Rheological blood properties versus physical exertion in the process of ageing

Właściwości reologiczne krwi a wysiłek fizyczny w procesie starzenia się

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Key words
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Abstract
Ageing has a strong influence on the changes of the rheological parameters of blood. Then the level of fibrinogen increases which influences the rise of plasma viscosity, red cell aggregation and the whole blood viscosity. The level of fibrinogen in humans varies from 2.0 to 4.0 g/l. Whereas in people ageing, who are over 60, its rate increases from 3.3 to 4.0 g/l, which is an upper limit of the norm. In old people the erythrocytes become less deformable, making for an increase of blood viscosity and decreasing the speed of the flow through the blood vessels. The foregoing rheological blood changes are factors of risk for cardiovascular diseases among old people. That is why it is essential to improve the rheological blood parameters in old people by the training application. It is observed that people who led a sedentary lifestyle and who take up regular physical activity have better blood parameters than those described above: a decrease of blood viscosity and positive changes of elastic red cell properties. The observed decrease of plasma viscosity after endurance training application can cause a permanent reduction of heart strain, an increase of tissue blood circulation and can result in a decrease of cardiovascular complications. In the review article the issue of changes of the rheological parameters of blood which take place while ageing and the influence of physical activity on rheological blood indicators have been presented.

Słowa kluczowe
krew, reologia, osoby starsze, wysiłek fizyczny

Streszczenie
Starzenie się ma silny wpływ na zmiany parametrów reologicznych krwi. Wraz z upływem lat obserwuje się wzrost poziomu fibrynogenu, co przyczynia się do wzrostu lepkości osocza, agregacji czerwonych krwinek i lepkości krwi całkowitej. U człowieka poziom fibrynogenu kształtuje się na poziomie od 2,0 do 4,0 g/l. Natomiast powyżej 60 roku życia wraz z wiekiem wartość jego wzrasta z 3,3 do 4,0 g/l osiągając górną granicę normy. Erytrocyty u osób starszych stają się coraz mniej odkształcalne powodując wzrost lepkości krwi, a tym samym zmniejszenie szybkości przepływu przez naczynia krwionośne. Powyższe zmiany reologiczne krwi u osób starszych są czynnikami ryzyka chorób sercowo-naczyniowych. Należy zatem dążyć do poprawy parametrów reologicznych krwi u osób starszych, poprzez m.in. zastosowanie treningu. U osób prowadzących siedzący tryb życia, które podjęły regularny trening fizyczny, nastąpiło obniżenie lepkości krwi oraz korzystne zmiany właściwości elastycznych czerwonych krwinek. Obserwowane obniżenie lepkości osocza po zastosowaniu treningu wytrzymałościowego, może powodować stałe zmniejszanie obciążenia serca, zwiększenie przepływu krwi przez tkanki, a co za tym idzie może zmniejszać ryzyko powikłań sercowo-naczyniowych. W pracy poglądowej przedstawiono problem zmian właściwości reologicznych krwi, jakie zachodzą podczas procesu starzenia oraz wpływ wysiłku fizycznego na wskaźniki reologiczne krwi u osób starszych.

The individual division on this paper was as follows: A – research work project; B – data collection; C – statistical analysis; D – data interpretation; E – manuscript compilation; F – publication search; G – grant and funding acquisition

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INTRODUCTION

The percentage of individuals at an advanced age is increasing very quickly both in Poland and abroad. Already the number of eighty-year-olds in Poland is slowly approaching the one million mark, while in the course of the next 15 years, as a result of increasingly better medical care, this particular age group will be fairly numerous[1].

Somatic illnesses occur the most often during the period of old age and include diseases of the cardiovascular system, an influence on which is exerted by, among other things, the rheological parameters of the blood. Taking into consideration the fact that these diseases concern an increasing section of society it follows to research to what degree an examination of blood rheology may be useful in diagnosis and therapy[2].

RHEOLOGICAL BLOOD PROPERTIES IN THE PROCESS OF AGEING

Ageing has a strong influence on changes in the rheological parameters of blood. Together with the pasing of time there is observed a growth in fibrinogen[3], which results in an increase of the plasma viscosity, the aggregation of red blood cells and the viscosity of the entire blood. Red blood cells become in old people increasingly less deformable causing an increase in blood viscosity, and with it a reduction in the speed of flow through blood vessels[4]. The flow of blood undergoes a reduction in speed which is conducive to an increased aggregation of red blood cells. The concentrations of cells (aggregates) that arise delay the flow of blood and the agglutinating undergoes a further acceleration. In such a case there can arise a vicious circle around disturbance in circulation[2].

The above changes amongst old people are risk factors in the appearance of cardiovascular diseases[5]. Ajmani and Rifkind[4] consider that the increase in the frequency of the appearance of cardiovascular and cerebrovascular diseases at an advanced age at least partly occurs as a result of the condition of excessive blood viscosity. Various factors influence blood viscosity like, for example, shear stress, haematocrit, plasma viscosity, the deformation and aggregation of red blood cells. Despite the fact that various factors influence blood viscosity, the condition of excessive viscosity may be brought about even by the increase of just a single one of these factors.

It is considered that aggregation is the first factor responsible for the growth in blood viscosity (with low shear stress)[4]. Aggregation is induced thanks to the creation of macromolecular bridges between the surfaces of neighbouring red blood cells. The natural macromolecular creating bridges between red blood cells is fibrinogen[2]. Research shows a strong dependence between the increased level of fibrinogen and the increase in the aggregation of red blood cells[3].

Together with the passing of the years an increase in the level of fibrinogen is observed[3,6]. This is confirmed by tests conducted by Kovacs et al.[7], in which the increase in the level of fibrinogen together with age is clearly documented. In a group of individuals from the age of 60 to 74 the level of fibrinogen represented 3.3 g/l while in older individuals it was already at a level of 3.5 g/l and in those tested who were over 90 the level of fibrinogen represented 4.0 g/l. Equally Hager et al.[8] in comparing the level of fibrinogen in individuals under the age of 41 with those over the age of 65 obtained a significantly higher level of fibrinogen (of 44%) in the group of older individuals. In those tested with cerebrovascular failure a higher level of fibrinogen occurs equally in older individuals (average age 59.17) than in the group of younger patients (average age 48.2) [9].

The increase in the level of fibrinogen can be caused by its quick production or a slowing down in its degradation. Increase in the production of fibrinogen can result in the degradation of the vascular endothelium or more frequent activation of the coagulation and delayed fibrinolysis [10,11].

Equally Bauer et al.[10] have reported a higher concentration of fibrinopeptide in older patients which points to an increased activation of prothrombin and in connection with this a quickened production of fibrinogen in those tested.

Research shows a strong correlation between the increased level of fibrinogen and the growth in the aggregation of red blood cells[12,13]. Hammi et al.[14] have shown differences in the aggregation indexes in a young and old population. They equally discovered that following the application of an anti-aggregative factor (dihydroergocryptine) there occurred a significant reduction in the aggregation of red blood cells despite an increase in the concentration of fibrinogen.

In patients suffering from various vascular illnesses there has been observed a significant dependence between the aggregation of red blood cells and the age of patients[5]. At an older age there appear changes such as: a reduction in the number of red blood corpuscles, the concentrations of haemoglobin and haematocrit which is conducive for symptoms of a small degree of anaemia[7], but in accordance with the Fahzeus-Linqvist law this improves the rheological properties of the blood.

Deformation of red blood cells is dependent on three factors: the shape of the cell, the elasticity of the cell membrane and the viscosity of the internal cell. The elasticity of the membrane is influenced by the protein of the cytoskeleton, lipids and cholestrol, while for viscosity the state of hydration and the haemoglobin content[15,16].

A subsequent parameter that has a huge significance for microcirculation is the deformability of red blood cells. The term deformability of red blood cells defines the ability of these cells to change their shape under the influence of forces exerted on them[17]. They have to change their shape in order to force their way through vessels of a diameter less than they have themselves. Normally red blood cells have the shape of a flattened biconcave disc. Such a disc, as opposed to a sphere, may be easily stretched, bent or coiled. Therefore it is equally considered the optimal shape for the flow of blood[2]. However, the red blood cells of healthy individuals may be divided into six different shapes. Research shows that in older individuals at the age of 60 and older, blood is dominated by flat RBC. In connection with this the blood of older people is more viscous and less 'capable of filtration' than the blood of those who are 59 years and younger [18]. Together with age the ability for deformation of

red blood cells lessens[19], which results in an increase in blood viscosity and with it a reduction in the speed of flow within the blood vessels [4]. The flow of blood undergoes a slowing down which is conducive to an increased aggregation of red blood cells[2].

Franzini et al.[20] attributed the significant fall in the deformation of red blood cells as a function of age, but made this property dependent on an increased level of cholesterol in the cell membrane and in vessel walls. This dependence was equally proven by Shiga and associates as well as by Annapurna et al.[21,22].

A reduced ability for red blood cell deformation results in a slowing down of the flow of blood through blood vessels – particularly through the capillary system of vessels, there exists a connection between the reduced proportions of cerebal blood flow and cognitive functions which as we know are significantly disturbed during the undergoing process of ageing [23].

The blood rheological properties influence the arterial hypertension. Koenig et al.[24] after testing a group of individuals aged 25 to 64, noticed a connection between the viscosity of the blood and its pressure – an increased plasma viscosity significantly influences arterial hypertension.

Smokers also displayed an increase in blood viscosity, partly through increasing haematocrit and the level of fibrinogen[4].

Drugs such as inhibitors of angiotensin convertor as well as beta blockers also have an influence on the haemorheological parameters of blood, something borne out by the research of Gibbs et al[25].

CHANGES IN THE RHEOLOGICAL PROPERTIES OF BLOOD AFTER THE APPLICATION OF PHYSICAL EXERTION

An improvement in the rheological parameters of blood amongst older individuals may be achieved through the use of endurance training. Barash et al.[3] have researched that in a group of individuals with coronary disease of the heart aged between 45 and 74 who lead a sedentary lifestyle there occurs a higher concentration of fibrinogen. While Ernst[26] concludes in his work that amongst individuals who regularly undertake physical exercise there occurs an improvement in the haemorheological parameters of the blood involving a reduction in blood viscosity as well as an improvement in the elastic properties of red blood cells. The observed lessening of plasma viscosity observed can, as is suggested, result in a constant reduction of heart strain, an increase in tissue flow and the subsequent reduction in the risk of cardiovascular complications[27].

Intensive physical exertion causes many changes in the organism which can directly or indirectly influence erythropoiesis. The stimulation of hemopoietic processes are borne out by the enhanced reticulocytosis observed both after individual exercises as during a training session.[28], as well as the increase in the pool of young red blood cells characterised by better rheological properties[29]. The phenomenon of 'rejuvenating' the red blood cell pool may favourably affect the supply of oxygen to tissues through the fact that younger cells are more elastic and therefore it is easier for them to overcome the resistance of the capillary vessels system[30].

There is observed in individuals undertaking physical exercise a lower concentration of haemoglobin and a lower level of haematocrit as well as the above mentioned reduced plasma and blood viscosity as well as greater elasticity in corpuscles in comparison to individuals who lead a sedentary lifestyle. It is considered that at the basis of the above changes lies the phenomenon of so-called haemodilution[31]. Increase in the plasma volume and the subsequent improvement in the liquidity of blood is considered to be an adaptive change in the circulatory system during physical exercise[16].

Haemological changes and particularly rheological ones that are brought about by exercise sessions can be significant for the improvement of the general state of health. Also for the reason that the rheological parameters of blood deteriorate with age it follows to encourage older people to undertake physical exertion.

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