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Physiological Reaction of Erythrocytes' Microrheological Properties in Persons of The Second Mature Age on Prolonged Hypodynamia.

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ABSTRACT

Rheological characteristics of erythrocytes mostly determine the processes of microcirculation and metabolism in tissues. Studying of their properties in untrained people can promote deeper understanding of hypodynamia state. In our research we enrolled 45 healthy people of both sexes of the second mature age who had avoided exercises within lifetime. The 1st control group was composed of 42 people of both sexes of the same age who had regularly trained in the athletics section thrice a week for not less than 10 years. The 2nd control group was composed of 46 people who had daily walked not less than 6 km in the course of the last 10 years. There were applied biochemical, hematological and statistical methods of investigation. Persons from the group of observation were noted to have strengthening of the processes of lipids' peroxidation in plasma and erythrocytes. Blood of the examined persons with hypodynamia was initially noted to have imbalance of arachidonic acid metabolites: the level of thromboxane B_2 in their plasma turned out to be higher in comparison with both control groups approximately by ¼, the level of 6-keto-prostaglandin $F_{1\alpha}$ was lower by more than 13%. It was accompanied in them by content lowering of the quantity of summary nitric oxide metabolites in plasma. Persons with low physical activity were noted to have content lowering of erythrocytes-discocytes in blood by more than 10.0% and quantity rise of erythrocytes' reversibly and irreversibly modified forms by more than 39.0% and in 2.3 times, respectively. Persons with hypodynamia were found to have strengthening of erythrocytes' aggregation: increase of erythrocytes' summary involvement into aggregates by more than 25.0% and quantity of these aggregates by 1/3 at decrease of freely lying erythrocytes approximately by 20.0%. Worsening of erythrocytes' microrheological properties in persons of the second mature age with low physical activity can weaken the processes of microcirculation and metabolism in the internals forming conditions for pathology development.

Keywords: the second mature age, prolonged hypodynamia, erythrocytes, aggregation, membrane's surface properties.

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INTRODUTION

Low physical activity is rather widespread among modern people [1]. It causes realization of many variants of hereditary predisposition to pathology [2]. It was traced in different categories of population of industrially developed countries [3] and confirmed in experiment [4,5,6]. Evident consequences of hypodynamia in a man can manifest themselves already in young age increasing the frequency of episodes of temporary disability because of weakening of functional reserves of the whole body [7,8]. While aging low physical activity leads to aggravation of many diseases and their chronic course [9,10,11].

It's noted that conditions for the rise of arterial pressure leading to gradual development of arterial hypertension and disturbance of metabolism [12] can be often formed against the background of hypodynamia. Besides, hypodynamia aggravates the course of already existing cardio-vascular pathology and promotes the formation of resistance to the conducted medication [13,14] in these patients. Taking into account the evidence of hypodynamia negative impacts on a body, it becomes urgent to estimate erythrocytes' microrheological properties against its background as they can strongly influence microcirculation and metabolism in the whole body. The following aim was put in our research: to estimate the state of erythrocytes' microrheological properties in persons of the second mature age who had avoided regular exercises within lifetime.

MATERIALS AND METHODS

The conduction of the research was approved by the local Ethics Committee of the Russian State Social University in May, 25th, 2016 (Record №5). All the examined persons gave written informed consent on participation in the conducted research.

The group of observation was composed of 45 people of both sexes (23 men and 22 women) of the first mature age (mean age 44.9±2.2 years) who had purposefully avoided regular physical exercises during lifetime. The first control group was composed of 42 healthy people of both sexes (22 men and 20 women) of the second mature age (mean age 42.8±2.6 years) who had regularly trained in athletics section thrice a week for not less than 10 years at duration of each training for not less than an hour. The second control group was composed of 46 people of the second mature age (mean age 43.7±2.3 years) who had tried to walk daily the distance of 5 km and had had no additional exercises. Existing in some persons from the group of observation and the control groups chronic diseases (chronic bronchitis, chronic tonsillitis, chroniccholecyctitis) had been in the state of stable remission for not less than 2 years. All the enrolled into the research persons were once observed and examined.

The activity of the processes of lipids' peroxidation (LPO) in blood plasma was determined according to the content of thiobarbituric acid (TBA)-active products in it by a kit of the firm "Agat-Med" (Russia) and according to the level of acylhydroperoxides (AHP). Antioxidant plasma activity [15] was registered. The content of thromboxane B_2 and 6-keto-prostaglandin $F_{1\alpha}$ in plasma of the examined persons was determined with the help of immune-enzymatic analysis by a kit of the firm "Enzo Life science" (USA). Summary content of nitric oxide metabolites [16] was also determined in plasma.

The evidence of the processes of intra-erythrocyte LPO was found out in washed and resuspended erythrocytes according to the concentration of malondialdehyde (MDA) and AHP quantity [15].

The state of erythrocytes' microrheological properties was judged by their cytoarchitecture and aggregation. The quantity of normal and modified erythrocytes' forms in blood was determined with the help of light phase-contrast microscopy [10]. The ability of erythrocytes to spontaneous aggregation was determined with the help of light microscopy by calculating the quantity of erythrocytes' aggregates, the number of proaggregated andnonproaggregated erythrocytes in Gorjaev's box.

Received in the research results were processed by Student's t-criterion.

RESULTS AND DISCUSSION

Persons from the group of observation were noted to have strengthening of LPO processes (Table).

The quantity of AHP and TBA-products in their plasma surpassed the values in the 1st control group by 40.6% and 33.0%, in the 2nd control group – by 38.1% and 30.9%, respectively. It took place against the background of weakening of plasma antioxidant activity in them in comparison with the 1st control group by 18.5%, in comparison with the 2nd control group – by 16.9%.

Blood of the examined persons with hypodynamia in the initial state was noted to have imbalance of arachidonic acid metabolites: the level of thromboxane B_2 in their plasma turned out to be higher in comparison with the 1st control group by 28.5%, in comparison with the 2nd control group – by 26.3%. The level of 6-keto-prostaglandin $F_{1\alpha}$ in the group of observation at that was lower in comparison with the 1st control group by 14.4%, in comparison with the 2nd control group – by 13.6% (Table). It was accompanied in them by content lowering of the quantity of nitric oxide summary metabolites in plasma (by 19.2% in comparison with the 1st control group and by 14.7% in comparison with the 2nd control group).

Erythrocytes of physically untrained persons were found to have the rise of AHP (by 29.6% in comparison with the 1st control group and by 28.3% in comparison with the 2nd control group) and MDA in comparison with the 1st control group by 38.9%, in comparison with the 2nd control group – by 34.0%.

Persons having low physical activity within lifetime, were noted to have lowering of erythrocytes-discocytes' percentage in blood (in comparison with the 1st control group by 12.2%, in comparison with the 2nd control group – by 11.2%) (Table). The quantity of erythrocytes' reversibly and irreversibly modified forms in their blood was increased in comparison with both control groups by more than 39.0% and in 2.3 times, respectively.

The examined persons with hypodynamia in the initial state were found to have strengthening of erythrocytes' aggregative properties at that. It was pointed at by their index increase of the summary erythrocytes' involvement into aggregates in comparison with the levels of the 1st and the 2nd control groups by 29.2% and 26.8%, and by quantity rise of these aggregates by 36.7% and 32.2% at the decrease of freely lying erythrocytes by 20.8% and 19.3%, respectively.

Prolonged support of physiological optimum in a body is possible only at high muscular activity [17,18]. It was noted long ago that hypodynamia could causeprepathological state and strengthen existing pathology [19,20]. Last decades notwithstanding the successes of medicine and propaganda of medical knowledge hypodynamia remains rather widespread among population of developed countries. Its consequences at that continue to damage economically because of high frequency of working capacity lowering [21] against its background. It's noted that formation of hypodynamia is accompanied by not only worsening of musculoskeletal system state but also lowering of metabolism intensity. Given situation negatively influences the functioning of the whole body [22,23].

Antioxidant protection weakening of a body leading to the growth of LPO intensity [24], has special significance for the development of most dysfunctions. Found surplus of lipids' peroxidation products in plasma and erythrocytes of persons with hypodynamia undoubtedly caused structural changes in these cells' membranes [25]. It inevitably disturbed selective permeability and membrane's viscosity in erythrocytes and negatively influenced the membrane-related proteins in the result of their secondary structure modification.

Found strengthening of erythrocytes' aggregation at hypodynamia could be estimated as the result of the combined impact of all the consequences of low physical activity on microrheological processes. Number increase of reversibly and irreversibly modified erythrocytes' forms inevitably led to quantity growth of erythrocyte aggregates in blood of these people and to the rise of involvement degree of erythrocytes into them. Found evidence rise of erythrocytes' aggregation in conditions of hypodynamia could be mostly explained by catecholamines' strengthening impact on them. Their level in blood at any dysfunction reliably rose [26].

Quantity increase of catecholamines in blood of persons from the group of observation should be estimated as one of compensatory mechanisms of metabolism intensification in tissues [27].

Vascular wall of persons with hypodynamia was noted to have synthesis lowering of biologically active substances which were able to limit erythrocytes' aggregation.

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The level of proaggregants in their blood increased at that. So, found in the group of observation intensification of thromboxane formation and production weakening of its functional antagonist – prostacyclin – formed imbalance of arachidonic acid metabolites [28,29]. Given disorders were aggravated in them by developing weakening of NO production in vascular walls. Probably, it took place in the result of endothelial NO-synthase suppression by strengthened LPO in plasma [30]. Besides, forming in these conditions microrheological dysfunctions of erythrocytes could aggravate themselves the trophism in vascular walls and inhibit the production of disaggregants in them.

CONCLUSION

Persons with protractedly existing hupodynamia are characterized by strengthening of aggregation and number increase of modified erythrocytes. It inevitably leads to quantity growth of erythrocyte aggregates in blood of these people and to degree rise of erythrocytes' involvement into them. Found evidence rise of erythrocytes' aggregation in conditions of hypodynamia can be mostly explained by the imbalance of biologically active substances influencing erythrocytes' aggregation. They are characterized by intensification of thromboxane formation and weakening of prostacyclin production. It is aggravated by weakening of NO production in vascular wall in them. Probably, LPO strengthening against the background of hypodynamia lies in the basis of these disturbances. Forming in these conditions microrheological dysfunctions of erythrocytes can worsen the processes of microcirculation and weaken tissue trophism forming conditions for pathology development.

Table 1: Hematological indices of persons who protractedly had low physical activity

Registered parameters	Persons with hypodynamia, n=45, M±m	Control1, n=42, M±m	Control2, n=46, M±m
acylhydroperoxides, D_{233} /1ml	2.32±0.57	1.65±0.20 p<0.01	1.68±0.17 p_1<0.01
TBA-compounds, mcmol / l	4.19±0.59	3.15±0.23 p<0.01	3.20±0.26 p_1<0.01
plasma antioxidant activity, %	26.5±0.48	31.4±0.46 p<0.01	31.0±0.37 p_1<0.01
thromboxane A_2, pg/ml	208.5±0.72	162.2±0.72 p<0.01	165.1±0.68 p_1<0.01
6-keto-prostaglandin $F_{1\alpha}$, pg/ml	83.0±0.35	95.0±0.45 p<0.01	94.3±0.54 p_1<0.01
Total metabolites nitrogen oxide, mcmol / l	31.2±0.28	37.2±0.32 p<0.01	35.8±0.32 p_1<0.01
acylhydroperoxides of erythrocytes, $D_{233}/10^{12}$ erythrocytes	4.03±0.017	3.11±0.016 p<0.01	3.14±0.011 p_1<0.01
malonicdialdehyde of erythrocytes, nmol/10^{12} erythrocytes	1.89±0.009	1.36±0.014 p<0.01	1.41±0.009 p_1<0.01
erythrocytes-discocytes,%	77.8±0.27	87.3±0.18 p<0.01	86.5±0.12 p_1<0.01
reversibly modified erythrocytes,%	14.1±0.19	9.5±0.10 p<0.01	10.1±0.07 p_1<0.01
irreversibly modified erythrocytes,%	8.1±0.10	3.2±0.15 p<0.01	3.4±0.10 p_1<0.01
sum of all the erythrocytes in an aggregate	40.7±0.14	31.5±0.10 p<0.01	32.1±0.07 p_1<0.01
quantity of aggregates	8.2±0.09	6.0±0.07 p<0.01	6.2±0.09 p_1<0.01
quantity of free erythrocytes	245.0±0.45	296.1±0.35 p<0.01	292.3±0.29 p_1<0.01

Note: p – reliabilityofvalues' differences of observation group with the level of the 1st control group; p_1 – reliability of values' differences of observation group with the level of the 2nd control group; reliability of differences between the 1st and the 2nd control groups was not discovered.

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