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Exercise and Lymphatic System

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Abstract

The human body has two main circulatory systems, the blood and lymphatic systems. Although both systems share many functional, structural and anatomical similarities, the two vascular systems have many differences in science and medicine. Although the blood vascular system has been studied extensively and extensively for a long time, the lymphatic system has been seen as secondary to the blood vascular system and has been considered less important. Although studies in this area have increased, the lymphatic system has not been a physiological system that has received great attention in the sports medicine literature, and misinformation has been derived and comments have been made about this area. The aim of this study was to reveal the effects of exercise on the lymphatic system and to explain its possible mechanisms of action.

Key words: Exercise ,Lymphatic system, Lymph node.

Özet

Egzersiz ve Lenfatik Sistem

İnsan vücudunun iki ana dolaşım sistemi vardır bunlar kan ve lenfatik sistemlerdir. Her iki sistem birçok işlevsel, yapısal ve anatomik benzerliği paylaşmış olmasına rağmen, iki vasküler sistemin bilim ve tıpta çok farklılıkları vardır. Kan vasküler sistemi uzun süre yoğun ve kapsamlı bir şekilde çalışılmış olsa da buna karşın lenfatik sistem kan vasküler sistemine ikincil olarak görülmüş, daha az önemli olarak kabul edilmiştir. Her ne kadar bu alanda çalışmalar artsa da, egzersizle ilgili olarak lenfatik sistem, spor tıbbı literatüründe büyük ilgi gören bir fizyolojik sistem olmamıştır ve bu alanla ilgili yanlış bilgiler türeyip, yorumlar yapılmıştır. Bu çalışmanın amacı egzersizin lenfatik sistem üzerine etkilerini ortaya koymak ve olası etki mekanizmalarını açıklamaktır.

Anahtar kelimler: Egzersiz, Lenfatik sistem, Lenf nodu.

INTRODUCTION

Lymphatic System

The lymphatic system consists of lymphatic tissue and lymphatic vessels. lymphatic tissue; It is a type of connective tissue containing a large number of lymphocytes and has a fundamental role in the immunological defense of the body against bacteria and viruses. It recovers excess tissue fluid through numerous microscopic vessels called lymphatic capillaries that penetrate almost all of the body's tissues (13).

Our environment is filled with countless pathogens bacteria, viruses, fungi, and other microbes that can cause disease. One of our defenses against these is the lymphatic system, a network of tissues, organs, and vessels that recover tissue fluid, clearing pathogens, activating immune responses, and returning fluid to the bloodstream. The components of the system include (a) lymph, the fluid that is collected from the tissues and returned to the bloodstream; (b) lymphatic vessels (also called mere lymphatics) that resemble veins and carry lymph; (c) lymphatic tissue consisting of deposits of lymphocytes in the connective tissues of various

organs such as the digestive and respiratory tracts; and (d) lymphatic organs, structures enclosed in a fibrous capsule and containing masses of organized lymphatic tissue (17).

The lymphatic system has three functions

Fluid recovery: The fluid constantly leaks from the blood capillaries into the tissue spaces. The blood capillaries absorb about %85 of this fluid, and the lymphatic system absorbs the other 15%. Without the lymphatic system, this %15 would lose 2 to 4 liters of water per day and a protein of up to one and a half times that of blood plasma. This individual will die quickly from the loss of blood volume and circulatory failure (13).

Immunity: Fluid recovered from body tissues is checked by the lymphatic system for toxins, microbes and other threats. The lymphatic system also maintains the openings of the digestive, respiratory and other pathways. When disease agents are detected, the immune cells of the lymphatic system are quickly mobilized to fight (13).

Lipid absorption: Special lymph vessels in the small intestine absorb dietary lipids. The lipids travel along the lymphatic vessels that eventually empty into the great left subclavian vein. From here, the bloodstream can distribute these lipids to the body for storage or immediate use (13).

Unlike blood capillaries, lymph capillaries have a wall structure that allows the passage of proteins and large molecular particles. The lymphatic capillaries are located close to the blood capillaries and are responsible for drawing the substances that leak out of the blood vessels into the lymphatic circulation (9). This fluid that enters the lymphatic vessels is called lymph. The protein content of lymph is 7gr/dl; this amount is usually lower than the plasma protein level. However, the amount of protein contained in the lymph may vary depending on the region it drains. Lymph is transported from the lymph nodes to the lymphatic trunks. The overlapping edges of endothelial cells act as valves that open and close due to pressure in the surrounding tissue fluid (17). Whenever the tissue fluid pressure is high, the flaps are pushed inward (open) and the fluid enters the lymph vessel. If the withdrawal of fluids from the spaces in the tissues into the lymphatic vessels is reduced, swelling may result due to fluid accumulation. Lymphatic capillaries join to form fine collecting vessels. These make up six lymphatic trunks, each of which drains a large part of the body. For example, the lumbar trunks drain the lumbar region and lower extremities. All lymphatic trunks merge to form only two collecting ducts, the largest lymph vessels. In total, the body has 600 to 700 lymph nodes, with the largest grouping found in the head and neck, around the intestines, axilla, and groin. As the lymph is transported through the lymphatic network, it travels through the lymph nodes where an immune response can be initiated if foreign matter is detected. Immune competent cells that follow the same pathway then return to the bloodstream (11, 13).

Features of Circulatory System and Lymphatic System

The lymphatic system is a linear network of lymphatic vessels and secondary lymphoid organs. Macroscopically, the blood vascular system is literally a circular system through which fluid (blood) leaves the heart; passes through arteries, arterioles, capillary plexus, venules and veins; and returns to the heart. In contrast, the lymphatic system consists of an extensive network of lymphatic vessels (lymphatics) that run from the head to the end of the body. This one-way transport system is a key component in maintaining normal interstitial fluid volume and protein concentration. Lymphatics transport fluid and protein against a central hydrostatic pressure gradient and against a protein concentration gradient. Lymphatic vessels also play out specific regional roles, such as the transport of fatty acids and cholesterol absorbed in the small intestinal mucosa (2,3,10). There are serious differences between circulatory vessels and lymph vessels. For example, lymph vessels are wider than blood vessels. n addition, the fluid in these vessels circulates in a narrower space, not throughout the body. In the cardiovascular system, blood is pumped from the main center and spreads throughout the body. Such a system is not used in lymph circulation (13).

Features	Blood Vessel	Lymphatic Vessel
Components	Blood, blood cells	Lymph (interstitial fluid rich in protein, fat and lipids, extra-mediated immune cells and large extracellular molecules)
Structures	Closed, circular	Open, linear
start/end locations	Heart/heart	Tissue/lymph vein connection of thoracic duct
Parts	Arteries, capillaries, venules, veins	Capillaries, anterior collectors, collecting vessels, thoracic duct, lymph nodes
Vascular Walls	Tight junctions, continuous basement membrane, pericytes or vascular smooth muscle cells	Overlapping lymphatic endothelial cells, non-tight junctions, discontinuous basement membrane, few pericytes (aggregation of lymphatic vessels has both continuous and wall cells).
Functions	Hemostasis, inflammation, leukocyte transport. barrier function. distribution for oxygen, nutrients and tissue waste.	Tissue fluid homeostasis, absorption of large molecules and lipids in the digestive tracts, transport of lymphocytes and antigen presenting cells to regional lymph nodes. transport of impaired extracellular molecules, cell debris, and lymphatic fluid

Comparison of Blood Vascular Endothelial Cells and Lymphatic Endothelial Cells (5)

Figure 1. Comparison of Blood Vascular Endothelial Cells and Lymphatic Endothelial Cells

Endothelial cells are attached to the surrounding tissue by protein filaments that protect the sac from collapsing. Unlike the endothelium of blood capillaries, the cells are not joined by tight junctions, but have large spaces between them for the passage of proteins, bacteria, and white blood cells. The movement of the skeletal muscles together with the muscles and valves in the structure of the lymphatic vessels provides circulation. The change in fluid pressure is also a driving force for lymph circulation. The fluid flow rate in the lymph vessels is about 100-500 times less than the blood flow rate (16).

After lymph formation, lymph begins to be drawn from the lymph capillaries towards the lymph collecting lymphatics. Since lymphatic vessels do not have a central pump like the circulatory system, their one-way valves prevent backward flow while supporting lymph transport. Collecting lymphatic vessels can be called prenodal or postnodal (afferent and efferent) (16)

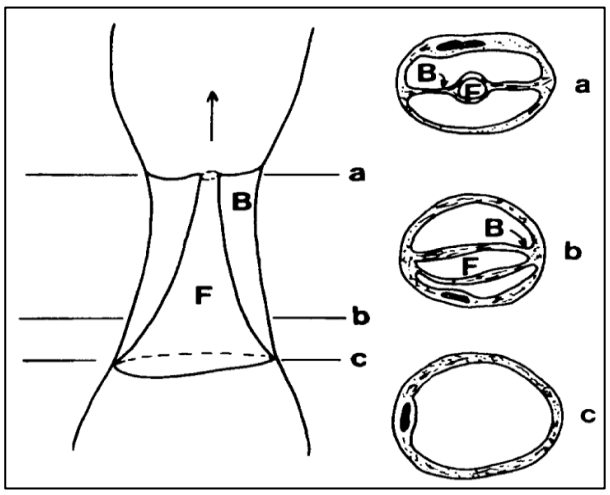

Figure 2. Lymphatic Valve System (16).

Lymph Nodes

Lymph nodes; They are small bean-shaped formations formed from lymph tissue. All collecting lymphatic vessels pass through these lymph nodes, which are capsular and arranged in clusters throughout the lymphatic system. There are hundreds of lymph nodes in the adult human body and vary in diameter from 1 to 10 mm. Lymph nodes act as filters and reservoirs. In addition, lymph nodes act as an incubator where white blood cells (sometimes tumor cells) proliferate while in the lymph nodes and reach the endothelial veins via blood. Also, the white cells in the nodes digest and destroy foreign and harmful molecules and particles. This contributes to lymph node protein dilution with fluid exchange with lymphatic vessels (1, 15).

Lymphatic System In Exercise

The main role of the lymphatic system during exercise is to reintroduce leaked fluids and plasma proteins into the cardiovascular system. Approximately 2-3 litres of fluid is returned to the blood by the lymphatics over a 24-hour period. Since the lymphatic vessels are the only way to return fluids and plasma proteins to the blood, it is unthinkable for the cardiovascular system to continue without the lymphatic system (12). Studies on lymphatic formation and transport of exercise have been studied directly on animals using cannulation of the lymphatic duct. In a study on sheep, an increase in the contraction of lymphatic vessels was observed after a short walk (approximately eight steps) and the flow rate in the lymphatic vessels doubled. 1-5 minutes after the start of the movement, the flow rate decreased to the

levels before the start of walking (14). Movement is known to increase lymph formation, but it is thought that this interaction is not directly due to the acceleration of lymph flow (14).

Coates et al. (6) examined how the lymphatic system in the hind legs of a sheep was affected after 2 hours of exercise. At the beginning of the exercise, the 15-minute constant exercise lymph flow rate increased 5 times compared to the resting flow. It was then gradually decreased and stabilized to 130% of the initial flow rate over a 30 minutes period. It is thought that the reason for the great increase in lymph flow rate is the increase in pressure in the working muscles and the lymphatic mobility caused by the increased sympathetic system. The combination of a larger vascular surface area and higher hydrostatic pressure likely contributed to the steady-state lymph flow values observed at 90–120 min of exercise (6).

Few studies have been conducted to examine the role of the lymphatic system in exercise. Havas et al. (8) investigated the effect of dynamic and isometric muscle contraction on lymph flow using lymphoscintigraphy. Lymph clearance (clearance of lymph from plasma per unit time) was measured in the legs of four sedentary men and four endurance-trained men (each leg was counted as an independent observation; therefore, n = 8 per group). In the study, different exercise models were applied as 100 repetitions at 65-minute intervals. The first of the exercise models are dynamic knee extension, and the other is isometric knee flexion and extension. The highest lymphatic flow in the study was found to be significantly higher in dynamic and isokinetic exercises. In addition, the lymphatic system clearance rate was found to be twice as high in those who had endurance training during the 65-minute rest break. The possible reason for this is the increased density of capillaries that adapt to long-term endurance training. The increase in capillary density provides a large surface area for vessel conduction and capillary filtration. If only the high capillary density had increased the rate of lymph clearance, the difference in rest would have been expected to occur in exercise. However, there was no significant difference between the groups in terms of lymph clearance during exercise. In addition, the fact that the rates in the first part of the 10-15 minute exercises (6, 7). increase 5 times and then go down to the stadium-stay and still 2-3 times more are not associated with the training level of the individuals.

Havas et al. (7) used lymphoscintigraphy to follow the lymph flow dynamics of the lower extremity for 2 hours at the steady-state level at 70% of the heartbeat. Similar to the results of this study, Coates et al. (6) increased the lymph clearance 5 times in the first 15 minutes of the exercise and the lymph clearance remained constant at 2-3 times the rest of the 2-hour load. Arterial pressure and cardiac outputs were significantly increased in the applied studies, resulting in higher capillary filtration in these factors. Increased capillary filtration may have caused an increase in interstitial pressure, which may have led to the entry of fluids and proteins in the interstitial space into lymph capillaries (4). In addition to these factors, it is known that internal and external factors affect the lymphatic velocity through lymphatic vessels (13).

CONCLUSION

To summarize the role of the lymphatic system in exercise, studies have found differences between exercise and rest. However, to the authors knowledge ,there are no studies comparing the effects of the lymphatic system in exercise according to gender or age factors. The studies are generally done in the lower body, so it is not clear what kind of lymph clearance the studies to be done in the upper body will cause. It is stated that the functioning of the lymphatic system is not clear according to important training elements such as the intensity and length of the exercise. Studies have examined the lymphatic systems of individuals doing endurance training, but it is not clear how it will differ according to other types of training. In the future studies, different exercise models and intensity can be examined in terms of lymphatic system.

Conflicts of Interest

The authors declare no conflict of interest.

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