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Health-Preserving Technologies in the Prevention of the Development of Functional Disorders of the Cardiovascular System in Pupils

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Abstract

Introduction. In modern conditions there is a tendency of increasing number of children with functional disorders of the cardiovascular system, especially at the beginning of the studying process, that specifies the necessity of wide integration of HPT.

Purpose. The evaluation of the role of the health-preserving technologies in the prevention of the functional disorders of the cardiovascular system among children of the primary school age.

Materials and methods. An in-depth clinical and instrumental examination of 153 children aged 6–11 years was carried out before starting school, during study period and after graduating from elementary school. The health-preserving technology of Professor O.D. Dubogay, HPT "Learning in Motion", was introduced and actively used in the secondary school No. 287 in Kiev, (methodological manual "Integration of informative and moving activities in the system of education and training of schoolchildren", Oryani, 2001) where 65 children (the main group) were examined. While in the secondary school No. 3 in Boyarka, 88 pupils were taught according to generally accepted methods (comparison group).

Results. When entering school, first-graders revealed a low level of functional capabilities of the cardiovascular system. Positive evidence of the HPT on the state of the cardiovascular system was revealed; the percentage of children with a high and higher than the average level of functional reserve of the heart (based on the Roufier test) after completion of the elementary school was 77.6% in the main group, and 8.4% in the comparison group; according to the clinically orthostatic test, the physiological reaction of hemodynamics to changes in body position is observed in 35.4% of the elementary school children and 21.5% in the comparison group. The main group the number of children with positive results of the Shalkov test was increased by 31.1% of, while in the comparison group it was decreased by 24.9%.

Conclusions. High medical ($Ke=8.1$), social ($Ks=0.75$) and economic efficiency of HPT was proved, which substantiates its widespread introduction into the work of educational institutions for the prevention of the functional cardiovascular pathology.

Keywords: pupils, health-preserving technologies, cardiovascular system, functional tests, prevention

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Здоровьесберегающие технологии в профилактике развития функциональных нарушений сердечно-сосудистой системы у школьников

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Резюме

Введение. В современных условиях наблюдается тенденция к увеличению количества детей с функциональными нарушениями сердечно-сосудистой системы, особенно с началом учебы в школе, что обуславливает необходимость широкого внедрения здоровьесберегающих технологий (ЗСТ).

Цель. Оценить роль здоровьесберегающей технологии в профилактике функциональных нарушений сердечно-сосудистой системы у детей младшего школьного возраста.

Материалы и методы. Проведено углубленное клинико-инструментальное обследование 153 детей в возрасте 6–11 лет перед началом обучения в школе, на протяжении обучения и после окончания младшей школы. В общеобразовательной школе № 287 г. Киева, где внедрена ЗСТ «Обучение в движении», обследовано 65 детей (основная группа), в общеобразовательной школе № 3 г. Боярка (Киевская область), где обучение проводится по общепринятым методикам, наблюдалось 88 школьников (группа сравнения).

Результаты. При поступлении в школу у первоклассников был выявлен низкий уровень функциональных возможностей сердечно-сосудистой системы. Доказано



положительное влияние ЗСТ на состояние сердечно-сосудистой системы, количество детей с высоким и выше среднего уровнем функционального резерва сердца (по результатам пробы Руфье) после окончания начальной школы в основной группе составляло 77,6%, а в группе сравнения – 8,4%; по данным клино-ортостатической пробы физиологическая реакция гемодинамики на изменение положения тела была у 35,4% школьников в основной группе и у 21,5% в группе сравнения. В основной группе увеличилось на 31,1% количество детей с положительными результатами пробы Шалкова, в группе сравнения – уменьшилось на 24,9%.

Выводы. Доказана высокая медицинская ($K_e=8,1$ у.е.), социальная ($K_c=0,75$) и экономическая эффективность ЗСТ, что обосновывает целесообразность ее широкого внедрения в работу общеобразовательных учреждений для профилактики формирования функциональной сердечно-сосудистой патологии у школьников.

Ключевые слова: школьники, здоровьесберегающие технологии, сердечно-сосудистая система, функциональные пробы, профилактика

■ INTRODUCTION

One of the main indicators of the country's social well-being is the state of the health of the child population. Unfortunately, recently in Ukraine there has been a tendency to worsen children's health [1, 2]. According to the results of research by the Institute of Pediatrics, Obstetrics and Gynecology of the National Academy of Medical Sciences of Ukraine named after Academician O.M. Lukyanova, about 70% of children already have health problems upon admission to school [1], which are exacerbated during studying [3, 4]. One of the ways to preserve and strengthen the health of the younger generation in organized children's groups is health-preserving technology (HPT) [5].

The HPT provides a comprehensive assessment of the conditions of a child's stay at school, allows to maintain the level of health with which he came to school, ensures the assimilation of healthy lifestyle skills, monitors the main indicators of schoolchildren's development, predicts possible changes in the children's health status, and provides for medical and hygienic, corrective and rehabilitation measures [6]. Each element of the HPT is aimed at preventing the formation of chronic pathology among schoolchildren, including the cardiovascular system (CVS) [7]. It is difficult to overestimate the impact of the school on children's health. Excessive school work without taking into account the physiological and psychological age characteristics of children, poor nutrition, restriction of physical activity – all this negatively affects the health status of students. Especially in this regard, children of primary school age are vulnerable [8]. Given the physiological characteristics of CVS in children of this age group, such as low blood pressure (BP) due to the low volume of circulating blood and low peripheral resistance, tachycardia, imperfect autonomic regulation of the heart rhythm, there is high risk of the formation of functional cardiovascular disorders.

■ PURPOSE OF THE STUDY

To estimate the impact of the author's HPT "Learning in Motion" by Professor A. Dubogay to prevent the development of functional disorders of CVS in children of primary school age.

■ MATERIALS AND METHODS

A dynamic in-depth clinical and instrumental examination of 153 children was carried out before starting school (2013), during their studying and after graduating from primary school (2017). 65 children studying in the primary grades of secondary school № 287 in Kiev, where the author's health-saving technology (HST) of Professor O.D. Dubogay is introduced and actively used. "Education in moving" (methodological manual "Integration of informative and moving activities in the system of education and training of schoolchildren", Oryani, 2001) made up the main group. The comparison group consisted of 88 pupils of secondary school № 3 in Boyarka (Kyiv Region), where training is carried out according to generally accepted methods.

The author's HST "Education in moving" is intended to expand the volume of physical activity of primary school pupils. It is based on imitative-motor reproduction of the content of the studied material directly in the classroom. The condition of the students is monitored by the teacher and parents according to the informative criteria presented in the "Diary of the development and health of schoolchildren 6–12 years old".

At the heart of the author's methodology "Education in moving", along with generally accepted requirements, such as the formation of healthy lifestyle skills, correct eating habits, the creation of favorable conditions for learning, is the provision of sufficient age-appropriate physical activity. The presentation of the new educational material takes place in the form of a didactic game with physical activity, which leads to its conscious memorization and the development of associative thinking in children. The integration of physical activity into the educational process also contributes to the preservation of health, prevents the development of functional disorders on the part of the organs of the cardiovascular and digestive systems, visual impairments and posture, improves the assimilation of school material, the physical and intellectual development of the child.

A complex estimation of the physical development of schoolchildren included anthropometric studies to determine body weight and length, chest circumference, body mass index, and the harmony of physical development was estimated in accordance with the order of the Ministry of Health of Ukraine No. 802 of 09/13/2013. "Criteria for assessing the physical development of schoolchildren".

Electrocardiography (ECG) was performed according to the standard method on a 6-channel electrocardiograph (CARDIMAX FX-326U FUKURA DENSHI CO., LTD, Japan) in standard II and left thoracic (V4, V5, V6) leads.

The function of external respiration was evaluated using spirometry using a SpiroSoft-SP-5000 spiro analyzer (Italy).

An in-depth medical examination of children was carried out by specialist doctors (pediatric orthopedist, pediatric surgeon, pediatric ophthalmologist, pediatric cardiologist, pediatric neurologist, psychologist, pediatrician).

According to the questionnaires we developed, we studied the history of students' lives, incidence, complaints, living conditions, eating habits, motor mode, factors that affect the health of students were taken into account.

Anti-infection resistance was estimated by the frequency and severity of acute respiratory infections (ARI), the number of missed days for each school year.

Psychological testing was conducted to assess school motivation, school anxiety and disadaptation.

The adaptation and reserve capabilities of the respiratory, autonomic nervous system and CVS were assessed by heart rate (HR), blood pressure (BP) – diastolic (BP), systolic (BP), pulse (PD), respiratory rate (BH). Adaptation potential (AP) of CVS was evaluated by the method of R.M. Baevsky (1979) and calculated by the formula:

$$AP(dmd) = 0.011 \times HSS + 0.014 \times ATS + 0.008 \times ATd + 0.014 \times vik + 0.009 \times MT - 0.009 \times DT - 0.27.$$

The level of $AP \leq 2.1$ points was assessed as satisfactory adaptation, 3.21–4.3 points – unsatisfactory, and failure of adaptation – at >4.31 points.

For an objective assessment of the vegetative status in addition to AP Bayevsky R.M. individually for each child, the Kerdo and Robinson indexes were calculated.

The functional capabilities and reserves of the CVS were evaluated using functional tests with physical activity (Shalkov test, Roufier test, clinooortostatic test). Functional tests of Shtange and Gench were performed to study the resistance of children to hypoxia.

For descriptive analysis, methods of variation statistics were used. For qualitative indicators, we analyzed the frequency distributions (in %). For quantitative parameters, we determined the average values of the indicators, their variability and statistical significance (arithmetic mean (M), standard deviation (SD), mean error of the mean (m), and confidence intervals. For comparative Xi-squared criterion was used between groups to analyze the frequency characteristics (quantitative characteristics) between groups. I assessed the significant difference between the groups using Fisher's exact test).

For quantitative indicators, the nature of the distribution (assessment of the normality of the distribution) of the attributes was determined beyond the Shapiro – Wilk criterion. For a comparative analysis of quantitative parameters, parametric (t-test) and nonparametric criteria (Wilcoxon and Mann – Whitney) were used. At the same time, a parallel assessment was carried out using parametric and non-parametric criteria, which provided additional control over the statistical evaluation of the analysis results.

The assessment of the weight and prognostic significance of individual factors was determined by calculating the relative risks (OR odds ratio) with a 95% confidence interval.

For all analysis results, their statistical significance was assessed at a level of no lower than 95% ($p < 0.05$).

For processing the primary data, we used the specialized licensed program Stata 12, which is certified for special analysis of clinical trials.

The coefficient of the health-saving orientation of the educational process was calculated in accordance with the methodological recommendations "Screening Assessment of the Adaptation and Reserve Capabilities of School Children" developed by the State Institution "Hygiene and Medical Ecology named after O.M. Marzeeva NAMS of Ukraine [9]. The coefficient of social efficiency (Ks) was calculated as the ratio of the number of parents who are satisfied with the introduction of the HPT school to the total number of respondents.

The cost-effectiveness of introducing HPT has been proven by calculating the reduction of direct and indirect material costs for pupils with seasonal SARS.

The study was carried out in accordance with the plan of research work of the Department of Children and Adolescent Diseases of the Shupyk National Healthcare University of Ukraine "Prerequisites for the formation of somatic pathology in children and adolescents and the improvement of therapeutic and rehabilitation measures" (state registration number 0114U002213).

■ RESULTS

The results of the study showed that children at the time of admission to school already had certain health problems. Disharmonious physical development was detected in 66.0% of first-graders, overweight and obesity – in 27.5%, a decrease in adaptive-reserve capabilities (23.5%) with an average level of motivation to study at school (77.5%) with a high level of anxiety (37.2%). Only 4 (6.2%) first-graders in the main group and 13 (14.7%) children in the comparison group were found to be practically healthy ($p < 0.05$). At the same time, among first-graders children of 6 years of age prevailed, which justified the need for a comparative analysis of the functional maturity of children of 6 and 7 years of age.

The majority of 6-year-old children showed a tension in the adaptive-reserve capabilities of CVS. When performing the Roufier's test in the main group of high and above average, the levels of adaptive capabilities of CVS were observed only in 25.5% of students of 6 years of age, and among 7-year-olds the indicator was 31.8%.

The Shalkov test in the main group among 6-year-old children was satisfactorily performed 37.9%, while among 7-year-old children 50.0% ($p < 0.05$). Thus, among the examined first-graders of the 6-year-old, signs of functional immaturity of the CVS were revealed, that is, they were more vulnerable to failure to adapt.

Analyzing the results of the survey, it was found that the most of the children do not spend enough time in the fresh air (83.1%). Perhaps this is due to the high school load, since homework in 50.5% of students took more than 1 hour. At the same time, the time that children spend on electronic devices was about 3 hours a day (69.2%). All this could not affect the level of physical activity of pupils throughout the day. And if in the main group a sufficient level of physical activity was achieved through the use of HPT, then in the comparison group in the first class, only 41.0% had it. About half of the first-graders of both groups regularly did morning exercises. It was found that 36.9% of first-graders do not eat porridge at all or eat no more than 1 time a week, only 72.7% of pupils consume milk and milk products daily. Skips breakfast every 4th pupil. In 24 families, children ate meat and fish dishes less than 1 time per week or did not eat at all. 88% of such families named the main reason for the lack of funds for the purchase of products. For the same reason, a sufficient amount of fresh vegetables and fruits is not enough for every second child in both observation groups. About a third of children misuse sugary sodas. Such an irrational diet combined with a lack of physical activity could not but entail the problems of overweight in children. Which was confirmed by our research. Obesity and overweight were observed in 20.0% of the first-graders in the main group and 33.5% in the comparison group ($p < 0.05$). Based on a thorough study of the history of pupils' lives, their social and living conditions, and food habits, statistically significant combinations of risk factors for the formation of functional disorders of CVS were identified with the creation of appropriate mathematical forecast models. Among the risk factors, the most significant was a burdened family history of obesity (prognostic factor (PK) = 2.7), a burdened family history of coronary heart disease and myocardial infarction (PK=5.0), bad habits of parents (such as smoking and alcohol abuse) drinks (PK=3.3), violation of the regime of the day, overwork, insufficient night sleep (PK=7.2), lack of exercise (PK=2.1).

The active use of HPT in the main group provided schoolchildren with a sufficient level of physical activity that corresponded to age-related physiological norms. At the same time, according to the canons of the HPT, enlightening work was actively carried

out for all family members on the importance of a balanced diet, adhering to the daily routine, and combating bad habits. As a result, after graduating from primary school in the main group, the number of children with normal BMI increased from 70.8% to 83.3% ($p < 0.05$), while the number of children with obesity and overweight in the main group decreased from 20.0% to 16.7%. Whereas in the comparison group a significant increase in the number of children with obesity and overweight from 33.5% to 50.0% ($p < 0.05$) was revealed. BMI dynamics in both observation groups is shown in Fig. 1. The difference between the observation groups is statistically significant after 2 years and for the period of graduation in elementary school ($p < 0.05$).

The fight against obesity and overweight is crucial in the context of the prevention of noncommunicable diseases (NCDs), which, in addition to obesity, include cancer, chronic respiratory and cardiovascular diseases. In the WHO global action plan 2013–2020 (Global Action Plan for the prevention of noncommunicable diseases), NCDs are recognized a significant socio-economic burden for any country, leading to long-term disability of the adult population, a decrease in the well-being of families, and an increase in the burden on the healthcare system.

Regular physical activity positively affects the condition of all organs and systems, including CVS. An increase in oxygen consumption during exercise is accompanied by an adaptive reaction of CVS (increased cardiac output, heart rate, moderately increased blood pressure, PD, peripheral vascular resistance [10–12]. Long-term adaptation of CVS to regular physical activity leads to maximum oxygen consumption due to increased volume circulating blood and tissue metabolism. In, under the influence of regular moderate physical exertion children of primary school age improve the work of the CVS mechanisms [13]. We have studied the specific features of the HPT and the compensatory and adaptive mechanisms of the dynamics of a 4-year use of the HPT "Education in Motion" by AP evaluation and functional tests results.

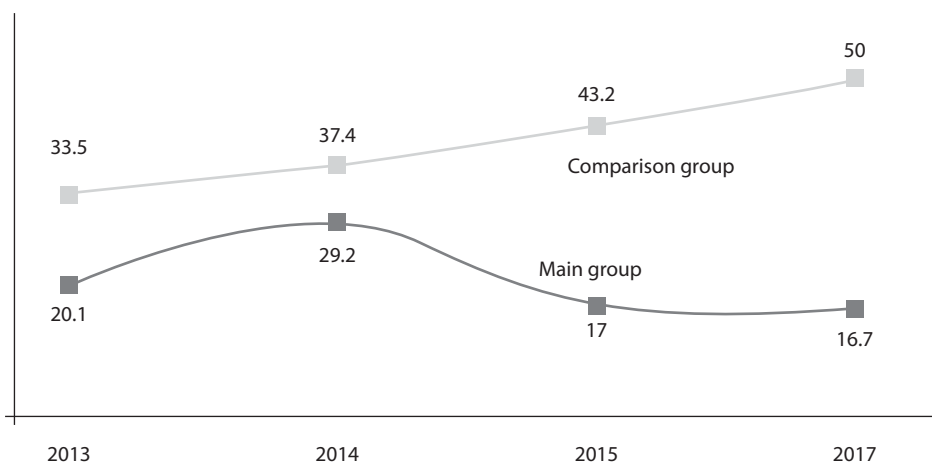


Fig. 1. The proportion of children with obesity and overweight over the years of study in elementary school (n=153)

After elementary school, a significant difference in AP values in the observation groups was determined. 97.2% had satisfactory adaptation in the main group after graduating from primary school, while in the comparison group only 33.3% ($p < 0.001$).

The level of adaptation cannot be estimated only at rest. For this, it is necessary to carry out functional tests with a load. In our study, we performed tests of Roufier, Shalkov and orthostatic. The results of evaluating the functional reserve of the heart when performing the Shalkov test are presented in Table.

In the main group, a significant increase of the number of pupils with satisfactory results was obtained (from 49.2% to 80.6%), while in the comparison group the number of children with a positive result at the time of graduation from primary school fell sharply from 44.3% to 19.4% ($p < 0.05$).

77.6% of schoolchildren in the main group and only 8.4% in the comparison group ($p < 0.05$) had a high and above average level of functional reserve of the heart (according to the Roufier test) after primary school.

The dynamics of changes in the percentage of children with high and above average levels of functional reserve of the heart are presented in Fig. 2.

In the main group during the orthostatic test, there was a significant increase of the number of children with a physiological reaction of hemodynamics with a change in body position (from 64.6% to 100.0%), and in the comparison group, they were 65.9% at the beginning of training and 44.4% after the end of grade 4 (Fig. 3).

To confirm the effectiveness of the application of the HPT "Learning in Motion", we evaluated the adaptation and reserve capabilities of schoolchildren and calculated the coefficient of effectiveness of the health-saving orientation of the educational process in schools according to the methodological recommendations [11]. The coefficient in the main group was 8.1 at a rate of at least 1.

Using electrocardiography (ECG) assessed the functional state of the myocardium of schoolchildren. At school age, the ECG is as close as possible to that of adults, but has a number of features – relatively high heart rate, respiratory arrhythmia and pulse lability, the P-R interval varies between 0.12–0.19 s, the QRS complex (0.07 ± 0.008) sec., which is interpreted as a slowdown of intraventricular conduction. The QT interval in this age group is in the range of 0.26–0.38 sec., the position of the heart axis is normal or vertical, the amplitude of the S wave decreases in V1 – V2 and V5 – V6 leads, the negative T wave in III standard and in V1 – V2 leads. An analysis of ECG data over the years of observation showed that 15.4% of first-graders of the main group and 38.5% of children in the comparison group showed an extension of the QT interval, which can be regarded as a variant of the age norm, functional disorders of metabolism and repolarization processes

The number of children with a satisfactory response to physical activity when performing the Shalkov test (n=153)

Functional reserve of the heart	The value of the indicator for years of observation absolute number / %			
	2013	2014	2015	2017
Main group (n=65)	32 (49.2)	36 (55.4)	39 (60)	29 (80.6)*
Comparison group (n=88)	39 (44.3)	16 (18.2)	21 (23.8)	7 (19.4)*

Note: * the difference is significant between the indices of the main group before using the HPT and after its use ($p < 0.05$).

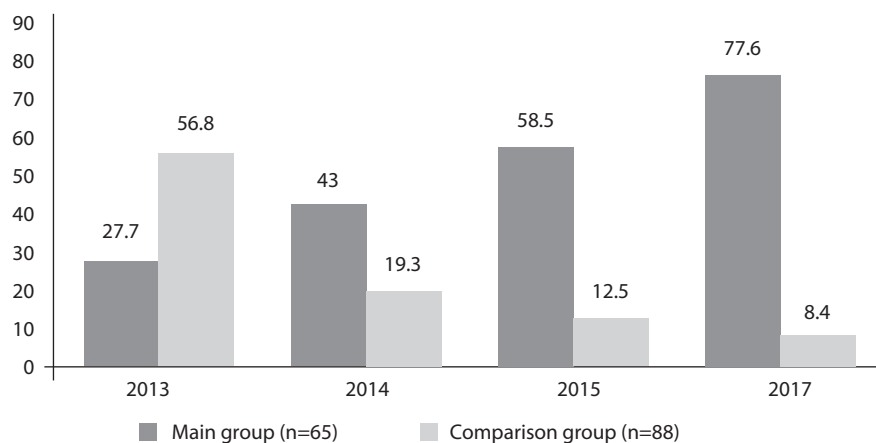


Fig. 2 The frequency of detection of children with high and above average reserve capabilities of CVS according to the results of the Roufier test in both observation groups over the years of observation

were observed in 43.1% of first-graders in the main group and in 29.5% in the comparison group; in 1.5% of schoolchildren in both groups, the ECG was low-voltage, which indicates a decrease in the general level of electrophysiological ability of the myocardium.

In the dynamics of observation in both groups, stabilization of the functional state of the CVS was noted, however, some intergroup differences were recorded. During the use of HPT, the number of children who had intraventricular conduction disturbances on the ECG decreased (from 26.2% to 2.8%) ($p < 0.05$), and in the comparison group there were 2 times more children at the time of graduation from primary school (5.6%).

In both groups, at the end of primary school, there were no children with an extended QT interval and low voltage on the ECG. In the main group, the number of schoolchildren with metabolic and repolarization disorders was significantly reduced (from 43.1% to 0%), while in the comparison group – from 29.5% to 8.3%.

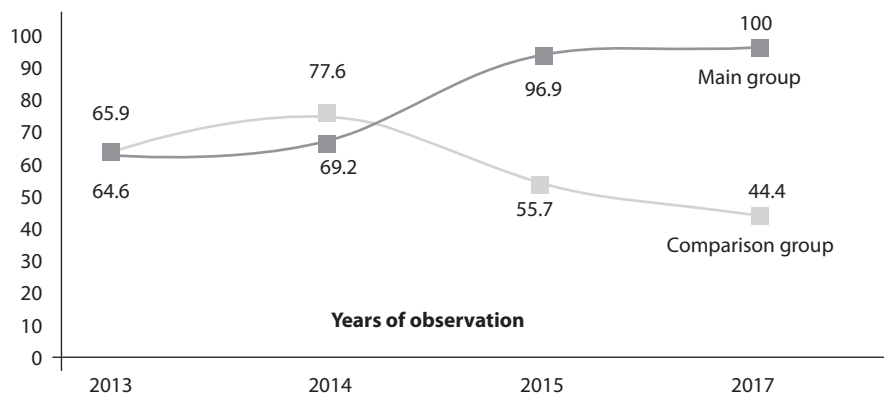


Fig. 3. The number of schoolchildren with a positive orthostatic test in both groups over the years of observation

An assessment was made of the state of anti-infectious resistance and adaptive capacity of pupils in elementary school by the frequency of SARS throughout the school year, by the presence of complications and the number of missed days of study due to illness. In the main group in grade 4, the average indicator of missed days of study for the academic year was 15.9 days, while in the comparison group this indicator was significantly higher than 53.9 days ($p < 0.05$). A similar trend was observed with respect to recurrent (4 or more episodes per year with a prolonged or complicated course) of respiratory diseases. In the main group, their percentage decreased from 5.0% to 2.5%, while among children in the comparison group this indicator was 3 times higher (7.5% at the end of primary school). At the same time, in the main group, the percentage of complicated forms of ARI decreased 4 times (from 15% to 3.5%) ($p < 0.05$), while in the comparison group it remained stably high (15–16%).

In the last year of primary school, where they used HPT, 17% of pupils never had SARS during the year, and in the comparison group the number of such children decreased from 13.0% to 5.0%. Thus, the incidence of ARI was lower in the main group where HPT was introduced, the course of the disease was more favorable, which indicates the presence of a high level of anti-infection protection in children and sufficient reserve adaptive capabilities.

The decrease in the number of cases of acute respiratory infections among primary school pupils has led to a significant economic effect. With the introduction of the HPT "Learning in Motion" we can expect a reduction in direct medical costs of 2.7 times and the cost of laboratory and instrumental examinations by 4 times.

The coefficient of social efficiency is also calculated, which demonstrates the degree of achievement of the social result in the form of satisfaction with services. He was 0.75. At the same time, during the use of the HPT, the attitude of parents to a healthy lifestyle has changed – the children began to observe the daily regimen, do morning exercises, play sports, eat rationally, and temper. Parents became more responsible for their own health, there was a motivation for regular exercise and good nutrition.

■ CONCLUSIONS

1. The author's methodology "Learning in Motion" provides a health-preserving focus of the educational process at school.
2. The introduction of the HPT in the educational process prevents the development of functional disorders of the cardiovascular system, provides a high level of adaptive and reserve capabilities of elementary school pupils.
3. HPT provides a high level of anti-infectious protection, which is manifested by a significant decrease in the frequency, duration and severity of ARI, prevents the formation of recurrent respiratory diseases.
4. The study proved high medical ($K_e=8.1$ cu), social ($K_s=0.75$) and economic efficiency (reduction of direct and indirect costs by 2.7–4 times), which allows us to recommend HPT "Learning in motion" for widespread adoption in educational institutions.

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