

Dynamics of Locomotor Apparatus' Indices of Preschoolers with Scoliosis of I-II Degree against the Background of Medicinal Physical Training

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ABSTRACT

For maximally efficient selection of scoliosis correction variants one should take into consideration the potential of each of them. We mean the dynamics of morpho-functional status of locomotor apparatus which is not fully studied yet. The dynamics of morphological and functional locomotor apparatus' characteristics of 5-6-year children with scoliosis against the background of often applied in this case medicinal physical training is not yet fully studied too. In our research we tracked the dynamics of morphological and functional locomotor system's peculiarities of 5-6-year old children with scoliosis of I-II degree against the background of regular medicinal physical training. It is established that living in Central Russia 5-6-year old children with scoliosis of I-II degree have typical symptoms of physical development inhibition. Because of that, they have lowering of somatometric indices, decrease of body muscles' strength and level of their tolerance, and degree lowering of spinal column mobility. A course of medicinal physical training of these children with scoliosis for half a year can lower the evidence of spinal curvature, increase the strength and level of common tolerance of body muscles. However, it won't ensure reaching the control level by these indices.

Keywords: Children, Preschool age, Scoliosis, correction, Morpho-functional Characteristics, medicinal physical training.

INTRODUCTION

Development of deviations from the optimal physiological status of a human being at any age is connected with presence of definite genetic mutations and negative environmental impacts. They mostly promote negative phenotypic manifestation of existing hereditary defects and the most often variant of them – polymorphism of single nucleotides^{1,2}. So, realization of many variants of human pathology takes place, including development of cardiovascular diseases³, their different complications⁴ and appearance of various metabolic disturbances⁵, social deviations⁶ and different abnormalities in locomotor apparatus⁷. At the same time, one can't help noticing gradual prevalence increase

of locomotor apparatus' disturbances during the last years in Russia. It happens especially often with preschoolers. Scoliosis plays the leading role among those disturbances⁸. According to the data of Russian Federal Service of State Statistics, there are nearly 2 mln. children with bearing disturbances and scoliosis at present in Russia⁹. According to available information the most frequent cases of scoliosis are registered at late preschool age, and its I-II degrees are met in 75-80% of all the cases¹⁰.

It was noticed long ago that weakening of supporting, elastic and shock characteristics of skeleton, ligaments and muscles had great signification for scoliosis development¹¹. Developing disturbances in structures of locomotor apparatus

influence rather negatively not only the state of spinal column but also create conditions for development and gradual progressing of many dysfunctions in a body¹², including even in adulthood^{13,14}. Durable course of the scoliotic process rather negatively influences the processes of osteogenesis, promotes weakening of ligaments and muscles and worsens the common state of a body³. Besides, functioning of some internals and hemodynamics in them are often disturbed at scoliosis. So, numerous functional disturbances in cells of different organs appear rather early. It is connected with synthesis weakening of protein and regulatory substances at output rise of trigger factors, apoptosis². Regular blood elements¹⁵, pulmonary and cardio-vascular systems^{16,17} react rather keenly on the presence of scoliotic process in children. In this connection, scoliosis in children is fairly considered to be a very dangerous disease leading to disturbances in many internals¹⁸. It happens because of hypoxia development against its background, weakening of metabolism and unfavorable morpho-functional changes in tissues^{19,20}.

Early diagnostics of developing abnormalities in structure and functioning of preschoolers' locomotor apparatus connected with manifestations of scoliosis, is necessary for maximally early beginning of its adequate correction. In these conditions it can become the basis for not only preventing scoliosis progression but also health provision of children's internals²¹. For maximally efficient selection of scoliosis correction variants one should take into consideration the potential of each of them. We mean the dynamics of morpho-functional status of locomotor apparatus which, unfortunately, is not yet fully studied. The dynamics of morphological and functional locomotor apparatus' characteristics of 5-6-year old children with scoliosis against the background of often applied in this case medicinal physical training (MPT) is not fully studied too.

The aim of research: to estimate the evidence of dynamics of morphological and functional locomotor system's peculiarities of 5-6-year old children with scoliosis of I-II degree against the background of regular MPT.

MATERIALS AND METHODS

Given research was conducted on children of late preschool age living in Central Russia (Moscow city and Moscow region). Into our research we took 34 healthy children of both sexes at the age of 5-6 years (height 123.6 ± 1.41 cm, body mass 24.2 ± 1.38 kg), and also 36 children of both sexes of the same age with scoliosis of I-II degree (height 119.5 ± 0.80 cm, body mass 21.6 ± 2.12 kg) at full absence of any accompanying diseases in them. Estimation of health state of all the children taken into the research was conducted basing on the analysis of information from their medical records. Given research was approved by local Ethics Committee of Russian State Social University May, 14th, 2015 (record !5). Both parents of each, taken into the research, child gave their consent in written form on participation of their children in the research. The children themselves gave their consent in oral form in presence of their parents and witnesses.

The degree of spinal column deviation in children from the vertical position was determined with the help of a test with pasting of prepared cord with a lead in the field of the 7th cervical vertebra by adhesive plaster²². The distance from the vertical position, found by this lead, till acanthas was considered to be the degree of spinal curvature in the frontal plane. The value of humeral index was calculated in the course of dividing the breadth value of a child's humerus from the chest side (cm) on the breadth value of a humerus from the back side (cm)²³.

The evidence of mobility of examined children's spinal columns was estimated in the course of body tilts forward, backwards and sideward. In the course of body tilts forward at straightened legs we determined the distance between the middle finger of each hand and floor surface (cm). In case of body tilts backwards we determined the difference (cm) between the lengths of the line connecting the acanthas' tops of the 7th cervical vertebra with the initial part of intergluteal fold (the estimation was carried out in vertical position and against the background of making tilts backwards). Lateral mobility of spinal column was found in the course

Table: Dynamics' peculiarities of morpho-functional characteristics of examined children with scoliosis against the background of MPT

Parameters	Group of children with scoliosis against the background of MPT, n=36, M±m			Control group n=34, "±m
	initial indices	3 months	6 months	
Deviation of spinal column from the vertical position, cm	4.6±0.24 p ₁ <0.01	3.0±0.48 p ₁ <0.01	1.52±0.12 p<0.01	0.2±0.004
Value of humeral index	0.70±0.15 p ₁ <0.05	0.74±0.14	0.79±0.10 p<0.01	0.90±0.06
Degree of spinal column mobility in the course of tilts to the left side, cm	21.5±1.31 p ₁ <0.05	23.4±0.46	26.5±0.39	32.8±1.45 p<0.01
Degree of spinal column mobility in the course of tilts to the right side, cm	22.6±1.42 p ₁ <0.05	23.8±0.46	26.0±0.24	32.5±2.44 p<0.01
Degree of spinal column mobility in the course of tilts backwards, cm	14.2±0.89 p ₁ <0.05	15.8±0.30	17.2±0.65	22.6±0.72 p<0.01
Chest circumference, cm	60.1±0.36	60.6±0.32	61.6±1.63	61.9±2.56
Waist circumference, cm	52.8±0.46	52.5±0.34	52.0±1.53	51.6±0.86
Thigh circumference, cm	33.5±0.85	34.1±0.76	35.2±0.47	35.8±0.65
Crus circumference, cm	24.5±0.49	24.7±0.51	26.2±0.61	25.4±0.46
Arm circumference, cm	16.1±0.36	16.9±0.28	18.6±0.26	17.2±0.37
Forearm circumference, cm	16.5±0.35	16.9±0.29	17.9±0.28	17.1±0.36
Value of dynamometry from the right side, kg	10.0±0.55 p<0.05	10.5±0.12	10.9±0.06	12.8±0.04
Value of dynamometry from the left side, kg	9.5±0.27 p<0.01	10.0±0.15	10.4±0.12	11.7±0.07
Value of torso strength, kg	34.2±0.16 p<0.05	34.9±0.12	35.6±0.14	36.8±0.31
Tolerance of back muscles (in the position on the abdomen), s	59.2±2.35 p ₁ <0.05	63.0±2.12	66.4±2.9	77.6±2.61 p<0.01
Tolerance of lateral muscles (in the position on the left side), s	57.1±1.57 p ₁ <0.05	59.6±3.05	62.5±2.14	68.2±2.15 p<0.01
Tolerance of lateral muscles (in the position on the right side), s	56.6±2.53 p ₁ <0.05	59.1±2.75	63.2±1.75	67.3±2.24 p<0.01
Tolerance of abdominal muscles, the quantity of possible body bendings	12.8±1.63 p ₁ <0.05	14.2±2.16 p ₁ <0.01	16.7±1.66	21.0±1.49 p<0.01

Conventional signs: p – values of parameters' differences of children with scoliosis and control group, p₁- values of accountable indices' dynamics in children with scoliosis in the course of correction in comparison with the initial ones.

of distance estimation between the ends of hands' middle fingers and floor at maximum tilt sideward from the position of standing strictly vertically. The more given difference was, the more was the mobility of spinal column in frontal plane²².

Estimation of circumference values of chest, waist, thigh, crus, arm and forearm was conducted by traditional methods with the help of a tape measure^{22,23}.

Determination of the level of back muscles' static tolerance was carried out against the background of maximum tilt backwards (body bending) from the position of lying on abdomen at obligatory legs' fixation. We carried out the estimation of period of this pose' keeping. According to duration of body keeping in the pose of the biggest lateral tilt (body bending in frontal plane) from the initial position of lying sideways, we estimated muscle tolerance of side body parts. The tolerance of muscle groups was determined in accordance with durable pose keeping on both sides separately. Clarification of static tolerance peculiarities of muscle group of anterior abdominal wall was conducted in position on the back with fixed legs, according to the number of body up-rises into sitting position²². Strength of hands' muscles was determined in the course of application of carpal dynamometer, and for back muscles – by application of torso dynamometer. Muscles' strength was determined in the course of counteraction to the process of their isometric contraction when muscle tension increased without any changes of muscle length^{22,23}.

All the children with scoliosis were recommended regular medicinal physical training 6 days a week for 6 months.

Recommended complex of medicinal physical training included²⁴: warm-up, execution in lying on the back position and lying on the abdomen position, and also in standing position with 2-3minutes' pauses between separate exercises, and delay.

Warm-up stage included circle walking on all fours. The duration of warm-up composed 2-3 minutes.

Exercises in lying position

1. Gradual "Traction" of spinal column. Being in lying on the back position, the child was stretching out by heels in "down" direction and, simultaneously, he was stretching out by his crown in "up" direction. It was repeated 3-4 times, each session lasted 10-15 seconds.
2. Exercise "Bicycle". In lying on the back position the child put his arms behind the head or along the body and was doing movements by his legs which imitated driving a bike. Medium rate was kept. He repeated the exercise 2-3 times with duration of each one - 30-40 seconds.
3. Exercise "Scissors". Being in lying on the back position with arms behind the head or along the body, the child fulfilled horizontal and vertical crossed strokes by his legs. Medium rate was kept. The exercise was repeated 2-3 times with duration of of each one - 30-40 seconds.
4. Exercise on traction. This exercise was like exercise 1 but the initial position was lying on the abdomen.
5. Exercise which imitated swimming. The child was lying on the abdomen; he was straightening his legs with his head being leaned on dorsal side of hands. He arched and tried to keep this position simultaneously with "swimming" movements:
 - arms were taken forward, legs were parted in opposite sides;
 - arms were parted in different sides, legs were joined;
 - arms were taken to shoulders, legs were kept together.
 They repeated 2-3 approaches with 10-15 exercises and had a little rest between them (duration 5-10 seconds).
6. Exercise "Scissors". The children were lying on the abdomen. The legs were kept straight; the heads were to lean on dorsal sides of hands. Then they raised their legs and fulfilled crossed vertical and horizontal strokes by them, turning them off the floor. Medium rate was kept. They repeated 2-3 approaches with duration of each one – 30-40 seconds.
7. Exercise on keeping. In lying on the abdomen position they straightened legs and leaned their heads on dorsal sides of hands. They

raised their legs and upper part of the body and bended in the field of loin. The legs were joined together, the arms were parted in opposite sides, the hands were turned upwards with keeping of this pose in given position for 10-15 seconds. One shouldn't decelerate his breathing in the course of the given exercise and just try to turn his thighs off the floor. They repeated 3-4 times with some rest between series of exercises (5-10 seconds).

Exercises in standing position:

8. Exercise with arms' rotation. The children were standing in front of a big mirror, the elbows were parted laterally, and the fingers were taken to shoulders. They fulfilled rotary movements backwards by their arms. Elbows were to draw a circle during rotation. The rate of movements was slow. They repeated 2-3 approaches of 20-30 seconds' duration with short rest between them.

9. Exercises on squatting. The children were standing in front of a big mirror, the arms were parted laterally, and the hands were turned upwards. Then they rose on tiptoe and again returned into the initial position. They repeated 5-10 squats with brief episodes of rest. The slow rate of exercises was kept.

Delay stage included circle walking on all fours. The duration of delay composed 2-3 minutes.

In the course of our research the children were observed and examined at the beginning, in 3 months and in 6 months of regular MPT.

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

RESULTS

Observed 5-6-year old children with scoliosis had some lagging of morpho-functional characteristics from children's level of the control group at the beginning (table).

Against the background of regular MPT sessions the children with scoliosis already in three months were noted to have lowering of deviation degree from the vertical position on 34.8% which additionally lowered to the end of correction till 1.52 ± 0.12 cm. In three months of regular MPT

sessions children with scoliosis had lowering of the value of humeral index on 5.7% which reached the values 0.79 ± 0.62 to the end of observation (table).

Application of MPT for 3 months provided the children with an upward trend of spinal column mobility in three planes which reached the level of statistical signification in 6 months of observation (to the right side till 26.0 ± 0.24 cm, to the left side till 26.5 ± 0.39 cm, backwards till 17.2 ± 0.65 cm).

In the course of MPT sessions the children with scoliosis already in three months were found to have significant positive dynamics of dynamometry indices. So, strength of hands' muscles from the right side reached 10.5 ± 0.12 kg, strength of hands' muscles from the left side reached 10.0 ± 0.15 kg, at the value of torso strength on average 34.9 ± 0.12 kg. In 6 months of MPT sessions children with scoliosis had additional growth trend of registered dynamometric parameters – on the right hand on 3.8%, on the left hand on 4.0%, at some rise of torso strength (table).

In the result of MPT course the examined children with scoliosis had significant rise of muscle tolerance of different muscle regions. So, the examined children already in 3 months were found to have rise of tolerance level of abdominal muscles on 10.9%, back muscles on 8.1%, lateral muscles from the left side on 4.4% and lateral muscles from the right side on 4.2%. But these results were not sufficient for reaching the level of the control group. Continuation of regular MPT sessions with children with scoliosis helped to deepen found positive dynamics of strength characteristics of back muscles and muscles of abdominal wall to the 6th month of research. However, it didn't allow them reaching the control level (table).

DISCUSSION

Collected by the present time data in physiology of preschoolers are still difficult to be called exhaustive²⁵. Conducted regular researches on peculiarities of functioning of their locomotor apparatus haven't yet given the necessary volume of information. It is acknowledged that different pathological manifestations in children's bodies can

appear at development of various abnormalities in environmental optimum which is necessary for their normal development¹¹. At present we see growing number of children with various disharmony of their physical status in developed countries. It was noticed that their locomotor apparatus was especially vulnerable^{8,18}.

Various abnormalities develop in children's musculoskeletal system in the process of intense growth against the background of unfavorable environmental impacts. Scoliosis is considered to be rather widespread. And frequency of its occurrence at present rose significantly²³. In Russia we have an evident growth trend of preschoolers' number with the given pathology. Disturbances in different internals' performance develop against the background of scoliosis with aging. It influences negatively their health on the whole. First of all, it is connected with weakening of metabolism, lagging of physical development and inhibition of psychic activity^{7,23}.

It was noted by researchers that the level of metabolic processes and success of internals' work are under strong impact of locomotor system. Low energy outlays, which are typical for bodies with scoliosis, inhibit anabolism in internals' cells and strengthen existing abnormalities in the body. Deceleration of oxygen and nutrients' inflow into muscles and bones against this background and inhibition of different metabolic products' removal out of them worsen the common state¹¹. All these factors lead to the situation when in conditions of scoliosis the work of locomotor system takes place at constant energy deficiency which is caused by hypoxia and deceleration of microcirculation against the background of arterioles' spasm and platelets' activation¹⁵.

It becomes clear that working out of effective variants of scoliosis correction and efficient approaches to its prophylaxis is becoming more and more actual for rehabilitation of children with scoliosis²⁶. Further investigations of impact mechanisms of various correction variants on a child's body with scoliosis should become a serious step for modern rehabilitology²⁷. Estimation of new and already known ways of given pathology

correction in children of preschool age should be carried out, taking into consideration the results of many-sided researches and obligatory account of morpho-functional status' dynamics of children with scoliosis against the background of their application..

In the result of conducted research we could state that systematic application of MPT sessions to 5-6-year old children with scoliosis influenced positively the values of humeral index, the level of muscle strength and tolerance. Significant energy outlays against the background of active muscle activity strengthened the course of processes in musculoskeletal system and most internals of a child's body. A demand for the course of restoration processes which can replace spent at MPT sessions energy resources in muscles, always lead to inflow of a great amount of nutrients and oxygen to bones and muscles. It causes active washing of toxic products out of them. All this provides strengthening of a child's growth and restoration of locomotor system on behalf of the increase of muscle mass, thickening of bones and optimization of their functional state.

Regular muscle activity at MPT sessions leads to active decay of energy containing molecules, simultaneously creating all the physiological preconditions for continuous resynthesis of macroergs²⁸. Existing situation also stimulates the synthesis of nucleic acids and proteins in locomotor system and internals. It should be considered as physiological basis for rehabilitating impact of medicinal physical training. Its sessions strengthen vital activity of the whole child's body²⁴. Developing against the background of MPT changes in children's bodies promote activation of trophism in cells as they stimulate circulation, breathing and functioning of enzymes. It creates the most favorable conditions for metabolism and child's adaptation to conditions of the environment.

So, application of medicinal physical training to 5-6-year old children with scoliosis for half a year increases the efficiency of organs' interaction providing positive changes in a body against the background of active muscle activity. It optimizes physical characteristics of a body. However, it doesn't allow removing all manifestations of scoliotic disturbances.

CONCLUSION

Living in Central Russia 5-6-year old children with scoliosis of I-II degree have typical symptoms of evident deceleration of physical development. In their case it is pointed by lowering of somatometric indices, decrease of body muscles' strength, level of their tolerance and degree lowering of spinal column mobility. A course of medicinal physical training, applied to these children for half

a year, can lower the evidence of spinal curvature, increase the strength and level of body muscles' common tolerance. However, it doesn't provide reaching the control level by these indices. Given research should be continued and directed at assessing the dynamics of somatic characteristics of children with scoliosis against the background of modern corrective effects. As such, we can offer to use daily long-term wearing of special medioprophyllactic clothes.

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