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Influence of blood flow restriction training combined with resistance training on physical function of college football players

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Abstract

Background: Blood flow restriction training can significantly improve muscle function in different populations. At present, there are few reports on the application of blood flow restriction training to physical training of football players. Objective: To investigate the effect of blood flow restriction training (BFRT) combined with moderate strength resistance training (hereinafter referred to as "combination training") on muscle function of high-level football players in colleges and universities. Methods: A total of 48 male football players aged (20.67±1.34) years old were studied. The changes of lower limb muscle strength, longitudinal jump, fast sprint and isokinetic muscle strength before and after 8 weeks of training were compared. Results: 1) The peak torque of knee extension and flexion on both sides increased significantly in both groups ($p < 0.01$). The peak torque of knee flexion and extension in both sides of the experimental group was significantly better than that in the control group ($p < 0.05$). 2) the squat, CMJ and SJ test scores of the experimental group were better than those of the control group (P=0.036, 0.049, 0.016); 3) the direction changing ability and 30-meter sprint performance of the experimental group were significantly improved (P=0.006, 0.036), the 30-meter sprint ability of the control group was significantly improved (P=0.047), the direction changing ability and 30-meter sprint performance of the experimental group were significantly better than the control group (P=0.022, 0.028); 4) Serum nitric oxide and vascular endothelial growth factor in the experimental group were significantly increased compared with before the experiment (P=0.001, 0.000), endothelin was significantly decreased compared with before the experiment (P=0.000), and nitric oxide and vascular endothelial growth factor in the control group were significantly increased compared with before the experiment (P=0.027, 0.000). Endothelin had no significant change compared with before the experiment (P=0.068); After the experiment, nitric oxide and VEGF in the experimental group were significantly higher than those in the control group (P=0.032, 0.001), and endothelin was significantly lower than that in the control group (P=0.000).

Conclusion: The effect of 8-week blood flow restriction training combined with moderate resistance training on the improvement of lower limb muscle function is significantly better than that of traditional high-intensity strength training, and has a significant effect on cardiovascular health level.

Key words: Blood flow restriction training, resistance training, college male football players, muscle function

1 Introduction

As the most popular sport in the world, football becomes more and more intense with the change of football concept. Chinese Super League game data analysis research shows that in 2023, the average number of physical confrontations per game will be 101.64, and the average number of sprint runs per game will be close to 200, which puts forward strict requirements on athletes' muscle function.

blood flow restriction training (BFRT), also known as pressure training (KAATSU training)[1], uses special pressure devices to restrict the local muscle arterial blood supply, inhibit venous blood outflow, and keep the muscles in a state[2] of blood accumulation and low oxygen. A large number of experimental studies have found that the training effect of blood flow restriction training combined with low-intensity resistance training is basically the same as that of traditional high-intensity resistance training. Biological studies have found that muscles can recruit more exercise units under hypoxia and high metabolic stress. At the same time, secreting more hormones such as vascular endothelial cell growth factor, nitric oxide, insulin-like growth factor-1 to improve muscle microcirculation function[3], and finally achieve the purpose of improving muscle function training. Scholars at home and abroad have found that BFRT is beneficial to football < (Brocherie et al.,2020), road cycling (Tang-chaisuriya et al., 2022), gymnastics (Yang et al al,2022), the athletes' maximum muscle strength, explosive power and muscle circumference all produced significant gains, and no adverse reactions such as arteriovascular sclerosis, coagulation and thrombosis occurred. However, at present, there are relatively few researches on the effect of pressure training on muscle function of football players.

Therefore, by comparing the effect of traditional high-intensity resistance training and BFRT combined with medium-intensity resistance training, this study explored the effect of BFRT combined training on lower limb muscle function of male football players in colleges and universities. In order to provide new ideas and methods for improving the muscle function of college male football players.

2 Research object and method

2.1 Research Objects

The study was conducted in March 2023 in a college of Physical education at a university in Chongqing. According to the G Power 3.1 software, for a repeated-measure analysis of variance (RM-ANOVA) with a significance level of α=0.05 and medium effect (f=0.25), a sample size of at least 36 participants is required to reach a statistical power of 0.95. At the same time, taking into account the 10% shedding rate, this study would require at least 40 participants. A total of 50 college men's soccer players were initially included, in combination with the reality of the football team and our goal of getting better results. In the training process, 2 players withdrew due to sports injury, and finally 48 experimental subjects (24 in the experimental group and 24 in the control group) completed the experimental intervention.

The inclusion criteria were as follows:

1. All subjects obtained the Level II and above athlete certificate.
2. The subjects had no serious sports injuries in the past six months.
3. Subject has no other health problems in the past six months and no long-term history of drug use.
4. The subject has never been exposed to BFRT training.

The experimental procedure adopted in this study is in line with the national ethical standards for biomedical research involving humans and the latest revised Declaration of Helsinki of the World Medical Association, and was approved by the Ethics Committee of Southwest University Hospital. All the subjects in this study gave informed consent and signed informed consent with the guardian of the subjects before the experiment began.

Table 1. Basic information of experimental subjects

Groups	Age	Years of training
Pressure group	20.00±0.63	8.46±.84
Control group	21.29±0.77	9.00±1.16
P	0.242	0.135

2.2 Research Design

During the training period of the subjects preparing for the 7th National Games in Chongqing, strength training was conducted three times a week for 8 weeks. The training content of the two groups of subjects was the same. The experimental group used the KAATSU master pressure training instrument for pressure training during the training process. The binding pressure of the pressure belt was 40 mmHg, the inflating pressure was 180 mmHg, and the pressure belt was bound in the middle and upper third of the thigh. All the test indexes were pre-measured before the formal experiment, and post-measured at the end of the 8-week experiment. The content of strength training is shown in the following table.

Table 2. Exercise intervention program

Training phase	Training content	Training intensity (1RM)	
		Experimental group	Control group
Acclimatization phase (Week 1)	Single leg Romanian hard pull Bulgarian single leg squat Flat street mat half squat BOSU ball on horse step system Bosu balance catch high lift leg	30-40%	70% - 80%

Stable stage (Week 2)	Bounce squats Front and back split leg squats Neck front half squat Bulgarian one-leg squat Single leg Romanian hard pull BOSU ball crosswise jump BOSU ball loaded dovetail flat street catch high lift leg	40-50%	70% - 80%
Intensive phase (Weeks 3-8)	Bounce squats Single leg Romanian hard pull Bulgarian single leg squat Balance pad half squat BOSU ball on swallow balance catch high leg lift Exercise pedal single leg squat with barbell piece	40-50%	70% - 80%

2.3 Research Methods

2.3.1 Longitudinal jump test

Adopt a squat jump (counter-movement jump; CMJ and SJ (squat jump) were used to measure the longitudinal jumping ability of the subjects. Each of the two tests performed three jumps and recorded the best results.

2.3.2 30m sprint run test

Using the smart speed section timing system (Fusion Sport, Brisbane, Queensland, Australia), to 30 m sprints test subjects, subjects, after sufficient warm-up start standing type, with the fastest speed finish 30 m distance; Each subject was tested twice, with the best result, and the interval between the two tests was at l east 5 minutes.

2.3.3 Direction change ability test

Using the smart speed section timing system (Fusion Sport, Brisbane, Queensland, Australia) for recor d. The Illinois Test (IIIionis) was used to test the subject's ability to change direction. Each subject was test ed three times, and the best score was taken as the test score. Between the two tests, the recovery time shoul d not be less than 5 minutes.

2.3.4 Isokinetic muscle strength test

The multi-joint isokinetic Test Training System (HUMAC NORM, USA) was used to test the knee isokinetic muscle strength, and the peak moment was tested at 60°/s angular velocity.

2.3.5 Biochemical index detection

On the day before intervention and in the morning of the second day after intervention, 5ml of whole venous blood was collected in the fasting state of the subjects and centrifuged at 3 000 r/min for 15 min. Serum was collected after centrifugation and stored in the refrigerator at -80 ℃. Endothelin and vascular endothelial cell growth factor were determined by ELISA, nitric oxide and endothelial nitric oxide synthase were detected by nitric acid reductase.

2.3.6 Data analysis

SPSS22.0 software was used for statistical analysis of the experimental data, and variance homogeneity test was used to screen the data. The data in this study were in line with normal distribution. General linear analysis was used to analyze the differences among the groups in the experiment, T-test was used to compare the intra-group data after the experiment, and general linear analysis was used to compare the differences between the groups. Continuous variables were expressed in the form of mean ± standard deviation. $P<0.05$ means statistically significant.

3 Findings

3.1 Changes of athletes' isokinetic muscle strength before and after the experiment

The change results of the peak torque of knee flexion and extension are shown in the table below. The peak torque of knee extension and flexion on both sides of the experimental subjects in both groups increased significantly ($p < 0.01$). After 8 weeks of experimental intervention, the peak torque of knee flexion and extension in both sides of the experimental group was significantly better than that in the control group ($p < 0.05$).

Table 3. Changes of isokinetic muscle strength before and after the experiment

Indicators	Groups	Before the experiment	After the experiment	P value
Right knee extensor	Experimental Group	180.06±18.01	220.56±15.42	<0.01
	Control group	174.47±19.43	208.41±16.50	<0.01
	P values	0.398	0.037	
Right knee flexor	Experimental Group	118.56±14.71	149.94±9.05	<0.01

	Control group	114.47±16.70	131.12±7.12	<0.01
	P values	0.462	0.00	
Left knee extensor	Experimental Group	173.19±19.06	214.44±15.92	<0.01
	Control group	169.59±25.42	200.82±18.57	<0.01
	P values	0.650	0.031	
Left knee flexor	Experimental Group	111.81±19.51	139.81±11.26	<0.01
	Control group	109.59±16.05	126.94±21.964	<0.01
	P values	0.722	0.044	

3.2 Changes of athletes' squat and longitudinal jump before and after the experiment

As shown in the following table, after 8 weeks of intervention, squat, CMJ and SJ in the experimental group were significantly improved compared with before the experiment (P=0.03, <0.01, <0.01), squat and CMJ in the control group were significantly improved compared with before the experiment (P=0.049, 0.046), while SJ showed no significant changes (P=0.08). After the experiment, the data comparison between the two groups showed that the squat, CMJ and SJ test scores of the experimental group were better than those of the control group (P=0.036, 0.049, 0.016).

Table 4. Changes of squat and longitudinal jump of subjects before and after the experiment

Indicators	Groups	Before the experiment	After the experiment	P value
Squats	Experimental Group	149.0625±23.21341	158.09±16.17428	0.033
	Control group	143.6471±19.30007	148.8±15.83068	0.049
	P values	0.471	0.036	
CMJ	Experimental Group	44.8750±4.09675	48.94±4.48516	<0.01
	Control group	43.6471±2.84915	46.22±3.23128	0.046
	P values	0.323	0.049	
SJ	Experimental Group	40.8125±4.30842	48.8750±4.75920	<0.01

	Control group	42.1765±2.89904	44.5294±4.98896	0.083
	P values	0.292	0.016	

3.3 Changes of athletes' changing direction ability and sprint running before and after the experiment

After 8 weeks of exercise intervention, the direction changing ability and 30-meter sprint performance of the experimental group were significantly improved (P=0.006, 0.036), while the 30-meter sprint ability of the control group was significantly improved without significant change in direction changing ability (P=0.047, 0.261). After the experiment, the direction changing ability and 30-meter sprint performance of the experimental group were significantly better than those of the control group (P=0.022, 0.028).

Table 5. Change of direction changing ability and sprint running before and after the experiment

Indicators	Groups	Before the experiment	After the experiment	P value
Ability to change direction	Experimental Group	16.63±0.82358	15.81 ±0.70	0.022
	Control group	16.68±0.74	16.47±0.76	0.261
	P values	0.853	0.006	
Thirty meter dash	Experimental group	4.58±0.035	4.38 ±0.029	0.028
	Control group	4.61±0.038	4.48 ±0.043	0.047
	P value	0.087	0.036	

3.4 Changes in blood cytokine levels of athletes before and after the experiment

As shown in Table 4, before and after the experiment, serum nitric oxide and vascular endothelial growth factor in the experimental group significantly increased compared with before the experiment (P=0.001, 0.000), endothelin significantly decreased compared with before the experiment (P=0.000), and nitric oxide and vascular endothelial growth factor in the control group significantly increased compared with before the experiment (P=0.027, 0.000). Endothelin had no significant change compared with before the experiment (P=0.068); After the experiment, nitric oxide and VEGF in the experimental group were significantly higher than those in the control group (P=0.032, 0.001), and endothelin was significantly lower than that in the control group (P=0.000).

Table 6. Changes of blood cytokines before and after the experiment

Indicators	Groups	Before the experiment	After the experiment	P value
Nitric oxide	Experimental group	39.74±6.72	44.74±8.06	0.001
	Control group	38.41±5.92	42.19±7.09	0.027
	p-value	0.443	0.032	
Endothelin	Experimental Group	58.85±9.17	47.07±7.24	0.000
	Control group	57.61±8.97	53.48±13.61	0.068
	P values	0.863	0.035	
Vascular endothelial growth factor	Experimental group	180.30±16.97	217.41±12.08	0.000
	Control group	182.40±13.19	206.19±10.03	0.000
	P values	0.612	0.001	

4 Discussion

4.1 The effect of blood flow restriction training on the muscle function of college male football players

This study shows that 8 weeks of blood flow restriction training combined with medium-intensity resistance training and high-intensity resistance training can significantly improve the isokinetor muscle strength, squat, longitudinal jump, direction changing ability and 30-meter sprint ability of male college football players. At the same time, the experimental results show that the blood flow restriction training combined with moderate strength resistance training can improve the isokinetic muscle strength, squat, longitudinal jump, direction changing ability and 30-meter sprint ability of football players better. The results of this experiment are basically consistent with the previous research results. After four weeks of pressure training on 20 professional free wrestlers, Shi Xiaolei[4] et al found that the peak moment of left knee flexion and right knee extension and the maximum static growth of bench press in the experimental group were significantly higher than those in the control group. The study of Che Tongbing also found that 6-week low-intensity resistance exercise combined with[5] pressure training significantly improved the lower limb strength of female wrestlers than high-intensity resistance training. Yamanaka[6] and Luebbers[7] et al. showed that combined pressure resistance training had a better effect on muscle strength improvement of football and weightlifting athletes.

This study speculated that the effect of pressure training on muscle strength improvement was mainly due to the regulation of the secretion level of muscle growth factor by pressure training. Biological studies have shown that pressure training can cause the accumulation of metabolites such as lactic acid in the pressure area, and cause the muscle to be in a local hypoxia state, thus increasing the secretion of nitric oxide synthase (NOS). Upregulation of serum nitric oxide (NO) secretion, NO can promote the activity, proliferation and differentiation[8] of myoblasts; Increase the blood supply of muscle tissue, up-regulate the glucose carrier GLUT4 level of muscle cells, improve glucose uptake, improve muscle energy metabolism, accelerate muscle tissue growth. In addition, studies have pointed out that short-term low-intensity compression and resistance training can stimulate the secretion of hepatocyte proliferation factor (HGF). Molecular studies have shown that HGF can directly activate muscle satellite cells and promote their division and differentiation, thus accelerating the growth of muscle tissue.

4.2 Influence of blood flow restriction training on cytokines of college football players

In this study, after 8 weeks of experimental intervention, as shown in Table 4, serum nitric oxide and vascular endothelial growth factor in the experimental group were significantly increased and endothelin was significantly decreased before and after the experiment, while serum nitric oxide and vascular endothelial growth factor were significantly increased and endothelin was not significantly changed in the control group. After the experiment, nitric oxide and vascular endothelial growth factor in the experimental group were significantly higher than those in the control group, while endothelin was significantly lower than that in the control group. The results of this study showed that the combination of pressure and resistance resistance training on athletes was basically consistent with the results of previous studies. Tan Chaowen's study showed[9] that the expression levels of endothelial growth factor and nitric oxide synthase were significantly up-regulated and the expression level of endothelin-1 was significantly down-regulated during low-load pressure training. LARKI N[10] et al. 's study on adults showed that a single acute blood flow restriction training could significantly increase the expressions of hypoxic-inducing factors, endothelial nitric oxide synthase and vascular endothelial cell growth factor in experimental subjects. HUNT[11] et al. also came to a similar conclusion that short-term pressure training could improve the expression of VEGF and enhance the bioavailability of nitric oxide in experimental subjects.

In this study, it is believed that the influence of pressure training on changes[12] in blood cytokine levels mainly comes from changes in blood vessel wall pressure and blood flow velocity. Under the influence of pressure band, blood vessels are in a state of compression, and when the effect of external pressure is lost, blood flow velocity will increase rapidly. The fluid shear stress of blood flow on the inner wall of blood vessels increases accordingly. Under the stimulation of shear stress, vascular endothelial cells adjust the vasodilation degree[13] through continuous release of nitric oxide, and inhibit the release of endothelin-1 to restrict blood vessel contraction[14]. The change of VEGF level may be caused by the continuous hypoxia of muscles under pressure. Hypoxic-ischemia environment will activate hypoxic-inducing factor[15] of vascular inner wall cells and thus promote the expression of VEGF.

5. Conclusion

The results of this study suggest that 8-week pressure training combined with medium-intensity resistance training can improve the isokinetic muscle strength, longitudinal jumping, sprint running and direction changing ability of male football players in colleges and universities significantly better than the traditional high-intensity resistance training. In addition, pressure training can also effectively regulate the levels of serum vascular factors such as nitric oxide, endothelin-1 and vascular endothelial growth factor, and improve the blood circulation function of male college soccer players. It lays a certain foundation for the improvement of the technical level of college men's soccer.

Reference:

[1] Lei Lin, Zhang Minghui, Ma Chunlian, et al. Muscle effect, dose-effect relationship and physiological mechanism of pressure resistance training. Journal of Tissue Engineering Research, 2019,27(26):4254-4264.

[2] Chen Keyi, Wang Dingxuan, Zhao Sike, et al. Research hotspots of pressure training in rehabilitation field and visual analysis of 10 years of literature. Journal of Tissue Engineering, 2019,26(15):2406-2411.

[3] Peng Yong, Hu Jiangping, Zhu Huan. Effects of low-load blood flow restriction and high-intensity resistance exercise on thigh microcirculation function of male athletic youth. Journal of Tissue Engineering, 2019,29(02):393-401.

[4] JI Xiaolei, Wu Xinyi, Sun Ke, et al. Influence of blood flow restriction on muscle strength and morphology of free wrestlers during special training. Chinese Journal of Sports Medicine,

2019,43(05):348-355.

[5] CHE Tongtong, LI Zhiyuan, Yang Tili, et al. Effects of 6-week low-intensity compression combined high-intensity resistance Training on the body core area and lower limb muscle strength of adolescent female wrestlers. Journal of capital institute of physical education, 2022 (03) : 333-341.

[6]Yamanaka T, Farley RS, Caputo JL. Occlusion training increases muscular strength in division IA football players. J Strength Cond Res, 2012, 26 (9) : 2523-2529.

[7]Yamanaka T, Farley RS, Caputo JL. Occlusion training increases muscular strength in division IA football players. J Strength Cond Res, 2012, 26 (9) : 2523-2529.

[8] Li Zhuoqian, Wei Wenzhe, Zhao Zhiguang, et al. Effects of different degree of blood flow restriction on serum growth hormone and testosterone secretion during low-intensity resistance exercise. China Sports Science and Technology, 2019,56(04):38-43.

[9] Tan Chao-Wen, Zhao Yan, Yu Ying-ying, et al. Effect and mechanism of low-load pressure training on improving blood pressure in spontaneously hypertensive rats. Sports Science, 2019,40(03):46-53+63.

[10]LARKI N KA, MACN EI L RG, DI RAI N M, et al. Blood flow restriction enhances postresistance exercise angiogenic gene expression. Med SciSports Exerc. 2012; 44 (11) : 2077-2083.

[11]HUNT JE, WALTON LA, FERGUSON RA. Brachial artery modifications to blood flow-restricted handgrip training and detraining. J Appl Physiol.2012; 112 (6) : 956-961.

[12] Zhao Zhi-guang, Cheng Jin-Na, Wei Wen-zhe, et al. Effects of pressure training and traditional muscle building training on some hormones and bioactive factors of elite male handball players. China Sports Science and Technology,2019,55(05):20-29.

[13] Liu C M, Zhuo J X. Effects of 6-month brisk walking exercise on blood pressure, NO and eNOS in middle-aged and elderly patients with essential hypertension. Journal of Guangzhou University of Physical Education, 201,41(02):104-107.

[14] Yuan Yuan, Lian Guili,Carrizzo A, et al. Novel nutrient mixture reduces blood pressure and enhances motor function in hypertensive patients by nitric oxide dependent mechanism. Chinese Journal of Hypertension,20,28(11):1097.

[15] Liu Shen, Ji Weixiu, Tang Jiafu, et al. Effects of pressure training on cardiovascular system. Chinese Journal of Sports Medicine, 2019,42(05):401-406.