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Restoration of erythrocyte microrheological peculiarities in 5-6-year-old children with scoliosis after daily usage of medioprophylactic clothes for six months

Bikbulatova Albina Akhatovna, Andreeva Elena Georgievna, Medvedev Ilya Nikolaevich*

ABSTRACT

Introduction: Efficient correction methods should be applied early at the detection of scoliosis. One of them is medioprophylactic clothes. However, the effect of medioprophylactic clothes towards the dynamics of erythrocyte microrheological features in children with scoliosis has not been fully studied.

Methods: In this study, we tracked indices changes of erythrocyte cytoarchitecture and aggregation in thirty-nine 5-6-year-old children with grade I-II scoliosis who wore medioprophylactic clothes (designed by one of the authors) daily for 6 months. Thirty-four healthy subjects were enrolled for the control group. The measurement was conducted at the beginning of the research and after 3 and 6 months of intervention.

Result: At their initial state of the observation, the experimental group had worse erythrocyte microrheological features because of physical development inhibition. Daily usage of medioprophylactic clothes for six months reduced the evidence of spinal curvature, increased force, and tolerance of body muscles, lowered reversible and irreversible modified erythrocyte, and weakened spontaneous erythrocyte aggregation.

Keywords: children, preschool age, scoliosis, erythrocytes, microrheological features, medioprophylactic clothes

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Russian State Social University
The Kosygin State University of Russia
Russian State Social University

INTRODUCTION

Nowadays, scoliosis is widespread among late preschoolers in Russia.[1] Scoliosis causes negative changes in the common functional states of a body.[2] Development of scoliosis negatively influences many processes of internal organs and systems.[3,4] Presence of scoliosis in children is usually accompanied by microrheological dysfunctions of regular blood elements, mainly erythrocytes. It is an important reason for hypoxia development in tissues of a child.[5] Chronic oxygen deficiency in children with scoliosis damages anabolic processes and aggravates scoliosis.[6]

The frequent occurrence of scoliosis and development of microrheological disturbances urges the search for efficient approaches to spinal curvature correction.[7] Earlier, we examined capabilities of various physical impacts on a body in human.[8,9] and animals.[10,11] Those studies investigated the disturbances' weakening of regular blood elements' microrheology. We showed the efficiency of such impacts. At the same time, low attachment of children to regular adequate physical activity, which should be long enough for the achievement of positive changes of scoliosis,[12] predetermines the urgency to search correction variants for their locomotor apparatus. Child's inclination to correct impact and capability of positive impact on erythrocyte microrheological features become the main criteria of the choice of therapeutic modalities. The data can become the basis for mass prophylaxis of scoliosis progression and for health preservation of the internal organs of children with developed scoliosis.[13] Wearing of medioprophylactic clothes (MPC)[14,15,16] can be considered as an alternative to physical rehabilitation. The attachment of children to such clothes is incommensurably higher compared to physical training.[17] However, the potential of MPC in correcting erythrocyte microrheological features has not been practically studied. This research aimed to estimate the effect of daily usage of MPC for six months towards the dynamics of erythrocyte microrheological features in 5-6-year old children with grade I-II scoliosis.

MATERIALS AND METHODS

The research was conducted in Central Russia (Moscow city and Moscow region). We took 34 healthy children of both sexes at the age 5-6 years (height 123.6±1.41 cm, body mass 24.2±1.38 kg),

*Correspondence to:
Medvedev Ilya Nikolaevich,
Russian State Social University
ilmedv1@yandex.ru

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and also 39 children of both sexes of the same age with grade I-II scoliosis (height 118.7±0.73 cm, body mass 21.2±2.10 kg) at the full absence of any accompanying diseases. The research was approved by local Ethics Committee of Russian State Social University on May 14th, 2015 (record №5). Parents of the children were given written an informed agreement on participation of their children in the research. The children themselves gave oral agreement in the presence of their parents and witnesses.

The degree of spinal column deviation was determined by pasting of special cord with lead in the level of the 7th cervical vertebra using adhesive plaster.[17] The distance from the vertical position to acanthus was determined with the help of this lead. It characterized the degree of spinal curvature in the frontal plane. The value of the humeral index was calculated by dividing the value of humerus width from the chest side (cm) with the value of humerus width from the back side (cm).[15]

The degree of spinal mobility in examined children was estimated using forward, backward, and sideward body tilts. In the course of forward body tilts with straightened legs, we determined the distance from the middle finger of each hand to the floor surface (cm). During backward body tilts, we determined the difference of line length (cm) which connected the tops of acantha of the 7th cervical vertebra and initial part of intergluteal fold. The estimation was conducted in vertical position. Lateral spinal mobility was measured using distance estimation from the end of the middle finger of each hand to floor at maximum sideward tilt from standing position. The more was the given difference, the more spinal mobility in frontal plane was.[18]

In our research, we determined the activity of lipid peroxidation (LPO) in blood plasma according to the content of thiobarbituric acid (TBA)-active products measured with the set produced by "Agat-Med" (Russia) and to the level of acylhydroperoxides (AHP).[19] We also measured antioxidant activity (AOA) of blood.[20]

In blood plasma, we determined the content of thromboxane A_2 metabolite – thromboxane B_2 – and prostacyclin metabolite – 6-keto-prostaglandin $F_{1\alpha}$ – by enzyme immunoassay using sets produced by "Enzo Life Science" (USA). We also determined the total content of nitric oxide metabolites[21] in plasma.

Erythrocytes were washed and resuspended. Then, we estimated the levels of cholesterol (CS) in the erythrocytes quantitatively by an enzymatic colorimetric method with the set produced by "Vital Diagnostikum" (Russia). Common phospholipids (CPL) was also measured according to the quantity of phosphorus.[22]

The evidence of the processes of intra-erythrocyte LPO in washed and resuspended erythrocytes was determined according to the concentration of malondialdehyde (MDA) in the reduction reaction of the thiobarbituric acid and to the quantity of AHP.[19]

We assessed the state of erythrocyte microrheological features by their cytoarchitecture and aggregation. We determined the quantity of normal and changed forms erythrocytes in blood with the help of light phase-contrast microscopy.[23]

The spontaneous aggregation of erythrocyte was evaluated with the help of light microscopy by calculating the quantity of erythrocyte aggregates, the number of aggregated and non-aggregated erythrocytes[23] in Goryaev's box.

All the children from experimental group were asked to wear daily medioprophylactic clothes, designed by the author, for scoliosis correction.[24] Control over the wearing of the children of the MPC was carried out by their parents. Applied MPC contained a button band and a panel. It was also provided by elastic straps in the upper part. Their ends were connected to both panel sides. The panel was made of an inelastic material, and there were pockets with inflexible plates in the area of blade bones' inner corner. The ends of elastic straps were fixed to both panel sides on the level of blade bones and pockets were attached to the reverse side of the panel. The panel and the button band were supplied with sleeves, collar, skirt or trousers of any material. Given MPC were put on in vertical position. The arms were drawn backward with the help of elastic straps. Inflexible plates pressed the inner part of blade bones, promoting flattening of the back. The presence of elastic belt didn't hamper normal breathing while ensuring right fit on the body. The clothes were worn during the whole day for six months. They were put off before going to bed.

The children from experimental group were observed and examined at the beginning and after 3 and 6 months of continuous MPC wearing. The control group was observed and examined once.

RESULTS

After 3 months of continuous MPC usage, the children with scoliosis had a lower deviation from the vertical position. It kept decreasing until the end of the research (1.46±0.14 cm). Wearing MPC for six months also increased humeral index to the value of 0.82±0.06 (table 1).

Table 1 **The dynamics of morpho-functional and hematological characteristics of examined children with scoliosis against the background of medioprophylactic clothes' wearing**

Registrated Parameters	A group of children with scoliosis against the background of medioprophylactic clothes' wearing, n=39, M±m			Control, n=34, M±m
	initial state	3 months	6 months	
Deviation of spinal column from the vertical position, cm	4.5±0.29	2.9±0.37 p_1<0.01	1.46±0.14 p_1<0.01	0.2±0.004 p<0.01
Value of humeral index	0.72±0.16	0.76±0.09	0.82±0.06 p_1 < 0.05	0.90±0.06 p<0.01
Degree of spinal column mobility in the course of tilts to the left side, cm	21,6±1,24	24,5±0,30	27,8±0,27 p_1<0,05	32,8±1,45 p<0,01
Degree of spinal column mobility in the course of tilts to the right side, cm	22.4±1.34	24.7±0.24	27.9±0.17 p_1<0.05	32.5±2.44 p<0.01
Degree of spinal column mobility in the course of tilts backwards, cm	14.5±0.72	16.3±0.41	18.7±0.38 p_1<0.05	22.6±0.72 p<0.01
erythrocytes-discocytes, %	76.5±0.19	80.8±0.16	84.2±0.17 p_1<0.05	87.5±0.16 p<0.01
reversibly modified erythrocytes,%	14.6±0.10	11.4±0.08 p_1<0.05	10.9±0.07 p_1<0.05	9.1±0.04 p<0.01
irreversibly modified erythrocytes,%	8.9±0.05	7.8±0.13	4.9±0.16 p_1<0.01	3.4±0.07 p<0.01
sum of all the erythrocytes in an aggregate	41.2±0.14	38.0±0.12	33.2±0.16 p_1<0.01	31.0±0.11 p<0.01
quantity of aggregates	7.9±0.09	7.3±0.08	6.6±0.10 p_1<0.01	6.1±0.08 p<0.01
quantity of free erythrocytes	245.1±0.34	260.8±0.36	281.3±0.29 p_1<0.05	294.6±0.27 p<0.01
thromboxan B_2, pg / ml	210.2±0.72	189.1±0.64	168.5±0.58 p_1<0.05	156.2±0.64 p<0.01
6-keto-prostaglandin $F_{1\alpha}$, pg / ml	72.6±0.34	75.7±0.58	78.1±0.44 p_1<0.05	80.7±0.45 p<0.05
nitric oxide's metabolites, umol/l	25.9±0.35	27.2±0.41	30.7±0.46 p_1<0.05	32.4±0.38 p<0.05

Conventional signs: p – signification of parameters' differences of children with scoliosis and control group. p_1 – dynamics' signification of accountable indices of children with scoliosis in the course of correction in comparison with the beginning

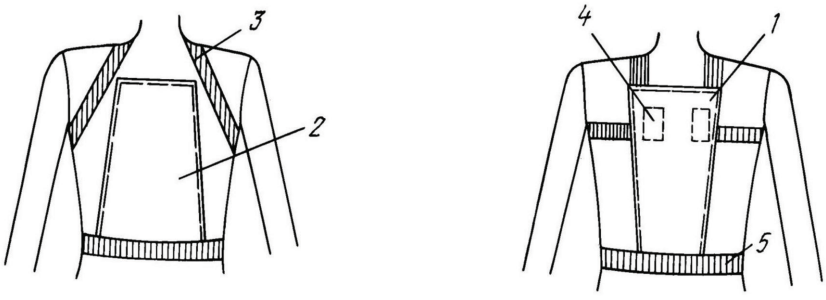

Figure 1 Schematic representation of medioprophylactic clothes
Legend: 1 - backrest, 2 - shelf, 3 - elastic straps, 4 - pockets on the back, 5 - elastic waistband

Moreover, application of MPC for 3 months increased spinal mobility in three planes. which reached the level of clinical significance after 6 months (to the right side 27.9±0.17 cm, to the left side 27.8±0.27 cm, backward 18.7±0.38 cm).

Daily wearing of MPC was accompanied by the weakening of LPO processes in plasma. After 3 months of observation, the quantity of AHP and TBA products in plasma was lowered from 2.21±0.18 D_{233}/1 ml and 4.38±0.24 μmol/l (control values – 1.65±0.14 D_{233}/1 ml and 2.99±0.22 μmol /l respectively) to 1.98±0.18 D_{233}/1 ml and 3.88±0.22 μmol /l respectively. By the 6th month of MPC application, the content of AHP in plasma reached 1.82±0.17 D_{233}/1 ml. The decrease of TBA-active compounds reached 3.38±0.19 μmol /l. Meanwhile, there was plasma AOA increase from 23.6±0.34% at the beginning to 26.1±0.24% by the end of observation (control values – 27.2±0.16%).

Initial imbalance of arachidonic acid metabolites in blood of children with scoliosis was gradually suppressed after daily MPC usage. By the 6th month of observation, the level of thromboxane B_2 in the plasma of experimental group turned out

to be higher in comparison with the control group, while the level of the derivative of its functional antagonist – 6-keto-prostaglandin $F_{1\alpha}$ was lower compared the control group (table 1). By the end of observation, the quantitative content of total nitric oxide metabolites in plasma was increased to the level approaching the control group.

In the experimental group, we noticed the reduction of CS level and the rise of CPL level in red corpuscles membranes. The continuation of MPC application allowed additional optimizing of erythrocyte lipid composition (CS 0.93±0.010 μmol/10^{12} erythrocytes, CPL – 0.69±0.003 μmol/10^{12} erythrocytes) and brought its values closer to the control level (CS – 0.89±0.009 μmol/10^{12} erythrocytes and CPL – 0.72±0.007 μmol/10^{12} erythrocytes). Activated LPO in erythrocytes of children with scoliosis (AHP 3.70±0.17 D_{233}/10^{12} erythrocytes, MDA 1.72±0.09 nmol/10^{12} erythrocytes) was significantly weakened after 3 months of intervention. After 6 months of continuous MPC application, the content of LPO products in erythrocytes was additionally lowered (AHP 3.22±0.24 D_{233}/10^{12} erythrocytes and MDA 1.43±0.14 nmol/10^{12} erythrocytes, respectively) and approached the control level (AHP 3.09±0.16 D_{233}/10^{12} erythrocytes, MDA 1.36±0.07 nmol/10^{12} erythrocytes, respectively).

The increase of discocyte percentage in the blood after six months of intervention was found in the experimental group (table 1). On the other hand, the quantity of reversible and irreversible modified erythrocyte form was lowered after six months of observation to 10.9±0.07% and 4.9±0.16%, respectively. The number of erythrocyte aggregates was also lowered after six months of intervention, approaching the level of the control group.

DISCUSSION

Different disturbances of musculoskeletal apparatus can often develop in the course of active growth under the impact of unfavorable environmental factors. Scoliosis is the most prevalent.[1] This disease is rather widespread in Russia among children and contributes greatly to its pathological aggravation.[2,4] It is known that scoliosis formation in children impairs metabolism, blood circulation, breathing, spring function of the spinal column, and function of many internal organs.[3,4] Development of disturbances of regular blood elements microrheological features at scoliosis plays a significant role in the formation of those impairments.

Erythrocytes are the most numerous blood component.[5] There is a significant weakening of antioxidant protection and increase of LPO intensity in plasma and cells. Products of lipid peroxidation of plasma and erythrocytes cause the reconstruction of erythrocyte membranes from the outside and inside, disturbing their functions. Those combined with CS growth and CPL decrease promote worsening of red corpuscles microrheological features.[25] This research showed that there was rise in reversible and irreversible modified erythrocyte forms, followed by reduction of erythrocytes-discocytes and increase of their ability to spontaneously aggregate. Inevitable disturbances of microcirculation in the internal organs[26,27] are the consequences of erythrocyte microrheological dysfunction in a young body.

In such conditions, the synthesis of biologically active substances in the vascular wall, which can limit erythrocyte aggregation, is reduced. As a result, the level of pro-aggregate rises in the blood. Intense thromboxane formation and weakening of its functional antagonist – prostacyclin – create an imbalance of arachidonic acid metabolites in children with scoliosis. Reduced NO production in vascular wall exacerbates the imbalance. This happens because of endothelial NO-synthase weakening by the surplus of LPO in plasma.[28]

The achieved normalization of the correlation in the blood of children with scoliosis of thromboxane and prostacyclin and the level of nitric oxide against the background of their regular wearing of MPC can be associated with the restoration of metabolic processes in tissues in them. Restoration of the optimal spatial arrangement of the spine and the entire trunk provides an improvement in the process of hemocirculation in the tissues, eliminating blood supply disorders in all parts of the capillary bed. This provides the conditions for optimizing the synthesis of enzymes, including in the walls of blood vessels. Developing at the same time, positive changes in microrheological properties of erythrocytes ensure complete elimination of negative manifestations of scoliosis in the child's body.

CONCLUSION

Daily wearing of medioprophylactic clothes for 6 months by 5-6-year-old children with scoliosis significantly improves their somatometric and erythrocyte architecture indices while reducing erythrocyte aggregation and LPO processes in plasma and erythrocytes.

CONFLICT OF INTEREST

No Conflict of interest to declare.

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REFERENCES

1. Topalis C., Anna Grauers, Diarbakerli E., Danielsson A., Gerdhem P. Neck and back problems in adults with idiopathic scoliosis diagnosed in youth: an observational study of prevalence, change over a mean four year time period and comparison with a control group. Scoliosis and Spinal Disorders. 2017; 8:12-20. doi: 10.1186/s13013-017-0125-z
2. Andreeva E.G., Getmanceva V.V., Golubeva T.A. The study of types of posture children's shapes preschool age. Sewing industry. 2012;6:14–17. .
3. Kovalenko V.S., Dzhandarova T.I. Mineral metabolism and indices of cardio-vascular system in children with inborn scoliosis and clubfoot. Bulletin of Medical Internet-Conferences. 2011; 1(7): 86-88.
4. Petrosova IA, Saidova SA, Andreeva EG, Sanginova DA. The results of anthropometric studies of school-age children. Bulletin of Kazan Technological University. 2016;19(17):98–100..
5. Nagibina E.V. Features of microrheological properties of erythrocytes in children of primary school age with a different functional state of the musculoskeletal system: the dissertation ... candidate of biological sciences. Kursk, 2013;177.
6. Lapshina E.V. The condition of musculoskeletal function and activity of platelets in children with scoliosis: the dissertation ... candidate of biological sciences. Kursk, 2011;152.
7. Petrosova I.A., Andreeva E.G., Tutova A.A., Ovsyannikova M.A. Development of a database of virtual mannequins of children's figures with the use of Microsoft's Kinect sensor. Proceedings of the "Design, technology and innovation in textile and light industry: Innovation 2016". Moscow: MSUDT, 2016:210–214.
8. Skoryatina I.A., Zavalishina S.Yu. Ability to aggregation of basic regular blood elements of patients with hypertension anddyslipidemia receiving non-medication andsimvastatin. Bali Medical Journal. 2017; 6(3):514-520. doi: 10.15562/bmj.v6i3.552
9. Kotova O.V., Zavalishina S.Yu., Makurina O.N., Kiperman Ya.V., Savchenko A.P., Skoblikova T.V., Skripleva E.V., Zacepin V.I., Skriplev A.V., Andreeva V.Yu. Impact estimation of long regular exercise on hemostasis and blood rheological features of patients with incipient hypertension. Bali Medical Journal. 2017; 6(3):514-520. doi: 10.15562/bmj.v6i3.552
10. Zavalishina S.Yu., Vatnikov Yu.A., Kulikov E.V., Yagnikov S.A., Karamyan A.S., Sturov N.V., Byakhova V.M., Kochneva M.V., Petryaeva A.V. Diagnostics of erythrocytes' microrheological features and early abnormalities of rats in the model of experimental hypertension development. Bali Medical Journal. 2017; 6(3): 470-475. doi: 10.15562/bmj.v6i3.589
11. Vatnikov Yu.A., Zavalishina S.Yu., Kulikov E.V., Vilkovysky I.F., Nikishov A.A., Drukovsky S.G., Krotova E.A., Khomenets N.G., Bolshakova M.V. Correctional abilities of regular muscle activity in relation to erythrocytes' microrheological features of rats with experimentally developed hypertension. Bali Medical Journal. 2017; 6(3):449-456. doi: 10.15562/bmj.v6i3.586
12. Zavalishina S.Y., Nagibina E.V. Dynamics of microrheology characteristics of erythrocyte in children 7-8 years with scoliosis with therapeutic physical training and massage. Technologies of Living Systems. 2012; 9(4):29-34.
13. Petrosova I.A., Saidov S.A., Guseva M.A., Andreeva E.G. Ergonomic clothes for disabled children. Proceedings of the "Actual problems of inclusion: quality of life, accessibility, education without borders." Moscow: MSUDT, 2016:32–36.
14. Andreeva E.G., Mokeyeva N.S., Glushkova T.V., Kharlova O.N., Chulkova E.N. Rehabilitation and prevention of disability: clothes and corrective devices: Handbook. Moscow: MSUDT; 2010:90.
15. Bikbulatova A.A., Andreeva E.G. Method of determining requirements for therapeutic and preventive garments. Sewing industry. 2013;1:37-40.
16. Bikbulatova A.A., Borisevich S.S., Andreeva E.G. Development of the composite material for the production of therapeutic-preventive school clothes. Design. Materials. Technology. 2016;4(44):53-56.
17. Getmanceva V.V., Pakhomova T.A., Andreeva E.G. The preferences of children clothing. Sewing industry. 2010;2:34–36.
18. Guseva M.A., Petrosova I.A., Andreeva E.G., Saidova S.A. Tutova A.A. Investigation of the system "man-clothes" in dynamics for the design of ergonomic clothing. Natural and Technical Sciences. 2015;11:513–516.
19. Gavrilov V.B., Mishkorudnaya M.I. Spectrophotometric determination of the content of lipid hydroperoxides in blood plasma. Laboratory work. 1983; 3:33-36.
20. Volchegorskij I.A., Dolgushin I.I., Kolesnikov O.L., Cejlikman V.Je. Experimental modeling and laboratory assessment of adaptive reactions of the organism. Cheljabinsk, 2000:167.
21. Metel'skaja V.A., Gumanova N.G. Nitric oxide: a role in the regulation of biological functions, methods for the determination of human blood. Laboratornaja medicina 2005 ; 7: 19-24.
22. Kolb V.G., Kamyshnikov V.S. Handbook of Clinical Chemistry. Minsk: "Belarus", 1982:367.
23. Kozinets G.I., Makarov V. A. Study of the blood system in clinical practice. Moscow, 1998. 480.
24. Kayumova R.F., Bikbulatova A.A. The outerwear correcting a bearing. Patent for the invention RU 2211651, 16.11.2001.
25. Vatnikov Yu.A., Zavalishina S.Yu., Pliushchikov V.G., Kuznetsov V.I., Seleznev S.B., Kubatbekov T.S., Rystsova E.O., Parshina V.I. Early-changes diagnostics of erythrocytes microrheological features in the model of dyslipidemia development in rats at the late stages of ontogenesis. Bali Medical Journal. 2017;6(1): 216-222. doi: 10.15562/bmj.v6i1.483
26. Zavalishina S.Yu. Hemostatic activity of a vascular wall at newborn calfs. Russian Agricultural Sciences. 2012; 1:37-39
27. Zavalishina S.Yu. Vascular hemostasis at calves in milk-and-vegetable phase of feeding. Zootekhniya. 2012;2:21.
28. Zavalishina S.Yu. Activity of a vascular hemostasis at calfs of a dairy food. Russian Agricultural Sciences. 2012; 4: 49-51.