

Comprehensive program for flat foot and posture disorders prevention by means of physical education in 6-year-old children

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Abstract

The search for technologies and methods to achieve a high effect from the impact of physical exercises on the correction of disorders of the musculoskeletal system in children continues to be an urgent problem. *The purpose* of this research is to test and evaluate the effectiveness of the use of means and methods of physical education for the correction of flat feet and posture disorders in 6-year-old children through a comprehensive online program for parents. *Materials and methods.* The participants in the research project were 6-year-old children, of which 10 children were in the control (CG) group and 10 children with their parents were in the experimental (EG) group. The participants in the research project were 10 6-year-old children in the control (CG) group and 10 children with their parents in the experimental (EG) group. The experiment was carried out in the fitness center of the Siberian Federal District (Russia). For parents of EG, an online pedagogical program has been prepared on the correction and prevention of flat feet and scoliosis. A milestone survey of parents and testing of the state of the arch of the foot, the functional state of the skeleton, the muscular system and the postural state of the children were carried out. *Results.* At the end of the research project, an increase in the values of test indicators in EG children was reliably established. The number of children with violation of the arch of the foot and posture has decreased. All mothers of the experimental group (EG) formed a conscious motivation about the need for regular corrective exercises and massage at home to prevent the occurrence of disorders of the musculoskeletal system in their children. *Conclusions.* The pedagogical technology proposed by us for joint training of children and parents in the methods of correction and prevention of the pathology of the musculoskeletal system turned out to be more effective than the traditional health-improving lesson only with children.

Key Words: flat foot, scoliosis, the musculoskeletal system disorders, physical education, online training of parents.

Introduction

A serious orthopedic disease of a person is flat foot, which negatively affects the function of the entire musculoskeletal system, violates posture, worsens well-being, and reduces endurance to physical exertion and performance. Musculoskeletal system disorders are often found among the child population of many countries: in Russia (Chernozemov et al., 2017), Ukraine (Kashuba et al., 2019; Hakman, 2020), the Czech Republic (Balkó et al., 2017) and other states. The number of musculoskeletal system disorders in childhood increases during the period of active growth, as well as during puberty.

Kirillov's research works (2003) proved that flat foot occurs as a result of congenital weakness of the lower leg and foot muscles, ligamentous apparatus or increased loads on the legs (obesity, weightlifting), rickets or foot injury. People suffering from flat foot are more likely to develop dystrophic disorders in articular cartilage, in intervertebral discs (osteochondrosis). Due to the displacement of the center of gravity of the human body caused by flat foot, this state leads to the vertebral column deformation and the formation of scoliosis (Erdenebileg et al., 2015). In 90% of cases, flat foot and scoliosis occur simultaneously. Therefore, recovery from flat foot reduces the risk of a person developing posture disorders.

It is commonly believed that human posture is the position of the body in various static poses and features of the muscles when performing various motor actions. Its formation is influenced by heredity and numerous environmental factors, what is especially noted in the studies of scientists from Mongolia

(Shagdarsuren et al., 2016). Maintaining the correct posture of a person is influenced by the consistency of contractions and uniform muscle traction of various muscle groups of the neck, back, pelvis and lower extremities (Bold, 2021).

The normal state of the musculoskeletal system is an important characteristic of a harmoniously developed person and serves as a marker of good physical and somatic health, especially for children and adolescents (Kashuba et al., 2017; Ivanchykova et al., 2018). Disorders of the musculoskeletal system are caused by an insufficiently developed muscular system and the inability of muscles to work in static mode for a long time (Kotliar et al., 2019). Such deviations from the norm adversely affect the functioning of the cardiorespiratory and nervous systems, also negatively affecting the children's mentality and reducing physical activity. All these facts lead to the development of inactivity and quality of life deterioration (Boak et al., 2014; Kozina et al., 2017; Timnea et al., 2019). The musculoskeletal system disorders are often associated with insufficient physical activity in children and adolescents (Drachuk et al., 2018; Furman et al., 2018), including ignoring physical education in educational institutions (Andrieieva et al., 2020). Disorders of the skeletal system are most often corrected by methods and means of physical culture with orthopedic correction (Nosova et al., 2015; Yarmak et al., 2017; Kashuba et al., 2019). For this purpose, physical exercises in the static mode of muscle work and fitness technologies are used (Ivanchikova et al., 2018) and karate means (Mischenko et al., 2020). For flat foot, corrective gymnastics exercises are used (Cruz-Ferreira et al., 2013). They have an effect on the muscles of the arch of the foot and toes, for the muscles of the thigh and lower leg.

There are known approaches to solving the problems of educational activity, including working with parents (Giuseppe Madonna & Patrizia Belfiore, 2020). There are training programs in which there is a section on the joint participation of teachers, coaches and families in increasing the children's physical activity. Such physical training technologies have shown a high positive result (Kriemler, 2011). However, the issues of using corrective gymnastics with the involvement of parents to correct flat foot and posture in children have not been fully studied. This fact does not allow achieving a high effect of correctional, pedagogical and health-improving effects of physical exercises on correcting violations of the arch of the foot and posture in children aged 6. Therefore, improving the methods of correcting flat foot and posture at an early age by means of physical culture and participation of parents in this process seems to be an urgent task.

The purpose of this research is to test and evaluate the effectiveness of the use of means and methods of physical education for the correction of flat feet and posture disorders in 6-year-old children through a comprehensive online program for parents.

Material & methods

At the beginning of the research project, we analyzed the medical records of children aged 6 attending preschool, and selected boys with a «flat foot» diagnosis. After a personal consultation with a pediatric orthopedist and his assessment of the initial condition of the arch of the foot and the musculoskeletal system as a whole, 20 children were selected, who were divided into control (CG) and experimental (EG) groups of 10 people each. Wellness activities among children suffering from flat foot and posture disorders have been carried out on the basis of the fitness park of the Siberian Federal District (Russia) since September 2020 until June 2021. In both groups, wellness gymnastics classes were held 2 times a week for 50-55 minutes. The parents' written consent to the children's participation in the project was received. The parents' signed an informed consent form, framed within the ethical regulations and following the Helsinki treaty (World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects, 2013).

In the experimental group, in addition to improving the children's health, parents were involved in the process, with whom we conducted an online training course once a week to familiarize and teach with the methods of flat foot correction and prevention of posture disorders.

Table 1. Content of the distance learning course for parents in EG group

The content of the work			
1 st week	2 nd week	3 rd week	4 th week
September			
Introductory meeting with parents "Flat foot and posture disorders in children and their correction". Parents' questionnaire.	Consultation "Means of physical culture in correcting flat foot and maintaining posture in children"	Consultation "Morning exercises in flat foot prevention and maintaining posture"	Consultation "Massage with flat foot to maintain posture"
October			
Consultation "Complex of physical exercises for correction of flat foot and posture disorders"	Consultation "Barefoot walking use to correct flat foot"	Consultation "Using the ball for flat foot treatment"	Discussion of the observation protocol

November			
Consultation "Physical exercises for strengthening the arch of the foot in a sitting position on a chair"	Consultation "Physical exercises to strengthen the arch of the foot in a standing position"	Consultation "Exercises for the leg and back muscles development"	Discussion of the observation protocol
December			
Master class "Game exercises as a means of adapting children to physical activity"	Consultation "Non-standard methods for flat foot prevention"	Recommendations for tempering the child's body.	Discussion of the observation protocol
January			
Video review about flat foot and posture disorders correction at home	Consultation "The effect of physical exercises on the musculoskeletal system of the child"	Consultation "Aquatic environment use in the correction of flat foot and posture disorders"	Discussion of the observation protocol
February			
Folder "Games and exercises in flat foot and posture disorder correction in children"	Case study "Negative flat foot impact over a child's musculoskeletal system"	Individual conversations "How to evaluate the arch of the foot by podometry"	Discussion of the observation protocol
March			
Case study "Prevention of children's musculoskeletal system deviations by means of physical culture"	Folder "Gymnastics in flat foot and posture disorders correction in different periods of a child's life"	Case "Outdoor games. Methods. Equipment in home conditions"	Discussion of the observation protocol
April			
Consultation "The use of floor mats for flat foot and posture disorders correction"	Video recordings of classes discussion	Consultation "The use of "Bosu" gym machine for flat foot correction"	Discussion of the observation protocol
May			
Preparation for the final testing of children to assess the condition of the arch of the foot and posture	Discussion "Evaluation of the children's arch of the foot and posture condition results"	Questionnaire of parents "Correction of flat feet and posture disorders in children"	Results of the work done for the 2020-2021 academic year

After the training, mothers of EG group children performed daily morning gymnastics and massage of the children's lower extremities and every day in their free time they performed a set of corrective physical exercises from a sitting position on a chair: extension and flexion of the toes; lifting socks and heels from the floor; circular movements with each foot; adduction and pulling socks to and from themselves; from a standing position: rise on tiptoes; stand on the outside of the feet; squats without lifting the heels from the floor; alternate walking on toes and heels, on the outer ribs of the feet, and other exercises. A set of physical exercises was performed to correct posture. Parents registered the condition of their children in the protocol weekly and sent us control data.

The technique used in the fitness park for correcting flat foot in children of CG and EG was based on general pedagogical principles: accessibility, individualization and an integrated approach. The main emphasis in working with children was placed on emotional physical exercises, which were used in recreational gymnastics. Complexes of physical exercises for different muscle groups and with a variety of sports equipment were carried out using the game method. Each complex consisted of three parts: preparatory, main and final. In the preparatory part, simple general developmental and corrective exercises (6-8 repetitions) were used. The main part of the lesson is saturated with symmetrically performed corrective physical exercises (8-10 repetitions). The final part included relaxation exercises performed lying on your back, breathing and special exercises.

At the beginning and at the end of the research project, parents were surveyed on the level of knowledge and skills of correction and prevention of flat foot in points (from 1 to 10 points).

A high-stakes assessment of the arch of the foot condition was carried out using the methods:

1. The heel pronation angle estimate, which indicates the displacement of the heel bone in relation to the hucklebone (degrees). The heel pronation angles up to 5° is considered normal. To establish the stage of deformation of the posterior part of the foot, a classification was adopted, where one of the indicators is the installation of the heel to the axis of the lower leg: stage I, 10-15°- stage IV – severe degree, deviation from the norm of 30° or more (Physical rehabilitation, 2005).

2. Bondarevsky's test for determining postural status (balance) while standing on one leg, s (Bondarevsky, 1966).

3. Podometry according to the M.F. Fridland index (Chernozemov et al., 2017). Determination of the height of the longitudinal arch of the foot (in numerical terms). The podometric index was calculated: $I = H/L \times 100\%$; I – the desired Friedland index, %; h – ball of the foot, cm; L – foot length, cm. Depending on the digital value, an index assessment of the height of the arch of the foot was carried out.

Somatoscopy method (Chernozemov et al., 2017) was used to perform a high-stakes assessment of the posture of CG and EG children in points (from 0 to 5). At the beginning of the research project, the analysis of the somatoscopic examination results of the children's in both groups posture showed that the initial signs of spinal column curvature were noted in 60.0% of children of the control group and 70.0% of children of the experimental one. In this regard, the active flexibility of the spine was investigated by tests: «front bend from a standing position on a bench», cm and «side bend», cm. The strength of the back and trunk muscles was evaluated using the tests: «holding the body in a horizontal position while lying on the hips», s, «sit-up to a sitting position (hands behind the head) in 30 seconds», number of times. Statistical processing of the obtained data was carried out using the computer program STATISTICA 10.0. The differences were statistically significant at $p < 0.05$.

Results

The parents' of children in CG and EG questionnaire results at the beginning and end of the experiment allowed comparing their level of awareness about flat foot and posture and correcting their disorders by means and methods of physical culture for health improving and increasing the child's quality of life, Figure 1.

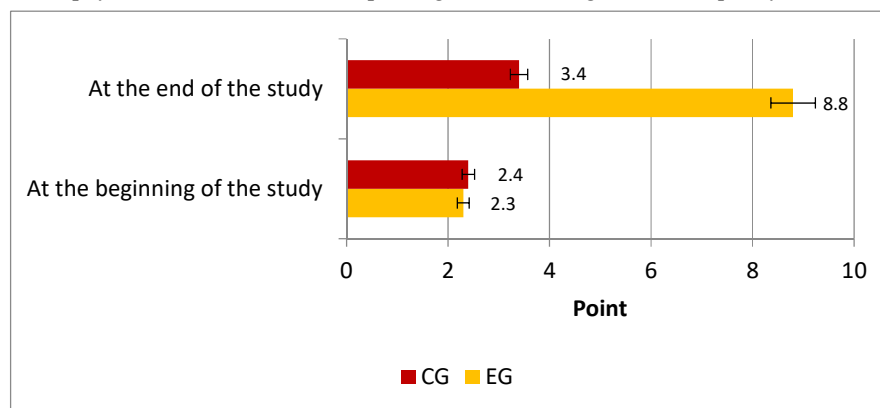


Fig. 1. The high-stakes level of parents' awareness about flat foot, posture disorders and methods of their correction in children

At the beginning of the research project, the level of parents' knowledge about flat foot, posture disorders and methods of their correction was low and did not significantly differ between CG and EG (2.4 ± 0.4 and 2.3 ± 0.3 points, respectively), $p > 0.05$. At the end of the project, the level of knowledge of CG mothers increased by 41.4%, and in EG increased by 3.8 times (from 2.3 ± 0.3 to 8.8 ± 1.3 points), $p < 0.05$. The vast majority (90.0%) of EG parents noted that the online course increased their knowledge of violations not only of the arch of the foot, but also other deviations of the musculoskeletal system and methods of correction in children. At the end of the project, 50.0% of CG mothers and 100% of EG mothers had a conscious motivation about the need for regular corrective exercises and massage to prevent the occurrence of the musculoskeletal system disorders in their children in the future. An important role in assessing the effectiveness of flat foot correction in children by means of physical culture is assigned to methods of monitoring the condition of the arch of the foot. The results of the analysis of the heel pronation angle assessment, Bondarenko balance test and podometry in children using the Friedland index at the beginning and end of the research project are presented in Table 1.

Table 1. High-stakes indicators values of the condition of the children's arch of the foot ($M \pm m$)

No	Indicators	CG		EG	
		At the beginning of the project	At the end of the project	At the beginning of the project	At the end of the project
1	Heel pronation angle, degree	15.8 ± 2.2	12.6 ± 1.8	16.2 ± 2.5	$8.5 \pm 1.3^*$
2	Friedland Index, %	22.4 ± 2.9	25.6 ± 3.2	21.7 ± 2.7	$29.7 \pm 3.6^*$
3	Bondarevsky test, s	4.3 ± 0.7	5.6 ± 0.9	4.4 ± 0.8	$7.3 \pm 1.0^*$

Note.* the difference is significant ($p < 0.05$)

At the end of the research project, there was an improvement in the values of all indicators of the arch of the foot state in children of both groups. A significant improvement in all values of indicators was registered only in children of the experimental group, $p < 0.05$. In this group, the largest increase in all test indicators is recorded at the end of the project, compared with the increase in indicators in children of the control one, Figure 2.

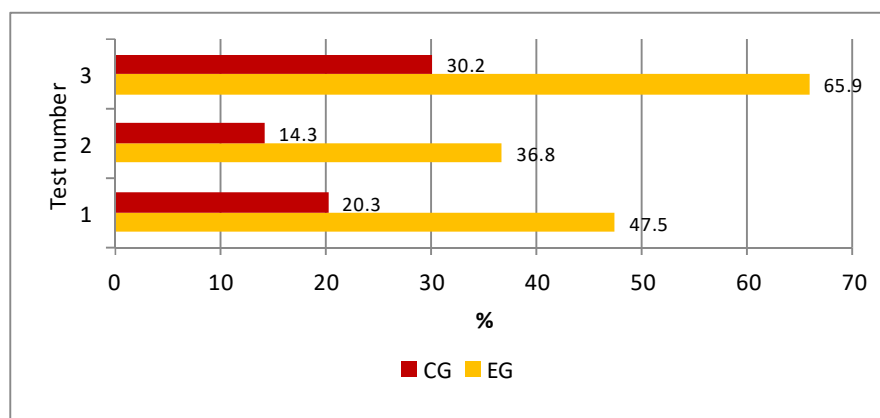


Fig. 2. The increase in the indicators values of the arch of the foot state in children at the end of the research project

A decrease in the heel pronation angle value, an increase in the arch of the foot height and postural status in children indicates a more pronounced positive correction of flat foot by the end of the project in EG children, compared with the results of the CG ones. At the end of the project, it was found that the children of both groups showed an improvement in the functional state of the musculoskeletal system, as evidenced by an increase in the testing values indicators, Table 2.

Table 2. High-stakes indicators values of the children's musculoskeletal system functional state ($M \pm m$)

No	Test	CG		EG	
		At the beginning of the project	At the end of the project	At the beginning of the project	At the end of the project
1	Front bend from a standing position on a bench, cm	2.8±0.33	3.8±0.68	2.6±0.37	4.3±0.82*
2	Side bend, cm	9.2±1.68	11.2±1.82	9.0±0.62	14.2±2.04*
3	Holding the body in a horizontal position while lying on the hips, s	22.0±2.64	27.4±3.12	23.2±2.75	34.8±3.78*
4	Sit-up to a sitting position, number of times	8.8±1.22	12.0±2.15	8.5±1.1	13.2±2.31*

Note.* the difference is significant ($p < 0.05$)

In EG children, where a comprehensive correction program with the participation of parents was used, the result in all tests was significantly higher than in children in CG, $p < 0.05$. This fact indicates the greater effectiveness of the online program proposed by us in improving the functional state of the «muscular corset» of the trunk. At the end of the research, the increase in the indicators values of the functional state of the musculoskeletal system in EG children was greater than in CG ones, Figure 3.

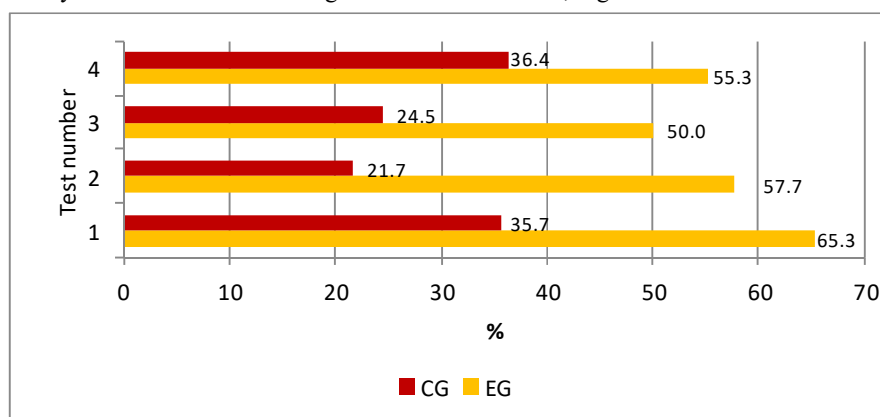


Fig. 3. The increase in the functional indicators values of the musculoskeletal system in children by the end of the research project

At the end of the research project, according to the results of the examination of a pediatric orthopedist, a decrease in the number of children with impaired posture was registered. In the CG, the number of such children decreased by 2 times (from 60.0 to 30.0%) in the EG, the number of such children decreased by 3.5 times (from 70.0 to 20.0%).

The conducted research project for correcting flat foot and posture disorders showed greater effectiveness in children of the experimental group, where parents were involved in the work, compared with the control one, where correction in children was carried out only in a fitness park.

Dicussion

The significant spread of the bone and muscle system disorders in children causes the need for further study of this problem, the development and improvement of health and prevention measures (Balkó et al., 2017; Kashuba et al., 2019; Hakman, 2020). It is necessary to take into account the developments of scientists in medical research on postural disorders (Metalnikov et al., 2022; Bold, 2021; Erdenebileg et al., 2015)

The results of our research analysis confirmed the information that flat foot in children is often accompanied by scoliosis and other disorders of the skeleton and postural status (Kirillov, 2003). This is due to the fact that a violation of the arch of the foot leads to a shift in the center of the body gravity, which contributes to the development of scoliosis (Erdenebileg et al., 2015). Therefore, correcting flat foot not only improves the condition of the arch of the foot, but also contributes to the correct position of the spinal column formation. The final results of our project showed that along with the correction of flat foot in children, their posture improved. At the end of the research project, the number of spinal abnormalities cases decreased in children of the control group by 2 times, in the experimental group by 3.5 times.

It is known that disorders of the arch of the foot and postural changes in children can be corrected by means and methods of physical culture (Nosova et al., 2015; Yarmak et al., 2017; Kashuba et al., 2019). Our research confirms the authors' conclusions about the positive result of the physical exercises and massage use in the correction of musculoskeletal system disorders. In our project, a positive change was noted on the part of the arch of the foot in both observation groups. The means and methods of physical culture were more effective in children of the experimental group, where parents were involved in health improvement. In the scientific literature, the experience of including parents to solve educational problems is known (Giuseppe Madonna, Patrizia Belfiore, 2020) and the comprehensive participation of teachers and parents in increasing children's physical activity, which showed a positive result (Kriemler, 2011).

Our proposed online course for parents of the experimental group to familiarize themselves with the methods of flat foot correction and skeletal disorders prevention has shown its effectiveness, compared with the control group. At the end of the research project, there was a more pronounced significant decrease in the value of the heel pronation angle, an increase in the height of the arch of the foot and the time of stable equilibrium in children of EG, compared with the results in CG. The active participation of parents in the rehabilitation of children allowed improving the functional state of the trunk «muscular corset» to a greater extent, as evidenced by the high-stakes testing results. At the end of the research, the increase in the indicators values of the functional state of the musculoskeletal system in children of EG was significantly greater than in children of CG.

In our opinion, an important result of the work done is to increase the level of parents' knowledge about the measures of correction and prevention of musculoskeletal system disorders in children, which does not contradict the results of research by other authors (Kriemler, 2011). According to our data, at the end of the research project, all mothers of the experimental group were motivated to carry out regular physical exercises and massage to prevent possible disorders of the musculoskeletal system in their children in the future.

Conclusions

The basis of the experimental comprehensive program for the musculoskeletal system disorders elimination in children in correctional gymnastics classes is based on the involvement of parents in recreational activities. For them, we have developed an online training program for correcting flat foot and posture disorders by means and methods of physical education.

As a result of the experimental work carried out, a decrease in the number of project participants with impaired posture was registered. In the experimental group, the number of children with spinal deviations decreased by 3.5 times (from 70.0 to 20.0%), in the control group, such children became 2 times less (from 60.0 to 30.0%). An analysis of the final results of the research project showed that the children of the experimental group had a more pronounced tendency to positive changes in the functional state of the musculoskeletal system. They had a 1.5-fold decrease in the heel pronation angle, an increase in the height of the arch of the foot by 16.0%, and an increase in the time of stable body balance by 30.4%. This indicates a significant development of the strength of the trunk muscles of the children of the experimental group, compared with the results of children in the control group.

A feature of the experimental complex program is the use of pedagogical technology of distance learning for parents of children in the experimental group. This provided 90.0% of parents with an increase in

the level of knowledge about the methods of correcting flat feet and postural disorders using the means and methods of physical culture and formed their motivation for the need for long-term regular physical exercises in the family and massage for their children.

Conflicts of interest. The authors declared no have conflict of interest concerning this work, authorship, and/or publications of this paper.

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