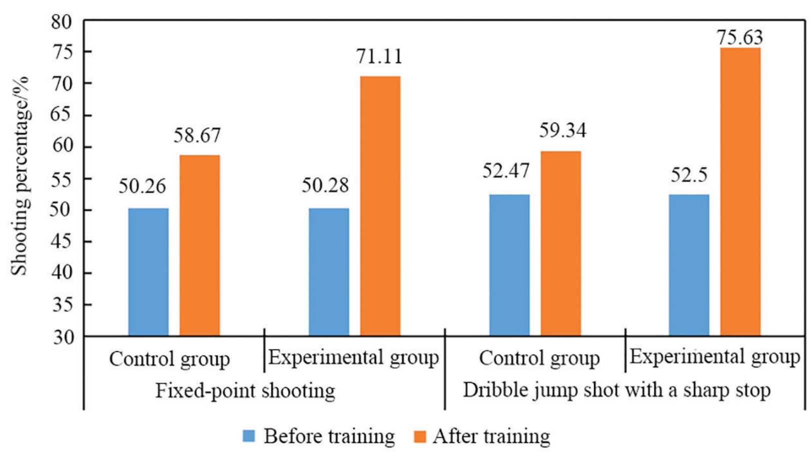

Figure 1: Shooting percentages of the control and experimental groups before and after training

4 Discussion

Basketball is a ball game with strong confrontation, which requires high physical strength quality of athletes. Improving the strength quality of the athletes can improve the athletes' advantage in basketball confrontation. Core strength training is a more targeted exercise than conventional strength training for the core region of the trunk consisting of the waist, pelvis and hip joints and their muscle groups, so it can improve the power transfer between the upper and lower extremities and the balance of trunk movement. In this paper, 20 male athletes from a university basketball team were randomly divided into a control group and an experimental group. The control group underwent six weeks of conventional strength training, and the experimental group underwent six weeks of core strength training. The isometric strength test, coordination and balance test, and shooting percentage test were carried out before and after training.

The isometric strength test found that core strength training influenced the strength of the low back muscles more than conventional training because the intensity and movement structure of core strength training targeted the low back muscles more. Core strength training affected the maximum strength and work capacity of the ankle joint more than conventional strength training because the exercise of leg support ability in the core strength training strengthened the dorsiflexor and anterior tibial muscles of the ankle joint. Core strength training also improved the maximal strength and external work capacity of the knee joint because the deep squats in core strength training improved the strength of the knee muscles.

The results of the balance ability test showed that the athletes had better static balance after core strength training. The reason for the above result was that the static balance of the human body mainly relied on the vestibular receptors in the central system, and training movements formed effective stimulation to the vestibular receptors, which enhanced their sensitivity and effectively improved the static balance. In addition, core strength training had a more significant effect on the dynamic balance ability of athletes. The reason for the significant effect was because the vestibular sense, proprioceptive sense and central system's ability to regulate muscles significantly affected dynamic balance ability, and the training movements not only enhanced the sensitivity of vestibular receptors but also exercised the skeletal muscles that maintain balance.

The results of the shooting percentage test demonstrated that the shooting percentage of athletes significantly improved in fix-point shooting and dribble jump shot with a sharp stop. The reason for the above result was because basketball players firstly hit the ground with lower limbs, then transmitted the power to the upper limbs through the core area of the torso, and finally threw the basketball to the basket through the pivoting of the fingers. This process required a coordinated effort from the core to control the stability of the entire body so that the force gained from hitting the ground could be transferred to the basketball intact. Core strength training focused on the core area of the body muscle groups, enhancing the maximum strength and external work capacity to make the control of the torso more effective and stable.

5 Conclusion

This paper briefly introduces the coordinated balance and core strength of basketball players. Twenty basketball varsity members from Chengdu College of University of Electronic Science and Technology of China were selected and randomly and equally divided into control and experimental groups. The control group received conventional strength training, while the experimental group received core strength training, both of which were trained for six weeks. Isometric muscle strength test, balance test and shooting percentage test were performed on both groups of athletes before and after training. The final results are as follows. (1) The isometric strength of both the control and experimental groups increased after training, but the isometric strength of the experimental group receiving core strength training was higher than that of the control group. (2) Both the control and experimental groups improved in the balance after training, but the experimental group receiving core strength training had better balance. (3) Both the control and experimental groups improved in shooting percentage after training, but the experimental group gained more improvement after core strength training.

The shortcoming of this paper is that there were fewer types of core strength training for athletes and fewer volunteers to test the effectiveness of core strength training, so the future research direction is to increase the types of core strength training and increase the number of volunteers to be tested. The contribution of this paper is to provide an effective reference for the enhancement of athletes' core strength, coordination and balance.

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