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Functional Features Of The Blood System Under Conditions Of Regular Muscle Loads.

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ABSTRACT

The internal environment of the body is represented by tissue fluid, lymph and blood. Their composition and properties are closely related. The blood, coming into contact directly with the endocardium and the vascular endothelium, ensures their vital activity, it transports nutrients and oxygen to all organs and tissues without exception. Hormones and various biologically active compounds are transported through the vascular wall into the bloodstream. Between the blood and the tissue fluid there is a constant metabolism and transport of water, carrying the metabolic products, hormones, gases, and biologically active substances dissolved in it. The internal environment of the body is a single system of humoral transport, including general circulation and movement in a sequential chain: blood - tissue fluid - tissue - tissue fluid - lymph - blood. Regular active muscular work leads to significant changes in the physico-chemical and physiological properties of blood. At the same time, the volume of circulating blood decreases slightly, the number of formed elements increases, the buffer and colloid-osmotic properties of the blood change, the activity of the coagulation and anticoagulation systems increases. As a result of performing muscular activity, part of the plasma through the walls of the capillaries leaves the vascular bed into the intercellular space of the working muscles. As a result, the volume of circulating blood may decrease. The changes in the blood occurring against the background of muscular activity, as a rule, are adaptive in nature and are aimed at maintaining the vital activity of the organism.

Keywords: hematopoiesis, bone marrow, physical activity, sport, muscular activity.

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INTRODUCTION

The study of the manifestations of the human body in different conditions of existence is of great importance for the comprehension of its biological and social activity [1, 2, 3]. The internal environment of the body is represented by tissue fluid, lymph and blood [4]. Their composition and properties are closely related [5]. The blood, coming into contact directly with the endocardium and the vascular endothelium, ensures their vital activity, it transports nutrients and oxygen to all organs and tissues [6, 7]. Hormones and various biologically active compounds are transported through the vascular wall into the bloodstream [8].

Between the blood and the tissue fluid there is a constant metabolism and transport of water, carrying the metabolic products, hormones, gases, and biologically active substances dissolved in it. Consequently, the internal environment of the body is a single system of humoral transport, including general circulation and movement in a sequential chain: blood - tissue fluid - tissue - tissue fluid - lymph - blood [9].

It has been observed that the state of the blood largely depends on many internal and external factors, among which physical activity is prominent. It is known that muscular activity accompanies all processes of human existence at all its life stages. In this regard, the goal was set in the work: to consider the main changes in the blood formation process against the background of regular muscular activity [10].

Active muscular work leads to significant changes in the physico-chemical and physiological properties of blood. At the same time, its volume slightly decreases during circulation, the number of formed elements increases in it, its buffer and colloid-osmotic properties change, and the activity of coagulation and anticoagulation systems increases [11].

During muscular work, part of the plasma passes through the capillary walls from the vascular bed into the intercellular space of the working muscles. As a result, the volume of circulating blood decreases. Since the formed elements remain in the vascular bed, the ratio between the total volume of the circulating plasma and the formed elements changes so that the hematocrit rises. This phenomenon is called working hemoconcentration [12].

For example, if the volume of blood at rest is equal to 5.5 liters, of which 2.9 liters is plasma and 2.6 liters are formed blood cells, which corresponds to a hematocrit of 47%. During operation, approximately 500 ml of plasma is removed from the vessels, the volume of circulating blood is reduced to 5 liters. Since the volume of blood cells does not change, the hematocrit increases to 52% [13].

Under conditions of rest, lactic acid enters the blood mainly from red blood cells and from the intestinal mucosa. The main organs of the body, utilizing lactic acid from the blood, are the liver, heart and muscles. In the liver, lactic acid is oxidized or used to synthesize glycogen, and in the heart and inactive muscles it serves as an oxidation substrate for their energy supply [14,15].

At the beginning of work, regardless of its power, the formation of lactic acid in the working muscles is enhanced. This is due to the relatively slow deployment of oxidative processes in muscle cells and their inadequate supply of oxygen, since oxygen transport systems (respiration, blood circulation) are not able to quickly increase their activity. By entering the blood, lactic acid shifts the acid-base balance, reducing pH. Therefore, the higher the concentration of lactic acid in the blood, the lower its pH. The total amount of lactic acid produced in muscles during the work depends on three main factors: 1) work capacity; 2) the duration of the work; 3) the amount of working muscle mass [16].

When operating at relatively low power — up to 50–60% of maximum aerobic work after a period of work, the content of lactic acid in muscles and blood begins to gradually decrease, and in the process of working, the concentration of lactic acid in blood may differ slightly from rest conditions. Such a decrease in the concentration of lactic acid during work shows that the rate of cross-formation in active muscle cells becomes lower than the rate of its utilization by the liver, heart, and inactive muscles [17,18].

With heavy muscular work, the content of lactic acid in the blood significantly exceeds the level of rest, in some limits it is the greater, the higher the power of the work performed. The highest concentration of lactic acid is achieved at work, which can last no more than 1-3 minutes [19]. Erythrocytes play a huge role in ensuring muscle function, highly specialized cells, the main function of which is related to the presence of hemoglobin in them, which ensures oxygen transfer and the possibility of transporting carbon dioxide by blood. The rate of formation of red blood cells in the bone marrow is 2-3 million per second, the average duration of their life in peripheral blood is 100-120 days [20].

The greatest increase in the concentration of erythrocytes in the blood was registered after a very hard short-term work: after running 100 m, the concentration of erythrocytes increases by more than 20%. During prolonged work (3000 m run) - by 10% [21].

True erythrocytosis - an increase in the content of erythrocytes in the circulating blood as a result of increased bone marrow hematopoiesis. The most striking example of true erythrocytosis is an increase in the content of erythrocytes (and hemoglobin) in people living at high altitudes (in the mountains) [22].

During very long muscular work, along with the breakdown of erythrocytes, an increase in plasma volume can occur (due to the reverse movement of fluid from tissue spaces into the bloodstream). As a result, the concentration of erythrocytes in the blood decreases, and working erythropenia develops [23].

The magnitude of intravascular hemolysis is most dependent on the increased trauma of red blood cells due to mechanical shaking of the body (especially when running on hard ground) and due to the high speed of blood flow during muscular work. As a result of the destruction of red blood cells in the blood plasma and urine, hemoglobin and hematin appear, and plasma haptoglobin decreases. This occurs after a very long intense muscular work (marathon run, long march), but in all cases the degree of hemolysis is extremely small [24,25].

The number of leukocytes in the blood of a healthy person varies within fairly wide limits - from 4,000 to 10,000 in mm^3. In assessing the quantitative changes of leukocytes in the blood, not only the change in their total number is significant, but also shifts in the leukocyte formula. During muscular work, an increase in the content of leukocytes in the circulating blood is observed - working leukocytosis with a simultaneous decrease in eosinophils in the blood (eosinopenia). If the picture of red blood during muscular work and after it reflects changes in blood volume, then changes in white blood cannot be explained solely by this reason. The degree of working leukocytosis is significantly greater than the degree of working hemoconcentration, and changes in time differently than the volume of circulating blood [26].

The concentration of leukocytes in the circulating blood increases during the work and depends on its power. By the end of long-term work, the concentration of leukocytes in the blood may be three or more times higher than the level of rest and reach 30-40 thousand in mm^3. Within certain limits, the degree of leukocytosis depends on the duration and work [27,28].

Platelets play a leading role in the process of blood coagulation, in addition, they have immunogenic properties [29]. During muscular work, the content of platelets in the circulating blood slightly increases [30]. Immediately after work, there follows a period of rapid decrease in their concentration in the blood, which lasts 30-60 minutes [31]. Then comes a period of rapid increase in platelet concentration, and 1-2 hours after work, their number exceeds the pre-working level [32]. Over the next few hours, the original platelet count in the blood is restored.

During muscular work, the activity of the coagulation and anticoagulation systems is enhanced. In the process, blood clotting increases, and as a result, bleeding time, blood clotting time and prothrombin time are reduced. The thromboplastin content is somewhat increased, which can be associated with an increase in the blood of the antihemophilic factor necessary for the formation of thromboplastin. Moreover, during muscular work in the blood, the content of platelets increases, their adhesiveness increases, which can also cause increased blood clotting. An increase in the concentration of fibrinogen in the blood during muscular work further enhances the aggregation of platelets and erythrocytes [33].

Along with the increased activity of the coagulation system during muscular work, the activity of the anticoagulant system is enhanced. The fibrinolytic activity of the blood increases dramatically, determined by the rate of dissolution of blood clots that can form on the walls of blood vessels. For example, after a 5-minute maximum aerobic work to failure, fibrinolytic activity increases by 7 times, due to the appearance in the blood of plasminogen activators. With easier work, fibrinolytic activity increases gradually: from several minutes to several hours, depending on the power of the work performed. Thus, muscular work causes faster blood clotting, which is compensated by a faster breakdown of the fibrin threads of blood clots [34].

In general, the anticoagulant (fibrinolytic) activity of the blood increases during operation more than its coagulation ability, ensures the maintenance of the liquid state of the blood and prevents the increase of its viscosity [35].

CONCLUSION

Regular active muscular work leads to significant changes in the physico-chemical and physiological properties of blood. At the same time, the volume of circulating blood decreases slightly, the number of formed elements increases, the states of the buffer and colloid-osmotic properties of the blood change, the activity of the coagulation and anticoagulation systems increases. The basis of these changes is the withdrawal of a part of the plasma through the walls of the capillaries from the vascular bed to the intercellular space of the working muscles during active work. The changes in the blood occurring against the background of muscular activity are adaptive in nature and are aimed at maintaining the vital activity of the organism.

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