

## Aerobic Exercise and Hemorheology

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**Abstract:** Hemorheology is an important factor of normal blood flow. Decreased physical function or diseases will cause abnormal hemorheology. Aerobic exercise can optimize the indicators of hemorheology, prevent complications, improve quality of life. This article reviewed the effects of aerobic exercise on the hemorheology in ill population and middle-aged and older population, aimed to analyze the relationship between aerobic exercise and hemorheology, and provided reference for investigation in this field.

**Keywords:** Aerobic exercise, Hemorheology, Middle-aged and older population.

### 1. INTRODUCTION

Aerobic exercise is referred to the exercise of more than 40 min with sufficient oxygen, with the heart rate accounting for 60-80 % of the maximum heart rate. Aerobic exercise can increase cardiopulmonary endurance and oxygen uptake, and promote the generation of collateral circulation to recover damaged organs.

Usually, Tai Chi, swimming, gymnastics and rehabilitation training are aerobic exercise. Anaerobic exercise is referred to the situation that oxygen uptake cannot meet the demand of exercise, and the body is in hypoxia.

In 1950s, Copley first presented "hemorheology" as "the study in the components in blood and the flow characteristic of blood". Currently, hemorheology is referred to the study in blood circulation, component flow and deformability. Blood circulation is indispensable for life. Blood transports nutrient to tissues and organs. Under fixed blood pressure and vascular volume, blood flow is mainly regulated by hemorheology. Increased blood viscosity is associated with blood circulation disorder, increased circulatory resistance and slow blood flow, and finally, decreased blood input in tissues and organs, leading to metabolic disorder caused by ischemia and hypoxia in tissues and organs. Abnormal hemorheology is the basis of thrombus, edema and inflammation, and usually occurs in sub-health status. Therefore, most

investigators consider hemorheology as a indicator of sub-health.

Hemorheology includes whole blood viscosity (BVH, BVL), erythrocyte aggregation (EA), plasma specific viscosity (PV), red blood cell (RBC) and platelet electrophoresis time (s), whole blood reduced viscosity (BVH, BVL), erythrocyte sedimentation rate (ESR), hematocrit (HCT), red blood cell deformability (TK), fibrinogen (FIB) and red blood cell hardness (IK), BVH, BVL, PV, EA and TK are main indicators. BVH is predominantly attributed to TK, higher BVH, weak TK and RBC elasticity, abnormal vascular wall. BVL is dependent on EA, BVH and BVL. Plasma viscosity is closely associated with plasma proteins, especially FIB. EA can reflect erythrocyte aggregation objectively.

Abnormal hemorheology will cause impairment of blood circulation. Blood viscosity can influence blood circulation or blood perfusion volume directly. Increased blood viscosity and circulatory impairment as well as slow blood flow will decrease the blood flow in organs and tissues, especially microcirculation perfusion, cause insufficient blood and oxygen, leading to decreased tissue function and finally diseases, such as hypertension, coronary heart disease, diabetes, peripheral vascular disease and anxiety, although there are many predisposing factors, these disease are closely related to abnormal blood viscosity.

## 2. EXERCISE AND HEMORHEOLOGY

### 2.1. The Effect of Aerobic Exercise on the Hemorheology of Patients

#### 2.1.1. *The Effect of Aerobic Exercise on the Hemorheology of Patients with Cerebral Infarction*

The blood supply in patients with cerebral infarction is obstructed, causing insufficient supply of blood and oxygen, which will result in necrosis and damage to relevant neurological function. The morbidity accounts 3/4 of cerebrovascular diseases with a high mortality. More than half recovered patients will have disability to some degree, particularly hemiplegia. Clinical and experimental studies showed abnormal hemorheology was a predisposing cause of cerebral infarction.

Zhen Jun, et al performed intervention of aerobic exercise (5 times/week, for 4 weeks) in 80 patients with cerebral infarction, measurement of hemorheology showed significantly improvement of BVH, BVL and PV in each group. Li Dan, et al performed intervention of aerobic exercise (3 months) in 60 patients with cerebral infarction and found decreased BV and TK in all patients, meanwhile, they suggested that exercise could improve blood flow, decrease the risk of recurrent cerebral infarction and improve quality of life.

Zhou Hua, et al investigated the hemorheology of 80 patients with cerebral infarction and found that the peak velocity and mean blood flow velocity were significantly improved in the 14-day exercise group. Rehabilitation exercise can increase the blood circulation in patients with cerebral infarction and prevent lower limb thrombosis. Exercise can increase blood flow, accelerate blood flow velocity, increase vascular shear force, promote the production of NO and optimize vascular function. Long-time exercise can effectively prevent arteriosclerosis.

Aerobic exercise is important for the recovery of activities of patients with cerebral infarction and can significantly increase the hemorheology. Aerobic exercise can decrease blood viscosity, increase blood supply to the brain, promote cerebral metabolism, prevent the risk of recurrent cerebral infarction and improve the prognosis. Rehabilitation training can not only increase limb movement abilities to the most extent, but also optimize hemorheology

parameters and decrease the possibility of relapse of cerebral infarction.

#### 2.1.2. *The Effect of Aerobic Exercise on the Hemorheology of Patients with Diabetes*

Diabetes is a common disease and induced by deficiency of insulin due to islet B cell damage. Generally, hemorheology will change, such as increased blood viscosity, increased ESR, HCT, FIB and EA. These measurements will increase regardless of body shape. Aerobic exercise can increase oxygen consumption, promote metabolism and affect the hemorheology of diabetes patients.

Lin Hua, et al measured the hemorheology of 74 patients with type 2 diabetes, and found the BVL and FIB was significantly decreased, and the TK was significantly increased in the exercise group after 1.5 months of exercise. Zheng Xiajing measured the hemorheology of 40 diabetes patients, and found that the BV and HCT in the exercise group after 6 weeks of treadmill exercise were significantly lower than those before therapy [1]. TK was significantly increased, and this was basically consistent with Lin Hua's study.

Aerobic exercise can accelerate the generation of RBC, decrease the aging of RBC, increase new RBC and TK. Simmonds, et al performed the intervention of medium-load treadmill exercise for 18 weeks in 18 patients with type 2 diabetes, and the hemorheology showed that aerobic exercise improved the concentration of FIB and plasma [2]. They also demonstrated that the hemorheology and health of elderly women with type 2 diabetes had been improved after routine walking for 12 weeks [3]; EA was significantly decreased, indicating that exercise had changed the intrinsic properties of RBC and decreased EA.

These studies provided scientific evidences for the development of exercise for elderly patients with type 2 diabetes. With increasing risk of cardiovascular diseases, aerobic exercise can enhance anti-inflammation and prevent arteriosclerosis, this will affect the blood flow and hemorheology significantly.

#### 2.1.3. *The Effect of Aerobic Exercise on the Hemorheology of Patients with Hypertension*

The pathogenesis of hypertension is complex. Hypertension patients usually have dizziness, vomiting, fatigue and headache, and the blood of hypertension patients will have some

concentration, viscosity, aggregation and coagulation, this will affect systemic blood circulation, especially microcirculatory disturbance. Therefore, the diagnosis and treatment of hypertension is not only dependent on blood pressure control, but also protecting the vascular endothelial function and decreasing the incidence of complications in hypertension patients.

From the view of hemorheology, the change of viscous shear stress and flow rate is the fundamental cause of hypertension. The change of BV can affect peripheral resistance and further blood pressure, while EA affects BVL and deformability affects BVH.

Kilic-Erkek performed the intervention of medium-intensity swimming in hypertension rats (SHR) and found that swimming could decrease the EA of SHR [4]. Liu Tao, et al measured the hemorheology in 90 hypertension patients and found that Tai Chi for 6 months could significantly decrease BVH, BVL, PV, ESR, HCT and EA [5]. Wang Lei, et al divided 60 hypertension patients into 3 groups and performed intervention of walking, the hemorheology was changed, the BVH, BVL, PV and HCT were significantly improved in the exercise group [6]. The intermittent exercise group had more significant improvement. Coppola L obtained similar conclusion in his study. SZU-LING CHOU, et al suggested that cyclic intermittent aerobic exercise could effectively relieve the trend of increasing EA and decreasing deformability [7]. Feng Hong found the BVH, BVL, PV, ESR and HCT were not significantly changed in middle-aged and older hypertension patients after one-time intermittent aerobic exercise. As the exercise intensity was low, there was less sweat and no dehydration.

### **2.2. The Effect of Aerobic Exercise on the Hemorheology of Middle-Aged and Older Patients**

China has entered aging society. Increased cholesterol in food, the lack of exercise and abnormal lifestyle result in increasing incidence of hypertension and coronary heart disease, pose a threat to national health. The damage of hemorheology in the elderly has definite clinical manifestations, including increased BVH, BVL and PV, injured TK and increased EA. Because of the pro-inflammatory state in the elderly, the concentration of BIF is usually increased, this

finding could explain higher plasma viscosity and RBC aggregation in elderly subjects [8].

High blood viscosity will impact the microcirculation and normal physiological functions, or even cause cardio-cerebrovascular diseases, such as hypertension and cerebral thrombosis. Decreased blood viscosity is beneficial to the health of the elderly, can increase blood flow, enhance metabolism, decrease the aging of tissue cells, thus whole blood viscosity is an important indicator of blood viscosity.

Dan Sun observe the hemorheology measurements of 60 middle-aged and older persons with winter swimming, and found that the HCT, FIB, whole blood viscosity and ESR were significantly decreased in the exercise group. Stratton J R, et al demonstrated that 6-month aerobic exercise could improve aerobic exercise ability and decrease the concentration of plasma FIB in elderly male by 13%, and frequent exercise could improve PV, BVH and BVL. Yao Binbin observed the hemorheology measurements of 60 elderly persons after 18-week Tai Chi, and found that Tai Chi could decrease the BVH, BVL, PV and HCT in middle-aged and older persons [9].

Aerobic exercise can activate the antioxidantase, remove excessive free radicals generated during exercise, increase RBC fluidity and deformability, and accelerate the remove of aging RBC. Newly generated RBC can replace aging RBC, decrease RBC rigidity and increase RBC elasticity. Increased TK and decreased blood volume will decrease HCT, both will decrease BVH and BVL and improve hemorheology. Zhang Xinyu measured the hemorheology of 74 middle-aged and older persons after 24 weeks of aerobic dancing, and found that aerobic dancing could improve aerobic exercise ability, increase blood volume, enhance TK and decrease BVH and BVL. Keeping exercise could increase PV and RBC volume, promote microcirculation, improve hemorheology and maintain the blood supply in tissues and organs. Ren Chaoxue, et al obtained similar conclusion [10]. In his study, the 30 middle-aged and older persons in the exercise group took dancing exercise for 6 months. The observation of hemorheology showed 6-month Fitness Qigong and dancing could decrease the blood viscosity and improve hemorheology in middle-aged and older persons.

### 3. CONCLUSION

Aerobic exercise can effectively prevent and relieve vascular diseases and metabolic diseases through regulating the indicators of hemorheology. Decreased blood viscosity is beneficial to blood perfusion into tissues and muscles, and can optimize microcirculation, enhance the capacity of carrying oxygen and nutrient delivery in blood. It can also promote the excretion of metabolic waste and promote body health. Long-time aerobic exercise, such as jogging, swimming, brisk walking and Tai Chi can make people comfortable. With decreased metabolism in organs, the elderly usually have fatigue and loss of appetite. Keep aerobic exercise can enhance the activities of tissues and cells, and improve physical conditions.

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