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Effect of resistance exercise on self-management ability and vascular endothelial diastolic function and atherosclerosis in patients with hypertension

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Abstract: Objective To investigate the effect of resistance exercise on self-management ability, vascular endothelial relaxation and atherosclerosis in patients with hypertension. **Methods** A total of 160 patients with hypertension treated in Sinopharm Dongfeng General Hospital from December 2019 to January 2022 were enrolled in this study. Patients were divided into study group (n=80) and traditional group (n=80) by random number table method. The traditional group was given routine aerobic exercise training based on drug therapy, and the study group was given anti-resistance exercise training based on traditional therapy. Patients in both groups were given intervention for 3 months, and the changes of vascular endothelial relaxation function and atherosclerosis were compared and analyzed before and after training. **Results** After training, the systolic blood pressure and diastolic blood pressure of the patients were analyzed. and diastolic blood pressure of the two groups decreased significantly compared with those before training (P<0.05), and the study group was significantly lower than the traditional group (P<0.05). The scores of self-management ability (45.28±3.17 *vs* 40.10±2.22) in the two groups were significantly higher than those before training (31.48±3.18 *vs* 31.54±2.58); The serum levels of lipoprotein-associated phospholipase 2 (Lp-PLA2) and homocysteine (Hcy) in two groups decreased significantly compared with those before training (P<0.05), and the levels of serum Lp PLA2 and Hcy in the study group were significantly higher than those in the traditional group (P<0.05). The change rate of artery diameter and the change rate of artery diameter of endothelium-dependent vasodilation function in the two groups were significantly higher than those before training, and the study group was significantly higher than the traditional group (P<0.05). There was no significant difference in carotid intima-media thickness between the two groups after training and before training, and there was no significant difference between the study group and the traditional group (P>0.05). **Conclusion** Anti-resistance exercise can improve vascular endothelial relaxation function and atherosclerosis status, inhibit the expression of Lp -PLA2 and Hcy, reduce blood pressure continuously, and improve the self-management ability of patients with hypertension.

Keywords: Resistance exercise; Hypertension; Vascular endothelial relaxation; Atherosclerosis; Lipoprotein-associated phospholipase 2 Homocysteine

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Hypertension has no typical clinical symptoms and the diagnosis rate is low. It is usually detected during a physical examination. However, long-term uncontrolled blood pressure can be complicated by a series of serious complications, such as hypertensive nephropathy and stroke, which increase the mortality and disability of patients, seriously impair the quality of life of patients, and bring a huge burden on the family and the social healthcare[1]. Effective control of blood pressure through daily management to reduce the incidence of hypertension-related complications is the key to improving patient prognosis and reducing healthcare costs[2-3]. However, the management of hypertension is a long process, and long-term medication and poor lifestyle changes make it difficult for some patients to adhere to the medication, often leaving the disease unchecked, thus triggering cardiovascular and cerebrovascular accidents[4]. Rehabilitation training is of great significance in the prevention, control and management of hypertension, but the actual application is mostly based on aerobic exercise such as brisk walking, aerobics, cycling, jogging, etc., which has the characteristics of non-interruption, strong rhythm, low intensity and long time, etc. However, aerobic training often fails to improve the muscle strength of patients and change the body's internal environment, which is difficult to improve the patient's prognosis in a sustained way[5-6]. Resistance exercise is an exercise that relies entirely on the patient's own strength to overcome a certain external resistance, which mainly includes static and dynamic exercises, and is the main means to enhance muscle strength and endurance, and the resistance can come from other people, specialized equipment, themselves, gravity, elastic bands, etc.[7]. Abnormal endothelial diastolic

function and atherosclerosis are common in hypertensive patients, especially in hypertensive patients, there is a correlation between carotid intima-media thickness (CIMT) and endothelial diastolic function, and abnormalities of endothelial diastolic function may be an important part of atherosclerotic changes in the development of atherosclerosis [8-9]. Lipoprotein-associated phospholipase 2 (Lp-PLA2) and homocysteine (Hcy) are involved in the development of cardiovascular and cerebrovascular diseases [10-12]. Resistance exercise can effectively regulate blood pressure levels in hypertensive patients, but there are fewer studies on the correlation between resistance exercise and vascular endothelium and atherosclerosis in hypertensive patients. Based on this, the present study investigated the effects of resistance exercise on self-management ability, endothelial diastolic function and atherosclerosis in hypertensive patients, in order to clarify the application value of resistance exercise. The results of the study are reported as follows.

1 Material and methods

1.1 General information

One hundred and sixty hypertensive patients who were treated at the State Pharmaceutical Dongfeng General Hospital from December 2019 to January 2022 were included in the study.

Inclusion criteria: (1) meeting the diagnostic criteria of essential hypertension; (2) aged 20 to 75 years; (3) living in the community with a fixed residence; (4) having complete clinical data; (5) having indications of resistance exercise [hypertension not reaching the critical level (systolic blood pressure ≧ 200 mmHg or diastolic blood pressure ≧ 125 mmHg), having normal cognitive function, and having no somatic disabilities]; (6) patients were elementary school and above literacy level.

Exclusion criteria: (1) people with cognitive or psychiatric disorders; (2) people with serious other diseases or complications that affect exercise performance, and people with poor compliance; (3) pregnant and lactating women; (4) people with secondary hypertension; (5) people who need to stay in bed for a long period of time; (6) people with advanced vital functions; (7) patients with glomerulonephritis and aortic valve closure insufficiency; (8) people with malignant tumors; (9) people with a combination of other serious diseases; and (10) people with a combination of other serious diseases. Those who failed to complete the whole study process. All patients were informed about the trial and signed an informed consent form, and the study was reviewed and approved by the Ethics Committee of the hospital (LW-2023-036).

1.2 Intervention methods

All patients were given collective health education, regular follow-up guidance, curative guidance, dietary guidance, etc., and were treated with antihypertensive drugs such as angiotensin receptor antagonists, calcium antagonists, angiotensin-converting enzyme inhibitors, diuretics, and other drugs according to the individual conditions of the patients.

1.2.1 Traditional group

Patients were given conventional aerobic exercise training including jogging, tai chi, etc., 30 min/time, 2 times/day.

1.2.2 Study group

Resistance exercise training was given on the basis of the training of the traditional group, and the specific measures were as follows.

(1) A resistance exercise training group was set up, including 2 sports rehabilitation therapists, 4 nursing staff, 1 chief physician, and 2 community nurses. Prior training was given to the members of the group, so as to enable the members of the group to master the essentials of the resistance exercise and precautions when exercising.

(2) Resistance exercise using elastic band resistance upper limb exercise method, specific training time was 9:00 a.m. to 11:00 a.m. Each exercise would be conducted 8-16 times as a group, with an interval of 30-40 seconds between each exercise, every 1-2 days once, 3 times a week.

(3) Standing straight arm chest expansion: this exercise targets the latissimus dorsi and other back muscles. The patient should stand upright, feet shoulder-width apart, head up, and chest out. Each hand holds one end of an elastic band. While inhaling, lift both arms forward and then laterally to shoulder level, with fists facing outward, achieving a chest expansion pose. Pause briefly, then exhale and return to the starting position.

(4) elastic band boxing: this exercise strengthens the upper limb muscles. The patient uses an elastic band, placing it behind their back and threading it through the left armpit to the left hand. The right hand holds the band at the starting position, keeping the upper body straight. The left hand, gripping the other end of the band, makes a forward punching movement, while the right hand remains stationary for 30 seconds. Repeat the action with the right hand.

(5) Upright arm bending: this exercise targets the biceps. The patient stands with one foot in the middle of the elastic band, feet parallel and shoulder-width apart, hands naturally at the sides holding the band. Inhale and bend the elbow to lift the band, then exhale and return to the starting position.

(6) Standing shoulder external rotation: this exercise focuses on the internal and external oblique muscles. The patient stands upright, feet shoulder-width apart, with the elastic band fixed to the upper edge of a crossbar. With elbows bent and positioned in front of the chest, both

hands pull the band to rotate the shoulders outward to their maximum extent, then return to the starting position.

Both groups of patients underwent this training regimen for three months. After the training period ended, patients continued with their regular oral antihypertensive drugs.

1.3 Observation indicators

1.3.1 Levels of Lp-PLA2, Hcy

All patients got 2-3 mL of venous blood drawn before and after training, centrifuge at low temperature and separate the upper serum layer, and use enzyme immunoassay to detect serum levels of Lp-PLA2 and Hcy.

1.3.2 Blood pressure

The patients' systolic and diastolic blood pressures were measured and recorded before and after training using an electronic sphygmomanometer, and the blood pressure was taken as the average of three consecutive measurements.

1.3.3 Self-management behavior scale

The self-management behavior scale was used before and after the training to assess the patients' self-management ability, including dimensions such as dietary intake, cognitive symptom management, endurance exercise, doctor-patient communication, physical exercise, etc., with a total score of 50 points, with the higher scores indicating better self-management behaviors, and with scale reliabilities of more than 0.85[4].

1.3.4 Vascular endothelial diastolic function

Endothelium-dependent diastolic function of the patients was determined by ultrasound before and after the training, and the selected indexes included the rate of change of arterial internal diameter, the rate of change in arterial internal diameter of the non-endothelium-dependent vasodilator function, which can reflect the endothelium-dependent vasodilatory function mediated by blood flow, and the ultrasound equipment was purchased from SIEMENS (721PP).

1.3.5 Atherosclerosis

The carotid intima-media thickness of the patients was also measured by ultrasound before and after the training, and the left and right carotid arteries were measured three times each, and the average value was taken as the final value.

All of the above measurements are strictly quality control management, indoor and inter-room quality control in the determination of various indicators, the investigation to ensure that the investigation of the validity of the survey is 100.0%.

1.4 Statistical methods

All data were analyzed using SPSS 24.00 software, and count data were expressed as %. Comparisons between groups were made using the chi-square test. Measurement data that conformed to a normal distribution was expressed as $\overline{x} \pm s$, and independent samples *t* test was used for comparison between groups, and paired *t* test was used for pre- and post-training comparisons. Multiple time point comparisons should be analyzed using repeated measures ANOVA. $P<0.05$ was considered a statistically significant difference.

2 Results

2.1 Comparison of general information

The patients included in the study were divided into 80 cases in the study group and 80 cases in the traditional group by using the method of randomized numerical tables.General information such as age, gender and years of education were compared between the two groups and the differences were not statistically significant ($P>0.05$). **[Table 1]**

2.2 Comparison of systolic blood pressure and diastolic blood pressure before and after training

The systolic blood pressure and diastolic blood pressure of the two groups of patients after training decreased significantly compared with that before training ($P<0.05$), and the study group was significantly lower than the traditional group ($P<0.05$). **[Table 2]**

Tab.1 Comparison of general information between two groups (n=80, $\overline{x} \pm s$)

Groups	Years of education (years)	Body mass index (kg/m^2)	Duration of illness (months)	Gender (male/female, case)	Age (years)	State of an illness (Stage 1/ 2/ 3, case)
Study group	16.25±1.59	22.82±1.46	9.17±0.15	43/37	54.19±2.84	33/37/10
Traditional group	16.33±1.22	22.87±1.22	9.22±0.24	42/38	54.67±3.18	35/36/9
χ^2 /t value	0.111	0.142	0.132	0.025	0.452	0.125
***P* value**	0.904	0.862	0.878	0.874	0.614	0.939

Note: BMI is the body mass index; a means the patients is divided into stage 1, stage 2, and stage 3 according to the reference [12].

2.3 Comparison of self-management behavior scale between the two groups of patients before and after training

The self-management behavior scores of the two groups after training were significantly higher compared with those before training, and the study group was significantly higher than that of the traditional group (P<0.05). **[Table 3]**

Tab.2 Comparison of changes in systolic and diastolic blood pressure between two groups before and after training (n=80, mmHg, $\bar{x}$ ±s)

Groups	Systolic blood pressure		Diastolic blood pressure	
	Pre-training	Post-training	Pre-training	Post-training
Study group	154.22±4.85	124.59±10.78[ab]	98.28±3.38	72.57±3.18[ab]
Traditional group	154.09±9.18	134.09±11.15[a]	98.43±3.34	78.47±4.68[a]
t value	0.118	5.479	0.294	9.327
P value	0.819	<0.001	0.712	<0.001

Note: compared with the pre-training of the same group;[a] P<0.05; compared with the post-training of the traditional group, [b] P<0.05.

Tab.3 Comparison of self-management ability scores between two groups before and after training (n=80, $\bar{x}$ ±s)

Groups	Pre-training	Post-training
Study group	31.48±3.18	45.28±3.17[ab]
Traditional group	31.54±2.58	40.10±2.22[a]
t value	0.131	11.972
P value	0.896	<0.001

Note: compared with the pre-training of the same group, [a] P<0.05; compared with the post-training of the traditional group, [b] P<0.05.

2.4 Comparison of serum Lp-PLA2 and Hcy levels before and after training

The serum Lp-PLA2 and Hcy levels of the two groups of patients decreased significantly after training compared with before, and the study group was significantly lower than that of the traditional group (P<0.05). **[Table 4]**

Tab.4 Comparison of serum Lp-PLA2 and Hcy levels between two groups before and after training (n=80, $\bar{x}$ ±s)

Groups	Lp-PLA2 (μg/L)		Hcy (μmol/L)	
	Pre-training	Post-training	Pre-training	Post-training
Study group	313.26±24.68	165.20±18.48[ab]	18.37±1.11	7.19±0.13[ab]
Traditional group	313.09±25.09	223.09±20.17[a]	18.27±0.82	13.20±1.74[a]
t value	0.043	18.928	0.648	30.808
P value	0.966	<0.001	0.518	<0.001

Note: compared with pre-training, [a] P<0.05; compared with traditional group after training, [b] P<0.05.

2.5 Comparison of vascular endothelial diastolic function before and after training

The rate of change in arterial internal diameter and the rate of change in arterial internal diameter of non-endothelium-dependent vascular diastolic function of the two groups of patients after training were significantly higher compared with that before training, and the study group was significantly higher than the traditional group (P<0.05). **[Table 5]**

Tab.5 Comparison of vascular endothelial diastolic function between two groups before and after training (n=80, %, $\bar{x}$ ±s)

Groups	Rate of change in arterial internal diameter		Rate of change in arterial internal diameter of non-endothelium-dependent vascular diastolic function	
	Pre-training	Post-training	Pre-training	Post-training
Study group	7.89±0.46	11.38±0.85[ab]	11.47±2.16	15.35±1.46[ab]
Traditional group	7.84±0.41	9.17±0.47[a]	11.98±1.45	13.29±1.00[a]
t value	0.726	20.351	1.753	10.412
P value	0.469	<0.001	0.082	<0.001

Note: compared with pre-training, [a] P<0.05; compared with traditional group after training, [b] P<0.05.

2.6 Comparison of carotid artery intima-media thickness before and after training of the two groups

There was no significant difference between the carotid intima-media thickness of the two groups of patients after training compared with that before training, and there was no significant difference between the study group and the traditional group (P>0.05). **[Table 6]**

Tab.6 Comparison of carotid intima-media thickness between two groups before and after training (mm, $\bar{x}$ ±s)

Groups	Case	Pre-training	Post-training
Study group	80	1.34±0.24	1.30±0.11
Traditional group	80	1.33±0.18	1.32±0.18
t value		0.298	0.848
P value		0.766	0.398

3 Discussion

The prevention and treatment of hypertension is a critical research area in cardiovascular medicine and poses a significant challenge due to the aging population. Currently, the prevalence of hypertension in our country is the highest worldwide, and its prevention and treatment need to be solved urgently[14-15]. In terms of

fundamentals, the management of hypertensive patients in the past was based on group training management and lacked individualized training management. Conventional aerobic exercise has some efficacy in reducing patients' recent blood pressure, but the blood pressure lowering effect is often difficult to maintain[16]. In this study, resistance training was given to patients, and the results showed that resistance training could effectively reduce patients' blood pressure and improve their self-management ability. Compared with aerobic exercise, the heart rate response caused by resistance exercise is lower, and it has good application safety. However, resistance exercise needs to be targeted in practical application, and the exercise intensity is the key to evaluating the quantification and scientificization of the exercise program, which ensures the effectiveness of the exercise intensity as well as the safety of the exercise[17-18]. This study uses elastic bands to train patients, simple and easy to implement, not only to ensure the operability of the exercise, but also at the same time for different patients, through a variety of forms of resistance exercise educational activities, to improve the health awareness of the patients, to strengthen the effective supervision of the patients' resistance exercise, to improve the effectiveness of the patients' resistance exercise[19-20].

Primary hypertension is a complex disease with multifactorial effects, and atherosclerosis plays a dominant role in the pathogenesis of primary hypertension. Lp-PLA2 belongs to the phospholipid family of isoforms, with a relative molecular mass of about 4.54×104, containing 441 amino acids, and is secreted and synthesized by macrophages and lymphocytes, and is capable of hydrolyzing oxidized lecithin on low-density lipoproteins, and can also be bound to LDL, thus dynamically reflecting the degree of intravascular inflammation, and is a diagnostic and predictive indicator of high sensitivity and specificity. It can also bind to LDL, thus dynamically reflecting the degree of intravascular inflammation, and is a diagnostic and predictive indicator of atherosclerosis with high sensitivity and specificity[21-22]. Hcy is an important intermediate product in the metabolism of methionine, and is also a cytotoxic sulfur-containing amino acid, and when the metabolic pathway of Hcy is impeded in vivo, it can make the serum level of Hcy rise, causing chronic pathological damage and triggering the onset of hypertension[23]. In this study, we showed that Lp-PLA2 and Hcy levels decreased after resistance training, suggesting that resistance exercise may inhibit Lp-PLA2 and Hcy expression in hypertensive patients. Resistance exercise can increase the level of high-density lipoprotein and promote blood circulation, thus regulating and improving lipid metabolism of patients, effectively lowering the level of blood lipids in patients, thus down-regulating the expression of Lp-PLA2 and Hcy, and promoting the recovery of patients and improving the prognosis of patients[24]. Resistance exercise training can increase vascular compliance in young normotensive subjects, increase vascular compliance in healthy men, and can slow or reduce the progression of atherosclerosis associated with aging.

In addition to elevated blood pressure and atherosclerosis, patients with hypertension often have different degrees of endothelial dysfunction such as decreased endothelial function and changes in the structure of the vascular wall, especially vasospastic contraction of the body can cause vascular endothelial cell ischemia and hypoxia, which can further exacerbate the damage of endothelial cells, triggering weakening endothelium-dependent diastolic response[25-26]. Studies have shown that abnormal endothelial diastolic function is one of the main mechanisms and pathogenic links in the formation of hypertension, and has the effect of promoting the proliferation of vascular smooth muscle cells, which may be an important impact factor leading to hypertensive carotid artery intima-media thickness[27-28]. The results of this study showed that the carotid intima-media thickness was significantly reduced after resistance training, indicating that resistance exercise can improve the endothelial diastolic function and atherosclerosis in hypertensive patients. Resistance exercise can improve cardiopulmonary function, improve and increase muscle strength and cardiac function, increase basal metabolism, help patients to achieve a good level of physical fitness, improve vascular endothelial diastolic function and atherosclerosis, improve immune function, and play a sustained antihypertensive effect[29-30]. Resistance exercise helps to increase muscle mass, contributes to the synthesis and secretion of muscle factors in skeletal muscle, maintains the body's own ability of movement, balance and strength, can promote the exchange of substances between the liver and other organs or cells, and reduces the development of chronic diseases. In addition, this study also compared the carotid artery intima-media thickness before and after training of the two groups, but did not find any difference between the two groups before and after training, and the carotid artery intima-media thickness did not appear to be significantly reduced after training of the two groups, probably due to the fact that atherosclerosis is a slower process, and long-term studies are required to observe more significant changes.

In conclusion, resistance exercise can improve the vascular endothelial diastolic function and atherosclerosis of hypertensive patients, inhibit the expression of Lp-PLA2 and Hcy, play a sustained antihypertensive efficacy, and improve the self-management ability of patients. However, due to economic pressure, the number of cases included in this study is relatively small, which makes the study have limitations and lack of long-term efficacy analysis, which will be further explored and analyzed in the follow-up study, in order to improve new ideas and methods for the prevention and treatment of clinical hypertension.

Conflict of interest None

Reference

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·论　著·

抗阻力运动疗法对高血压病患者血管舒张功能及粥样硬化的作用

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摘要:目的　探讨抗阻力运动疗法对高血压病患者自我管理能力、血管舒张功能与粥样硬化的改善作用。**方法**　将 2019 年 12 月到 2022 年 1 月于国药东风总医院诊治的 160 例高血压患者纳入研究,采用随机数字表法将患者分为研究组(n=80)及传统组(n=80)。传统组在药物治疗的基础上予常规有氧运动训练,研究组在传统组基础上予抗阻力运动训练,两组患者均予干预 3 个月,比较并分析训练前后患者血管舒张功能与粥样硬化变化情况。**结果**　研究组和传统组患者训练后的收缩压及舒张压与训练前对比显著下降(P<0.05),且研究组显著低于传统组(P<0.05)。两组训练后的自我管理能力评分(45.28±3.17, 40.10±2.22)与训练前对比(31.48±3.18, 31.54±2.58)显著升高,且研究组显著高于传统组(t=11.972, P<0.05)。两组患者训练后的血清脂蛋白相关磷脂酶 2(Lp-PLA2)、同型半胱氨酸(Hcy)水平较前显著下降,且研究组显著低于传统组(P<0.05)。两组患者训练后的动脉内径变化率、非内皮依赖性血管舒张功能动脉内径变化率与训练前对比显著升高,且研究组显著高于传统组(P<0.05)。两组患者训练后颈动脉内膜中层厚度与训练前对比差异无统计学意义,且研究组和传统组差异无统计学意义(P>0.05)。**结论**　抗阻力运动可改善高血压患者血管舒张功能与粥样硬化状况,抑制 Lp-PLA2 和 Hcy 的表达,持续降低血压,提高患者的自我管理能力。

关键词：抗阻力运动；高血压；血管舒张功能；粥样硬化；脂蛋白相关磷脂酶 2；同型半胱氨酸

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Effect of resistance exercise on vascular diastolic function and atherosclerosis in patients with hypertension

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Abstract: Objective　To investigate the effect of resistance exercise on self-management ability, vascular diastolic function and atherosclerosis in patients with hypertension. **Methods**　A total of 160 patients with hypertension treated in Sinopharm Dongfeng General Hospital from December 2019 to January 2022 were enrolled in this study. Patients were divided into study group (n=80) and traditional group (n=80) by random number table method. The traditional group was given routine aerobic exercise training based on drug therapy, and the research group was given resistance exercise training based on traditional therapy. Patients in both groups received intervention for 3 months, and the changes of vascular endothelial diastolic function and atherosclerosis were compared and analyzed before and after training. **Results**　After training , the systolic blood pressure and diastolic blood pressure of the two groups decreased significantly compared with those before training (P<0.05), and the study group was significantly lower than the traditional group (P<0.05). The scores of self-management ability (45.28±3.17, 40.10±2.22) in the study group and traditional group were significantly higher than those before training (31.48±3.18, 31.54±2.58); The score of self-

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management ability in study group was significantly lower than that in traditional group (t = 141.972, P<0.05). The serum levels of lipoprotein-associated phospholipase 2 (Lp-PLA2) and homocysteine (Hcy) in two groups decreased significantly compared with those before training (P<0.05), and the levels of serum Lp-PLA2 and Hcy in the study group were significantly higher than those in the traditional group (P<0.05). The change rate of artery diameter and the change rate of artery diameter of endothelium-dependent vasodilation function in the two groups were significantly higher than those before training, and the study group was significantly higher than the traditional group (P<0.05). There was no significant difference in carotid intima-media thickness between the two groups after training and before training, and there was no significant difference between the study group and the traditional group (P>0.05). **Conclusion** Resistance exercise can improve vascular endothelial relaxation function and atherosclerosis status, inhibit the expression of Lp-PLA2 and Hcy, reduce blood pressure continuously, and improve the self-management ability of patients with hypertension.

Keywords: Resistance exercise; Hypertension; Vascular diastolic function; Atherosclerosis; Lipoprotein-associated phospholipase 2; Homocysteine

Fund program: Hubei Provincial Health Commission Research Project Approval (WJ2019F067); Municipal Level Guiding Scientific Research Project in Shiyan City (21Y86); Sinopharm Dongfeng General Hospital Excellence Program (Hospital Project) Youth Talent Project Approval (2022Q01)

高血压无典型临床症状,确诊率较低,常于体检时发现,但是长期血压未得到有效控制,可并发高血压肾病、脑卒中等一系列严重并发症,使患者死亡率及致残率升高,严重影响患者生活质量,给家庭及社会医疗带来巨大负担[1]。通过日常管理有效控制血压,降低高血压相关并发症的发生率,是改善患者预后及降低医疗成本的关键[2-3]。然而高血压的调控是一个漫长过程,长期服药与生活方式的改变,导致一部分患者难以坚持,往往放任疾病发展,诱发心脑血管意外[4]。康复训练在高血压的防控管理中具有重要意义,但实际应用中多以快步走、有氧操、骑车、慢跑等有氧训练为主,具有不中断、节奏性强、强度低、时间长等特点,但有氧训练往往无法提高患者肌肉力量,改变机体的内环境,从而很难持续性的改善患者预后[5-6]。而抗阻力运动是完全依靠患者自身力量克服一定外界阻力的运动,主要包括静力性练习和动力性练习,是增强肌肉力量和耐力的主要手段,阻力可来自他人、专门器械、自身、重力、弹力带等[7]。血管内皮舒张功能异常与粥样硬化在高血压患者中常见,尤其是高血压病患者颈动脉内中膜厚度(carotid intima-media thickness, CIMT)与血管内皮舒张功能间存在相关性,血管内皮舒张功能异常可能是动脉粥样硬化改变发生发展中的重要环节[8-9]。而脂蛋白相关磷脂酶 2(lipoprotein-associated phospholipase 2, Lp-PLA2)及同型半胱氨酸(homocysteine, Hcy)参与心脑血管疾病的发生、发展[10-12]。抗阻力运动能有效调节高血压患者血压水平,但目前关于抗阻力运动与高血压患者血管内皮及粥样硬化间的相关性研究较少。基于此,本研究具体探讨了抗阻力运动对高血压病患者自我管理能力、血管内皮舒张功能与粥样硬化的改善作用,以明确抗阻力运动的应用价值。现将研究结果报道如下。

1　资料与方法

1.1　一般资料　将 2019 年 12 月至 2022 年 1 月于国药东风总医院诊治的 160 例高血压患者纳入研究。纳入标准:(1) 符合原发性高血压的诊断标准;(2) 年龄 20~75 岁;(3) 在社区中居住,具有固定住所;(4) 具有完整的临床资料;(5) 具有抗阻力运动的指征[高血压没有达到危重级(收缩压≥200 mmHg 或舒张压≥125 mmHg),具有正常认知功能,无躯体残疾情况];(6) 小学及以上文化水平。排除标准:(1) 存在认知或精神障碍者;(2) 有严重的其他疾病或并发症而影响运动进行者,依从性不佳者;(3) 妊娠与哺乳期妇女;(4) 继发性高血压者;(5) 需长期卧床者;(6) 生命功能处于晚期者;(7) 肾小球肾炎,主动脉瓣关闭不全患者;(8) 有恶性肿瘤者;(9) 合并其他严重疾病者;(10) 未能坚持整个研究过程者。所有患者均对本试验知情并签署知情同意书,且本研究通过本院伦理委员会审核及批准(LW-2023-036)。

1.2　干预方法　所有患者均予集体健康宣教、定期随访指导、用药指导、饮食指导等,并根据患者个体情况规律予血管紧张素受体拮抗剂、钙离子拮抗剂、血管紧张素转换酶抑制剂、利尿剂等降压药物治疗。

1.2.1　传统组　予常规有氧运动训练,主要为慢跑、

太极拳等,30 min/次,2 次/d。

1.2.2　研究组　在传统组训练的基础上给予抗阻力运动训练,具体措施如下。(1) 成立抗阻力运动训练小组,包括运动康复治疗师 2 名、护理人员 4 名、主治医师 1 名、社区护士 2 名,并对小组成员进行先期培训,使小组成员掌握抗阻力运动的要领及运动时的注意事项。(2) 抗阻力运动:采用弹力带抗阻上肢锻炼方法,训练时间具体时间为上午 9:00—11:00,每个动作 8~16 次为一组,每个练习动作间歇 30~40 s 之间,隔 1~2 日 1 次,每周 3 次。(3) 站姿直臂扩胸:锻炼肌群为背阔肌及其他背部肌肉,患者身体直立,双脚与肩同宽平行站立,抬头挺胸,两手分别握住弹力带一端,吸气时两臂同时经前平举向后拉至侧平举,拳心向外,成挺胸姿势,停顿后呼气还原至起始位。(4) 弹力带打拳:锻炼肌群为上肢肌肉,患者弹力带反放于背部穿过左腋下至左手,起始姿势为右手紧握弹力带,上身保持笔直姿势,左手紧握弹力带另一端。左手紧握弹力带做向前的打拳动作,右手紧握弹力带一端固定不动,完成 30 s 后换右手重复上述动作。(5) 直立臂弯举:锻炼肌群为肱二头肌,患者单脚踩住弹力带中部,双脚与肩同宽平行站立,双手自然下垂并握住弹力带,呼气还原,吸气屈肘。(6) 站姿肩外旋:锻炼肌群为腹内、外斜肌肌群,患者身体直立,两脚开立,与肩同宽,弹力带固定于横杆上缘,屈肘置于胸前,双手拉弹力带使肩缓慢外旋直至最大位置,然后再返回开始位置。两组患者均予训练 3 个月,干预结束后,患者继续规律口服降压药物。

1.3　观察指标

1.3.1　Lp-PLA2、Hcy 水平　所有患者在训练前与训练后抽取静脉血 2~3 mL,低温离心后分离上层血清,采用酶联免疫法检测血清 Lp-PLA2、Hcy 水平。

1.3.2　血压　在训练前后采用电子血压计测定与记录患者的收缩压与舒张压,血压取连续 3 次测量的平均值。

1.3.3　自我管理行为评分　在训练前后采用自我管理行为量表进行评定患者的自我管理能力,包括饮食摄入、认知性症状管理、耐力锻炼、医患交流、体能锻炼等维度,总分为 50 分,分数越高表明自我管理行为越好,量表信效度都在 0.85 以上[4]。

1.3.4　血管内皮舒张功能　在训练前后采用超声测定患者的血管内皮依赖性舒张功能,选择的指标包括动脉内径变化率、非内皮依赖性血管舒张功能动脉内径变化率,可反映血流介导的内皮依赖性血管舒张功能,超声设备购自西门子公司,型号为 721PP 型。

1.3.5　粥样硬化情况　在训练前后也采用超声测定患者的颈动脉内膜中层厚度,左右侧颈动脉各测量 3 次,取平均值即为最终值。

上述所有测定都严格质量控制管理,在各种指标测定中要进行室内与室间质控,调查中确保调查的有效率为 100.0%。

1.4　统计方法　所有数据均采用 SPSS 24.00 软件进行分析。计数资料以百分比表示,组间比较采用 χ^2 检验。符合正态分布的计量资料以 $\bar{x}\pm s$ 表示,组间比较采用独立样本 t 检验,训练前后对比使用配对 t 检验。多时间点比较采用重复测量的方差分析。$P<0.05$ 为差异有统计学意义。

2　结　果

2.1　一般资料对比　将纳入研究的患者采用随机数字表法分为研究组 80 例与传统组 80 例,两组患者的年龄、性别及教育年限等一般资料相比较,差异无统计学意义($P>0.05$)。见表 1。

2.2　两组患者训练前后收缩压与舒张压比较　两组患者训练后的收缩压及舒张压与训练前对比显著下降($P<0.05$),且研究组显著低于传统组($P<0.05$)。见表 2。

2.3　两组患者训练前后自我管理能力评分比较　两组训练后的自我管理能力评分与训练前对比显著升高,且研究组显著高于传统组($P<0.05$)。见表 3。

2.4　两组患者训练前后血清 Lp-PLA2、Hcy 水平比较　两组患者训练后的血清 Lp-PLA2、Hcy 水平较前显著下降,且研究组显著低于传统组($P<0.05$)。见表 4。

2.5　两组患者训练前后血管内皮舒张功能比较　两组患者训练后的动脉内径变化率、非内皮依赖性血管舒张功能动脉内径变化率与训练前对比显著升高,且研究组显著高于传统组($P<0.05$)。见表 5。

2.6　两组患者训练前后颈动脉内膜中层厚度比较　两组患者训练后颈动脉内膜中层厚度与训练前对比差异无统计学意义,且研究组和传统组差异无统计学意义($P>0.05$)。见表 6。

表 1　两组患者一般资料比较　($n=80, \bar{x}\pm s$)

Tab. 1　Comparison of general information between two groups　($n=80, \bar{x}\pm s$)

组别	受教育年限(年)	BMI	病程(月)	性别(男例)	年龄(岁)	高血压(例)[a]
研究组	16.25±1.59	22.82±1.46	9.17±0.15	43	54.19±2.84	33/37/10
传统组	16.33±1.22	22.87±1.22	9.22±0.24	42	54.67±3.18	35/36/9
χ^2/t 值	0.111	0.142	0.132	0.025	0.452	0.125
P 值	0.904	0.862	0.878	0.874	0.614	0.939

注:BMI 为体质量指数;[a] 为按参考文献[12]分为 1 级、2 级、3 级。

表 2　两组训练前后收缩压与舒张压变化对比　（mmHg, $\bar{x}\pm s$）

Tab. 2　Comparison of changes in systolic and diastolic blood pressure between two groups before and after training　（mmHg, $\bar{x}\pm s$）

组别	例数	收缩压		舒张压	
		训练前	训练后	训练前	训练后
研究组	80	154.22±4.85	124.59±10.78[ab]	98.28±3.38	72.57±3.18[ab]
传统组	80	154.09±9.18	134.09±11.15[a]	98.43±3.34	78.47±4.68[a]
t 值		0.118	5.479	0.294	9.327
P 值		0.819	<0.001	0.712	<0.001

注：与本组训练前对比，[a]*P*<0.05；与传统组训练后对比，[b]*P*<0.05。

表 3　两组患者训练前后自我管理能力评分比较　（$\bar{x}\pm s$）

Tab. 3　Comparison of self-management ability scores between two groups before and after training　（$\bar{x}\pm s$）

组别	例数	训练前	训练后
研究组	80	31.48±3.18	45.28±3.17[ab]
传统组	80	31.54±2.58	40.10±2.22[a]
t 值		0.131	11.972
P 值		0.896	<0.001

注：与本组训练前对比，[a]*P*<0.05；与传统组训练后对比，[b]*P*<0.05。

表 4　两组患者训练前后血清 Lp-PLA2、Hcy 水平比较　（$\bar{x}\pm s$）

Tab. 4　Comparison of serum Lp-PLA2 and Hcy levels between two groups before and after training　（$\bar{x}\pm s$）

组别	例数	Lp-PLA2（μg/L）		Hcy（μmol/L）	
		训练前	训练后	训练前	训练后
研究组	80	313.26±24.68	165.20±18.48[ab]	18.37±1.11	7.19±0.13[ab]
传统组	80	313.09±25.09	223.09±20.17[a]	18.27±0.82	13.20±1.74[a]
t 值		0.043	18.928	0.648	30.808
P 值		0.966	<0.001	0.518	<0.001

注：与训练前对比，[a]*P*<0.05；训练后与传统组对比，[b]*P*<0.05。

表 5　两组患者训练前后血管内皮舒张功能比较　（%，$\bar{x}\pm s$）

Tab. 5　Comparison of vascular endothelial diastolic function between two groups before and after training　（%，$\bar{x}\pm s$）

组别	例数	动脉内径变化率		非内皮依赖性血管舒张功能动脉内径变化率	
		训练前	训练后	训练前	训练后
研究组	80	7.89±0.46	11.38±0.85[ab]	11.47±2.16	15.35±1.46[ab]
传统组	80	7.84±0.41	9.17±0.47[a]	11.98±1.45	13.29±1.00[a]
t 值		0.726	20.351	1.753	10.412
P 值		0.469	<0.001	0.082	<0.001

注：与训练前对比，[a]*P*<0.05；训练后与传统组对比，[b]*P*<0.05。

表 6　两组患者训练前后颈动脉内膜中层厚度比较　（mm, $\bar{x}\pm s$）

Tab. 6　Comparison of carotid intima-media thickness between two groups before and after training　（mm, $\bar{x}\pm s$）

组别	例数	训练前	训练后
研究组	80	1.34±0.24	1.30±0.11
传统组	80	1.33±0.18	1.32±0.18
t 值		0.298	0.848
P 值		0.766	0.398

3　讨　论

目前我国高血压患者的数量居世界首位，其防治问题亟需解决[14-15]。既往高血压患者的管理，均以群体训练管理为主，缺乏个体化训练管理。常规的有氧运动对降低患者近期血压具有一定疗效，但降压效果往往难以维持[16]。本研究给予患者抗阻力训练，结果显示抗阻力训练能有效降低患者血压，提高自我管理能力。与有氧运动相比，抗阻力运动引起的心率反应较低，具有很好的应用安全性，但抗阻力运动在实际应用中需有针对性，运动强度为评价运动方案量化及科学化的关键，既要保证运动强度的有效性，又要保证运动的安全性[17-18]。本研究采用弹力带对患者进行训练，简便易行，既可保证锻炼的可操作性，又可同时针对不同的患者，通过形式多样的抗阻力运动宣教活动，提高患者健康意识，加强对患者抗阻力运动的有效监督，提高患者的抗阻力运动效果[19-20]。

原发性高血压为多因素综合影响的复杂疾病，动脉粥样硬化在原发性高血压的发病中起着主导作用。Lp-PLA2 属于磷脂家族亚型，含有 441 个氨基酸，由巨噬细胞和淋巴细胞分泌合成，能水解低密度脂蛋白上的氧化卵磷脂，还可与低密度脂蛋白结合，从而动态反映血管内炎症的程度，是动脉粥样硬化的诊断及预测指标，具有较高的灵敏度和特异度[21-22]。Hcy 是蛋氨酸代谢过程中的重要中间产物，也是一种具有细胞毒性的含硫氨基酸，当 Hcy 在体内代谢途径受阻时，血清 Hcy 水平升高，引起慢性病理损害，诱发高血压发生[23]。本研究显示给予患者抗阻力训练后患者的 Lp-PLA2 和 Hcy 水平降低，提示抗阻力运动可能抑制了高血压患者的 Lp-PLA2 和 Hcy 表达。抗阻力运动能够使高密度脂蛋白水平升高，起到促进血液循环的作用，从而调节及改善患者的血脂代谢，有效降低患者的血脂水平，从而下调 Lp-PLA2 和 Hcy 的表达，促进患者康复及改善患者预后[24]。抗阻力运动训练可以增加年轻正常血压受试者的血管顺应性，增加健康男性体内的血管顺应性，可以减缓或减轻与衰老相关的动脉硬化进展。

除血压升高及动脉粥样硬化外，高血压患者往往存在不同程度的内皮功能下降及血管壁结构变化等内皮细胞功能障碍，尤其是机体的血管痉挛收缩可引起血管内皮细胞缺血、缺氧，进一步加重内皮细胞损伤，引发内皮依赖性舒张反应减弱[25-26]。研究显示血管内皮舒张功能异常是高血压形成的主要机制和发病环节之一，具有促进血管平滑肌细胞增殖作用，可能是高血压颈动脉内膜中层厚度增厚的重要影响因子[27-28]。本研究结果显示给予患者抗阻力训练后，患者颈动脉内膜中层厚度显著降低，表明抗阻力运动可改善高血

压病患者的血管内皮舒张功能及粥样硬化情况。抗阻力运动能够提高患者的心肺功能,改善并增加患者肌肉力量与心脏功能,提高患者基础代谢,协助患者达到良好的体态水平,改善血管内皮舒张功能与粥样硬化状况,提高免疫功能,发挥持续降压的功效[29-30]。抗阻力运动有助于增加肌肉质量,有助于骨骼肌合成,维持机体自身的运动、平衡、力量能力,可促进肝脏与其他器官或细胞间进行物质交流,降低慢性疾病的发生。此外,本研究还对比了两组训练前后的颈动脉内膜中层厚度,但并未发现两组训练前后存在差异,且两组训练后颈动脉内膜中层厚度未出现显著降低,可能是由于动脉粥样硬化是一个较为缓慢的过程,需要长期研究才可能观察到较为显著的变化。

综上,抗阻力运动可改善高血压患者的血管内皮舒张功能与粥样硬化状况,抑制 Lp-PLA2 和 Hcy 表达,发挥持续降压功效,并能提高患者的自我管理能力。但由于经费限制,本次研究的纳入的病例数相对较少,研究具有一定局限性,且缺乏远期疗效分析,将在后续研究中进一步深入探讨分析,以便为临床高血压的防治,提高新思路及新方法。

利益冲突　无

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(上接第 838 页)

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