

## Correction of 6 to 10-year-old schoolchildren postures using muscular-tonic imbalance indicators

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### Abstract:

*Purpose:* to work out program of differentiated correction of 6-10 years' age schoolchildren's postures by means of physical education. *Material:* At initial stage (medical examination) 216 schoolchildren (girls and boys of 6-10 years' age) were examined. In children, who had no visible posture disorders, (n=156) we registered indicators of bioelectrical activity of back skeletal muscles on both sides of backbone. For this purpose we used method of surface electromyography. In the next stage 107 children of primary school age participated. Written consents of parents for children's participation in experiment were received. *Results:* the researches showed that stretched muscles of convex side generate bioelectrical activity of higher amplitude that the muscles of concave side. It causes backbone bending to the side of weakened muscles and creation of favorable for further backbone deformation's progressing conditions. The value of muscular tonus (in the form of electromyography signal from symmetric muscles of backbone) can be an informative indicator for diagnostic of backbone position's disorders and for efficiency of posture disorders in frontal plane efficiency. For local influence on back muscles we used asymmetric loads, which selectively strengthened muscles on the side of low reflex excitation. Besides, we used exercises, oriented on muscles' stretching and relaxation on the side of increased reflex excitation. Such methodic approach permits to reduce the difference of impulses flow from periphery (of muscles) between right and left torso sides to central nervous system. *Conclusions:* it is recommended to conduct current control over children's postures on the base of electromyography signals' form back symmetric muscles registration. The control data will permit for physical culture teacher to determine efficiency of correction trainings and analyze the whole system of correction influences. It will also permit to promptly correct loads, analyze correctness of exercises' fulfillment, and introduce individual changes in content of health related trainings.

**Keywords:** posture, students, spine, stress, physical culture.

### Introduction

Posture is one of primary school age children's health characteristics. That is why prophylaxis of posture disorders requires attention from parents, medical personnel and school teachers. Physical education classes can be considered to be the most effective measures of posture disorders' prophylaxis and correction. Special physical exercises and proper organization of school health related measures influence on formation of children's correct posture to the largest extent. The quality of surroundings and children's annual medical examination are of not less importance.

Recent years the cases of deviations in primary school age children's muscular skeletal apparatus have been being registered still oftener. By different data disorders of posture is observed in 63% of children (Aks'onova, Varban, & Vasil'iev, 2012). For most of first form pupils posture disorders have become typical (Swamy, Isroff, Mhanna, & Chouksey, 2016). All these reduce indicators of schoolchildren's general health level. That is why it is necessary to support by all means and develop schoolchildren's motor fitness (Ivashchenko, & Yermakova, 2015a, 2015b; Bliznevsky et al., 2016; Pomeschchikova et al., 2016). It should be noted that in every age period posture has its own peculiarities. In different age periods child's steady vertical position is achieved at the account of muscular efforts of different level and different inter-location of body parts. That is why normal posture of pre-school age children, primary school children and adolescents will be characterized differently (Lovejko, 1982; Kozina, Repko, Ionova, Boychuk, & Korobeinik, 2016; Kuzmin et al., 2016). As per different data morphologically correct posture of schoolchildren is: head is bent forward a little, shoulders are at one horizontal level, shoulder blades are pressed to back, abdomen is a little convex, physiological curvature of backbone is noticeably expressed, spinous processes are located on one line (Popov, 1999; Potapchuk, & Didur, 2001).

The most stable posture is characteristic for children up to 10 years' age. It is difficult to achieve ideal posture, because it is individual for every person. Alongside with it the requirements to correct posture are common for all and can serve an "indicator" of posture disorders (Popov, 1999):

1 stage – little changes of posture, which can be removed by activation of child's targeted attention to this problem;

2 stage – increase of posture disorders' symptoms. These symptoms can be removed by unloading of child's backbone in horizontal position or by body suspension;

3 stage – posture disorders, which can not be removed by backbone unloading. For pre-school age children 1<sup>st</sup> and 2<sup>nd</sup> stages are the most characteristic, while for schoolchildren – 2<sup>nd</sup> and 3<sup>rd</sup> stages.

As per different definitions posture disorders shall be understood as unstable deviations of backbone in sagittal and frontal planes. In sagittal plane scientists distinguish five kinds of posture disorders, caused by reduction (two kinds) and increase (three kinds) of physiological curvatures. In case of physiological curvatures reduction, the following disorders take place: flat and flat-concave back. Reduction of physiological curvatures results in slouch, round back and round-concave back. (Ovechkina, Drozhzhina, & Suvorova, 1999; Coelho et al., 2014; Czaprowski, Pawłowska, Stoliński, & Kotwicki, 2014). In frontal plane species property of posture disorder is absent. Such posture disorder is called "asymmetric posture" and is caused by disorder in central location of spinous processes and their shifting from vertical axis (Popov, 1999; Böhm, & Döderlein, 2012). With posture disorders in frontal plane it is necessary to detect, if they are unstable or fixed (Chogovadze, 1987). In such cases external medical examination is of great importance. Other data point, that curvature of backbone in frontal plane can be conditioned by weakness of deep muscles of back (Dorokhov, & Novikova, 2002). It is caused by reduction of postural muscles' strength that results in muscular imbalance (Abu, 2003).

In other studied of posture disorders it was found the following: with asymmetric posture there exists asymmetry of muscular tonus from right and left torso sides and muscular general endurance is weakened (Popov, 1999; Komeili, Westover, Parent, El-Rich, & Adeeb, 2015); the highest quantity of posture disorders is observed in frontal plane (Chovgan, Ivanishyn, & Prezliata, 2014; Dudko, 2015); for correction of posture disorders close cooperation of rehabilitation team is required (Kovalenko, & Nechyporenko, 2014; Andrejeva, Mockiene, & Zukauskienė, 2015); it is necessary to correct psychological state and posture that is connected with formation of morphological features (Tamožanskaya, 2015). Success of early diagnostic of posture disorders can characterize analysis of reflex excitation of motor spinal cord, which innerves muscles on both sides of backbone (Spirin, & Denisov, 2002). But the mentioned methods require presence of appropriate instrumentation with necessary software and specialists-operators.

Among different approaches to early diagnostic of posture disorders we can mark out electromyography method. Standard electromyography permits to receive objective information about functional state of children's with scoliosis muscles; to conduct and realize assessment of rehabilitation process's effectiveness (Kupreenko, 2015). In other works it was possibilities of surface electromyography are shown for: differentiation of muscular fatigue under cyclic progressing load (Skladaniv'ska, 2014; Skladaniv'ska, & Sharafutdinova, 2014); determination of different body segments', responsible for posture, muscular activity (Perinetti, Türp, Primožič, Di Lenarda, & Contardo, 2011); study of muscular activity by non-invasive method and assessment of terms of muscular activation in motion (Agostini et al., 2010); study of changes in children's muscular activity in sitting position in time of fulfillment of a cognitive task (Igarashi, Karashima, & Hoshiyama, 2016). The authors note that study of electromyography activity of torso extensors permits the following:

– To assess if muscular activity varies depending on different degree of task's heaviness (Grazziotin dos Santos et al., 2015).

– To determine activity of backbone muscles during fulfillment of functional tasks by children with coordination disorders and without them (Kane, & Barden, 2012).

In such cases interpretation of electromyogram (EMG) to large extent depends on the following: methodic specificities of experiments (Cipin, 2015); theoretical knowledge and methodological principles, required for assessment of backbone abnormal functioning in school age children (Mihăilă, & Șlicaru, 2014).

In our previous works we determined that posture correction with the help of correction exercises can give good effect only if simultaneously habits of correct posture are formed. For this purpose it is necessary to create muscular-joint feeling, which permits to feel position of separate body parts (Razumeiko, 2015a). It was proved that prophylaxis measures are purposeful only at early stages of in work of muscular system. Traditional approach in the form of prophylaxis examination can not give confident information about initial stages of child organism's muscular work imbalance (Razumeiko, 2015b). It is important to substantiate selection of adequate tests (Khudolii, Iermakov, & Prusik, 2015; Khudolii, Iermakov, & Ananchenko, 2015) and pedagogic control over schoolchildren's motor qualities (Ivashchenko, Yermakova, Cieslicka, & Muszkieta, 2015; Ivashchenko, Yermakova, Cieslicka, & Śukowska, 2015; Ivashchenko et al., 2016). In our other researches it is noted that it is necessary to practice early diagnostic of posture disorders in children that is one of important elements of diagnostic and treatment of postural defects (Mrozkowiak, Posłuszny, Żukowska, Iermakov, & Szark-Eckardt, 2014). Schoolchildren's involvement in active practicing of health related physical culture and sports is of not less importance (Iermakov, et al., 2016; Kozina, Iermakov, Kuzmin, Kudryavtsev, & Galimov, 2016);

Pryimakov, Iermakov, Kolenkov, Samokish, & Juchno, 2016) as well as formation of their health culture (Kudryavtsev, Kopylov, Kuzmin, Ionova, & Yermakova, 2016).

Thus, from the point of view of physiological laws child's posture is a dynamic stereotype. It is proved by complex of worked out and mutually conditioned conditional reflexes in certain external medium. That is why child's posture can change, in spite of relative stability of anatomic factors. Posture can improve in the process of special physical culture and sports trainings. But posture can also worsen when stereotype disorders: when life regiment changes after starting learning at school. It is evident that early diagnostic methodic of posture functional disorders is required and it shall be adapted to competence of physical culture teacher.

*The purpose of the work* is to work out program of differentiated correction of 6-10 years' age schoolchildren's posture by means of physical education.

## Material & methods

### Participants

At initial stage (medical examination) 216 schoolchildren (girls and boys of 6-10 years' age) were examined. In the next stage 107 children of primary school age participated. Written consents of parents for children's participation in experiment were received. The research related to human use has been complied with all the relevant national regulations, institutional policies and in accordance with the tenets of the Helsinki Declaration (<http://www.wma.net/en/30publications/10policies/b3/index.html>). The study protocol was approved by the Ethical Committee of University.

### Procedure

1) *Expert assessment of children's postures*: for control of postures of the tested children we examined them for presence or absence of external signs of posture disorders. The examination was fulfilled by qualified medical doctors. Examination of 216 primary school pupils permitted to form group of 156 children, who had no external signs of posture disorders. In examination they used the methodic of posture assessment of Lovejko I.D. (1982).

2) *Electromyography*: in children without external signs of posture disorders (n=156) we registered indicators of bioelectrical activity of back skeletal muscles on both sides of backbone. For this purpose we used method of surface electromyography (EMG). This registration was fulfilled with the help of electromyography instrumentation complex.

Muscular asymmetry on right and left torso sides was determined by registration of bio-potentials of back symmetric muscles. As a result of researches we chose (*m. trapezius*) and (*m. latissimus dorsi*) back muscles. Just these muscles are in group of back anti-gravitation muscles. They characterize vertical symmetry of backbone that is the main link in backbone deformation (Vovk, Galian, & Ivanov, 2012). We determined asymmetry of *m. trapezius* and *m. latissimus dorsi* back muscles.

Electromyography of skeletal muscles on right and left torso sides was determined in rest state and in fulfillment of test exercise. Before the procedure we treated with antiseptic the areas of skin, which contacted with sensors. Then sensors, connected to myograph were fixed on the tested muscles. For fulfillment of test exercise the tested lied across bed with face downward and hands on belt. The sensors were attached to left and right halves of torso. First we measured indicators in rest state. Then the tested fulfilled exercise "Power endurance of back muscles" during 10 seconds. Registration of the mentioned muscles' activity took 2 seconds after fulfillment of test exercise. All indicators were registered by computer.

Methodic approaches to assessment of electromyography indicators (EMG) of muscles on both sides of backbone implied the following: registration of electric activity (EA) of back pair muscles (*m. trapezius* and *m. latissimus dorsi*) was conducted in standard way, i.e. we measured EMG amplitude of right side and left side back muscles and calculated asymmetry coefficient (relation of EMG amplitude on right side to EMG amplitude on left side).

The received data were analyzed in the following way: on backbone side with higher amplitude skeletal muscles' activity was noted as increased. Accordingly, on the opposite side it was noted as weakened (Latash, & Gurfinkel, 1976).

When studying EMG we analyzed the following (see fig. 1a):

- Maximal peaks of EA EMG amplitude of frequency spectrum on right and left sides;
- EMG power during 10 seconds;
- EMG mean amplitude for 10 seconds;
- Asymmetry coefficient.

Localization of skeletal muscles' increased activity was determined by shift of maximal peak to side of high frequency indicators. Accordingly, lower frequency was related to weakened activity of skeletal muscles. Higher EMG power in the range of high amplitudes on one side permitted to state the presence of back muscles imbalance.

3) *Correction of posture by means of physical education*: asymmetry of *m. trapezius* and *m. latissimus dorsi* was detected in 107 children. These children were divided into two control groups (CG1 – n=36, CG2 – n=35) and one experimental group (EG – n=36). In CG2 we did not conduct special experimental measures on

posture formation. In CG1 children were trained in special health group for posture disorders by program of Maier V.I. (2006). In EG we applied correction methodic, in which we used the data of electromyography.

During academic year with CG1 and EG children we conducted health related trainings, oriented on prophylaxis of posture disorders in frontal plane. Correction exercises in CG1 and EG took 25 minutes. The main part of CG1 and EG health related trainings included correction exercises (55–75% from total training time), relaxation exercises (5–10%), breathing exercises (BE) - (10%) and outdoor games - (10–15%). Distinctions in methodic of health related trainings were the following:

In Cg1 children were trained as per program for special health group of muscular skeletal apparatus disorders (Maier, 2006), where correction exercises were oriented on prophylaxis of posture disorders and were conducted without registration of one-side increased reflex excitation of appropriate muscles. The trainings were conducted by traditional methodic of symmetric training of muscles, which make natural “muscular corset”, with accent on development of strength and power endurance of the mentioned muscles.

In EG trainings were conducted by methodic, constructed on the base of EMG signals’ registration on back symmetric muscles, considering detected one-side increased excitation of back muscles. EMG indicators were registered one time every three months. So, during academic year EMG registration was carried out four times.

At the beginning of pedagogic formation experiment all EG children were offered equal quantity of exercises of symmetric and asymmetric character, considering the found localization of increased excitation on right or left torso sides. Fulfillment of asymmetric correction exercises was controlled by teacher on the base of indicators of back symmetric muscles’ imbalance. For obviousness and increase of children’s consciousness in fulfillment of correction exercises bright band was applied on one of lower limbs, which pointed localization of back muscles’ imbalance.

*Pedagogic testing:* the level of physical qualities of the tested children was assessed on the base of pedagogic testing results. For assessment of torso muscles’ power endurance we used test exercises (Lovejko, & Fonarev, 1988):

1. “Power endurance of abdomen muscles” was determined in the following way: from lying position with bent legs and arms crossed and positioned on shoulders – sit, then – return in initial position.

Methodic instructions: the quantity of repetitions is assessed; exercise is fulfilled in free temp with observation of technique of fulfillment (without jerks at the beginning of movement; both shoulder shall be raised simultaneously).

For assessment of abdomen muscles’ strength children were offered to fulfill maximal quantity of torso rising from lying to sitting position with arms crossed and positioned on shoulders; bent legs were hold by assistant. Temp of fulfillment was slow: not more than 16 times a minute. If torso was raised with one shoulder directed forward, testing was stopped. Norm of fulfillment was 15-20 times.

2. “Power endurance of back muscles” was determined from initial position: lying on abdomen across bench with hands on belt; then take horizontal position of torso and keep it.

Methodic instructions: the time of exercise’s fulfillment is assessed; when fixing legs, it is necessary to arch a little and keep head straight with shoulders on one level.

For assessment of back muscles’ strength pupil took position lying on abdomen across bench; upper part of torso shall be in the air with hands on belt (legs are hold by assistant). For control over technique of the test’s fulfillment spinous processes were marked with iodine solution. Power endurance of lumbar muscles was assessed by maximal time of this position holding. Stop-watch was started at the moment of taking torso horizontal position and stopped when torso took position below horizontal or technique of exercise’s fulfillment became incorrect (shifting of spinous processes to the right or to the left). Norm was 60-120 seconds.

3. “Power endurance of torso side”: initial position –lying on right (left) side across gymnastic bench; feet are fixed; one hand rests on floor and other is on belt. Then move hand from floor to belt and keep the position.

Methodic instructions: time of holding static position is registered; the exercise shall be fulfilled on right and then on left side. Between exercises there shall be passive rest of duration not less than two times longer than exercise’s fulfillment. Position is assessed until torso is in horizontal state.

For assessment of power endurance of torso right and left sides the pupils were offered to hold horizontal position lying on side across bench with hands on belt. The time of this exercise’s fulfillment permits to find functional potentials of torso sides’ muscles. Testing was stopped if torso dropped lower than horizontal position or if straight line “torso-legs” was disordered. Norm was 60-90 seconds.

The testing was carried out at the beginning and at the end of pedagogic experiment.

#### *Statistical analysis*

Statistical processing included assessment of mean arithmetic, confident interval. For characteristic of inter group differences we used Student’s t-criterion. Level of significance  $p < 0.05$  was considered confident. Processing of data was fulfilled in program Excel (Nachins’kaia, 2005).

#### **Results**

Registration of surface bioelectrical activity of back skeletal muscles and assessment of “muscular corset” state were used as method of detection of muscular asymmetry from right or left torso sides. Such choice

is conditioned by the following factors. Functional state of muscular skeletal apparatus muscles can be characterized by the following informative indicators: strength of muscular contraction, elasticity and stretching; degree of tiredness, muscular tonus. Even in state of complete rest skeletal muscle preserves its elasticity and certain tonus. These bio-mechanical indicators are rather well reflected by electromyography signal. For muscles, which are in norm, there exists muscular balance (symmetry): equality of tonus values of symmetric in respect to backbone muscles. With pathological processes there happens not uniform reduction of muscles' functional properties on both sides of torso that is connected with unequal bio-mechanical conditions of their work.

The stretched muscles of convex side generate higher by amplitude bio-electrical activity than muscles of concave side. It facilitates backbone bent to the side of weakened muscles and creation of favorable bio-mechanical conditions for further backbone deformation (Vovk, Galian, & Ivanov, 2012). The value of muscular tonus in the form of electromyography signal from symmetric muscles of back can be an informative indicator for diagnostic of backbone vertical orientation and be and indicator of disorders correction' efficiency.

In fig. 1a we can see that indicators of EA amplitude from right and left sides of *m. trapezius* in the range of 13-16 seconds do not coincide (difference more than 0.20 mV). Shift of maximal peak to the side of high frequency indicators points at increased activity of skeletal muscles on the right side. Components of *m. trapezius* EMG in the range of 16-18 seconds register expressed frequency EMG characteristics on torso right side. With it asymmetry coefficient is 0.22 mV. It points at increased activity of *m. trapezius* on the right side. Analysis of *m. latissimus dorsi* showed that in the range of 11–13 seconds no substantial differences in EA amplitude of the muscle was found. Though, in the range of 14–16 seconds we registered expressed EMG frequency characteristics on right side. Difference of EA indicators was 0.25 mV. It points at increased activity of *m. latissimus dorsi* on the right side. Coefficient of asymmetry was 0.50 mV.

From 156 children without visible signs of posture disorders in frontal plane, in 49 children (31.4%) we did not detect early symptoms of muscular imbalance on backbone both sides. However, in 107 of examined children (68.6%) we registered differences between EA of torso right and left sides' muscles. Analysis of the received data showed the following: in 82% of children on the right side and in 18% - on the left side amplitude of skeletal muscles electrical activity was higher than on opposite side. It is known that in formation of pupils' correct posture natural "muscular corset" participates. To large extent it determines firmness of posture, ability to keep body position for long period of time (Lovejko, & Fonarev, 1988; Golovina et al., 2000). For determination of muscles' functional potentials children were offered to fulfill test tasks, which characterize power endurance of abdomen muscles, muscles of torso sides and back.

Comparative analysis of pedagogic testing of back muscles' power endurance with proper indicators showed insufficient level of power endurance (see table 1). Statistical processing of results of torso sides' power endurance showed asymmetry in static power endurance of torso right and left sides in most of the tested children. Inter-group differences by development of torso sides' muscles were not confident ( $p > 0.05$ ). Comparative analysis of the data with proper standards also showed insufficient level of torso sides' static endurance.

Table 1. Indicators of torso muscles' power endurance in CG1 (n=36), CG2 (n=35) and EG (n=36) at the beginning and after pedagogic experiment

Testing	Groups	As on beginning of pedagogic experiment	After pedagogic experiment	Norm
Power endurance of back muscles (seconds)	CG1	41.7±1.6	46.9±1.8	60–120 seconds
	CG2	41.5±1.7	40.6±1.6	
	EG	39.2±2.2	59.6±3.6	
	p	>0.05	<0.05	
Power endurance of abdomen muscles (quantity of times)	CG1	16.8±0.9	19.2±1.8	15–20 times
	CG2	16.5±0.9	15.1±0.9	
	EG	15.7±0.9	21.2± 1.2	
	p	>0.05	>0.05	
Power endurance of torso side muscles (seconds) from the side of weakened EA of back muscles	CG1	57.4±2.8	76.4±3.4	60–90 seconds
	CG2	58.1±1.9	54.2±2.6	
	EG	56.3±2.1	83.8±2.8	
	p	>0.05	>0.05	
Power endurance of torso side muscles (seconds) from the side of increased EA of back muscles	CG1	61.08±2.8	82.1±3.3	60–90 seconds
	CG2	60.3±1.9	59.1±2.1	
	EG	59.4±1.9	84.7±2.8	
	p	>0.05	>0.05	

Notes: CG1-control group 1; CG2 – control group 2; EG – experimental group; h – level; of confidence.

For local influence on back muscles we used loads of asymmetric character, which selectively strengthened muscles on side of weak reflex excitation. Besides, we used exercises, directed on muscles' stretching and relaxation on the side of increased reflex excitation. Such approach permits to reduce difference of

impulses flow from periphery (muscles) on right and left torso sides to central nervous system. It will prevent from asymmetry of muscular tonus in the future.

Methodic of differentiated correction of posture disorders in EG children implied the following: registration of electromyography signals permitted to analyze every child's bioelectrical activity of back symmetric muscles. It permitted to determine on what sides of backbone activity of skeletal muscles is increased; accordingly this side was loaded with stretching or relaxing exercises. The side of weakened activity of skeletal muscles was loaded by strengthening exercises. Thus, teacher's actions were directed at "equalizing" of skeletal muscles' activity on both sides of backbone with the help of asymmetric loads. Alongside with asymmetric exercises we used correcting symmetric exercises (Razumejko, 2016).

After three months of prophylaxis measures repeated EMG registration permitted to find relevance or non relevance of the offered prophylaxis measures, considering specific features of functioning of lumbar symmetric muscles of every child. For example in the tested (16. 7%) EG children the offered correcting method ensured expressed positive dynamic. It reflected in approximation of torso right and left sides' EMG characteristics. EMG characteristics of back muscles (of pupil K. after three months of prophylaxis measures) witnessed about clearly expressed tendency to their approximation (see fig. 1b) In the figure we can see that indicators of EA amplitude from right and left sides of *m. trapezius* do not coincide in the range of 13-16 seconds (difference is 0.14 mcV, which increased by 0.06 mcV for three months). Components of *m. trapezius* EMG in the range of 16-18 seconds show expressed EMG frequency characteristics on torso right side (asymmetry coefficient was 0.10 mcV; its value reduced by 0.12 mcV). Analysis of *m. latissimus dorsi* showed that in the range of 11–13 seconds there was no substantial difference in EA amplitude of the muscle. Though, in the range of 14-16 seconds we registered expressed EMG frequency characteristics on right side. Difference of EA indicators was 0.25 mcV that points at increased activity of *m. latissimus dorsi* on the right side. Asymmetry coefficient was 0,10 mcV. In this case we can assume that the offered for this child training methodic positively influenced on removal of backbone symmetric skeletal muscles' imbalance. For the rest of children (83.3%) the offered level of load on the affected area of muscles turned out to be insufficient that was pointed at by the received characteristics of summarizing electromyogram.

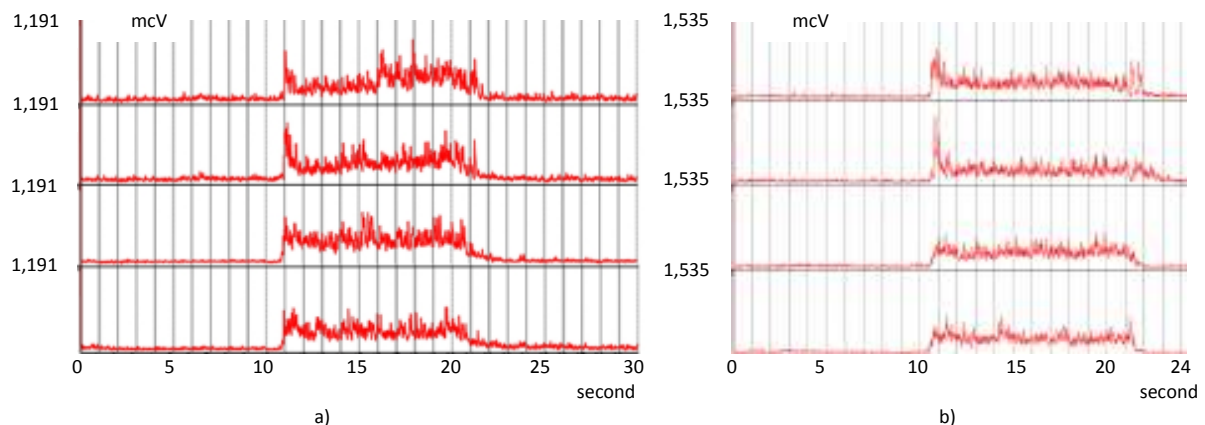


Fig. 1. Electromyogram of back muscles from torso right and left sides (the tested K., 9 years old): a – beginning of experiment; b – three months after experiment.

Current control over EG children's posture permitted for teacher to determine efficiency of correction trainings and fulfill analysis of all system of correction influences. It permitted to promptly correct loads, analyze technique of the fulfilled exercises; introduce individual changes in content of health related trainings. If children did not manifest positive shift in reduction of imbalance of back symmetric muscles, then current changes were introduced in content of correction trainings, in the form of increase of asymmetric correction exercises' percentage. After two control electromyography registrations all EG children were divided into three subgroups. Exercises in every subgroup were identical; distinctions were only in the volume of symmetric and asymmetric exercises.

In first subgroup (n=7) this correlation was as follows: 95% – symmetric exercises and 5% – asymmetric. In second subgroup (n=15) approximately 90% were symmetric correction exercises and 10% - asymmetric. In third subgroup (n=14) this correlation was 85% of symmetric exercises and 15% - asymmetric.

With equalizing of asymmetry of torso right and left sides' muscles (reflected in approximation of EMG characteristics) the portion of asymmetric exercises decreased and quantity of symmetric exercises – increased. Such approach permitted to render targeted influence in compliance with children's individual features.

It should be noted that it was practically impossible to predict the quantity of subgroup and children in subgroups at the beginning of experiment. Involvement in experiment children with different features of skeletal muscles imbalance could require higher or lower quantity of subgroups. Distribution of children into subgroups

for selection of effective correction programs is possible only on the base of confident feedback, which is ensured by current control on the base of back muscles' EMG indicators.

All correcting exercises were fulfilled in position unloading backbone: lying on abdomen, on back, on side, standing on knees. In such initial positions we achieved straightening of backbone and symmetric positioning of body parts. It permitted to increase effectiveness of physical exercises at the account of local influence on some muscular groups.

Formation of correct posture shall be realized through imaginable and visual idea of it. Imaginable idea is formed by physical culture words as ideal location of body in space (head, shoulders, legs, and torso). Visual picture was created by direct example of teacher's posture. At every training child shall see correct handsome posture of teacher, who demonstrates it during the whole lesson. For formation and mastering of correct posture's visual picture gym shall be equipped with mirrors for children to see themselves completely and analyze own posture.

The complex of correction exercises included exercises for stereotypes of correct posture. They are:

- 1) exercises, based on strengthening of muscular-joint feeling;
- 2) exercises with visual control over correct posture;
- 3) exercises for training balance;
- 4) balancing exercises.

Teacher shall form children's conscious attitude to posture formation as well as constantly encourage children, who try control their posture at classes and in everyday life. Verbal pedagogic influence will be more effective if it is realized on acceptable for children level and opens significance of handsome posture for health and high physical potential.

Every health related training traditionally consists of three parts. First part (preparatory) gradually adapt child's organism to physical load. Main content of this part includes different kinds of walks, run, jumps, general exercises in combination with breathing exercises. It takes 3-5 minutes.

Second part is the main (15-20 minutes) and is targeted at solution of main tasks on prophylaxis of posture disorders in frontal plane with the help of special correction exercises. In the main part formation of correct posture takes place on the base of:

- Increase of proprioceptive muscular feeling;
- Usage of visual control over keeping correct posture;
- Application of exercises for balance and balancing, requiring development of vestibular apparatus.

Application of different combinations of correction exercises with breathing exercises and relaxations of actively working muscles. For fixing of correct posture skills and increase of children's interest to health related trainings we used outdoor games.

The third, (final part, which takes 3-5 minutes) is pointed at gradual reduction of loads, calming of child's organism after active physical work, moving of respiration and blood circulation systems to calm rhythm of operation. The main content of this part includes exercises for relaxation, calm games for attention, coordination, balance.

Healths related trainings in CG and EG were practically identical. Specificities of EG health related classes implied selection of correction exercises for every child, considering one-side increased excitation of torso muscles.

At the end of academic year (by the finish of pedagogic experiment) CG and EG children passed repeated medical examination for presence or absence of posture disorders. We compared electromyograms of lumbar muscles of torso right and left sides and assessed power endurance of skeletal muscles, serving backbone.

Finalizing medical examination showed that in CG2 (children did not fulfill correction exercises) in 41.2% of children scoliosis signs of backbone were present. In CG1 (children were trained by program for special health group for muscular skeletal apparatus disorders) in 18.3% of children scoliosis signs were found. In EG (trainings considered detected muscular imbalance) scoliosis was not detected.

Pedagogic testing of torso muscles' power endurance permitted to determine muscles' condition, which make natural "muscular corset" (see table 1).

Low results of CG1 are explained by the fact that symmetric training of muscles restricted the volume of correction exercises. It manifested obviously in incorrect technique of exercise's fulfillment: with fatigue on one torso side the line of spinous processes shifted to the right or to the left. It required stoppage of testing. Statistical processing of back muscles' power endurance showed confident differences between results of control and experimental groups ( $p < 0.05$ ). These results permit to say that confident information about imbalance of back muscles on the base of EMG registration facilitates more effective strengthening of back muscles.

## Discussion

In posture defects in frontal plane removal main role is played by symmetric exercises, which ensure equalizing of muscular efforts and are directed at liquidation of muscular tonus's imbalance (Sharmanova, Fedorova, & Kalugina, 1999). Fulfillment of symmetric correction exercises with attention to central position of backbone, resistance to its deviation to the side of stronger muscles cause higher tension on weaker side

(Lovejko, & Fonarev, 1988). Results of series of experiments permitted to find that health related effectiveness of symmetric correction exercises fulfilled by children with one-side increased reflex excitation, is restricted by weakening of muscles on one side of torso. Weakness of muscles on one side of torso causes quicker fatigue and backbone side deviation. In this case it is necessary to stop correction exercise (Spirin, & Denisov, 2002).

One of the most important elements of correcting methodic of health related physical culture for primary school age children is selection of physical load level. Insufficient physical load will not result in expressed health related effect through insufficient mobilization of physiological functions. Excessive physical load can result in unfavorable after-effects in central nervous system, in muscular-skeletal apparatus (slowing of growth) and simply in loss of children's interest to the trainings.

In order to determine optimal limits of load it is necessary to clearly understand children's maximal potentials, information about which it is possible to receive with control tests (Khudolii, & Titarenko, 2010; Podstawski, & Boryslawski, 2014; Semanychyn, & Popel', 2015). In compliance with it correction exercises were dozed on the base of control testing of strength and power endurance of "muscular corset" muscles. In complexes of correction exercises we used power exercises with dynamic and static loads. Static exercises were preceded by dynamic power exercises. Approximately 95-85% from total quantity of correction exercises were dynamic exercises. Static exercises were 5-15%. In fulfillment of static correction exercises the load of them was 50-70% from maximal results, shown in control testing.

With regular repetition of one and the same correction exercises there takes place active adaptation to them. It reduces training effect (Spirin, & Denisov, 2002). That is why, when a child increased power endurance, the quantity of every exercise's repetitions also increased. If child fulfilled physical exercise for more than 10-12 times, then this exercises will be fulfilled with resistance (or weights).

The quantity of repetitions and rest intervals between exercises depended on children's functional potentials and was regulated by heart beats rate. According to the existing recommendations (Lovejko, & Fonarev, 1988), when correction exercises are fulfilled, pulse shall be within 120-160 ybeats per min. Restoration of HBR up to 110-120 bpm showed at children's readiness for fulfillment of the next series of exercises. When fulfilling static correction exercises the time of passive rest was twice bigger than spent for exercise's fulfillment (Liubomirskij, 1979; Shabunin, & Pavlova, 1979).

With increase of strength and power endurance of muscles we used exercises with combinations of different modes of muscles' functioning. Power exercises were combined with stretching and relaxation exercises (Razumejko, 2016). Health related effectiveness of such exercises is conditioned by increase of effectiveness of restoration processes in organism's different systems. Stretching exercises compensate residual processes in skeletal muscles in restoration period; reduce afferent flow from muscles to central nervous system, create better conditions for central nervous system's functioning (Roanova, 1995).

When fulfilling static exercises, children were trained not to stop breathing in static positions. For this purpose certain methodic technique was used (Kuz'menko, 2002), who practices pronouncing of different sounds at exhale during exercises. Children were informed about coordinating phases of breathing and movement: expressed movement phase coincides with exhale; less expressed movement phase is accompanied by inhale. Separate breathing phases (inhale, exhale) were coordinated with rational, physiological positions of torso, legs and arms (Kuznecova, Levitskij, & Iazloveckij, 1989).

Some specialists think that it is compulsory to include breathing gymnastic exercises in content of health related physical culture (Baljinder Singh, 2015). It is explained by the fact that the most frequently breathing deficit is combined with child's somatic weakness, functional deficit of muscular-ligament apparatus against the background of blood circulation relative weakness (Kalabina, 1977; Romanov, Isaev, Shevtsov, Romanova, Cieslicka, & Muszkieta, 2016). That is why at health related trainings in EG special attention was paid to formation rational breathing skills in fulfillment of physical exercises. For formation of children's responsible attitude to breathing exercises constant explanation of importance of correct "full" breathing for effective operation of muscles and the whole organism was practiced.

## Conclusions

Based on electromyography researches showed that stretched muscles of convex side generate higher by amplitude electrical signals, comparing with muscles of concave side (which are in relative contraction state). It causes backbone bent to the side of weakened muscles and creation of biomechanical conditions, favorable for further progressing of backbone deformation. Thus, the value of muscular tonus (in the form electromyography signal from symmetric muscles of back) can be an informative indicator for diagnostic of disorders of backbone vertical position, for correction of posture disorders in frontal plane.

We have worked out the methodic of early diagnostic of posture disorders in frontal plane for primary school pupils. It was underlined that the diagnostic concerns visually healthy children of 6-10 years' age, who passed standard medical examination and were recognized healthy and included in main health group. It was shown that medical specialists can determine only obvious disorders of posture in frontal plane. With the help of physical education means (physical exercises) physical culture teacher can determine posture disorder at early stages. With the help of the offered author's methodic the teacher can improve posture disorders in frontal plane.



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