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Methods of physical rehabilitation of schoolchildren aged 15-17 with cervical osteochondrosis
Métodos de rehabilitación física de escolares de 15 a 17 años con osteocondrosis cervical

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Abstract. Background. The problem of rehabilitation of children with cervical osteochondrosis can be solved by creating a special technique and performing additional exercises at home. The objective of the study is rehabilitation of high school students with osteochondrosis of the cervical spine. Methods: boys and girls aged 15-17 who were diagnosed with osteochondrosis of the cervical spine took part in the research. A total of 38 schoolchildren took part in the study. The study was conducted from February 28 to May 26, 2023 on the basis of several secondary schools in the city of Kirov. All students in both groups studied according to the standard program 3 times a week. Children from experimental group B additionally performed sets of physical exercises from the experimental methodology. The study used tests that evaluate the static strength of the abdominal and back muscles, the flexibility and endurance of the cervical spine and the speed and strength abilities of the arm muscles. When analyzing the results, their statistical processing was carried out using the arithmetic mean, square deviation, error and difference. Confidence at $p<0.05$. Results: According to the results of the research, it was found that children from the control group were able to slightly improve the studied indicators to 10.6%, the increase in indicators from the beginning to the end of the study on all tests turned out to be unreliable ($p>0.05$). In the experimental group, at the end of the study, the indicators for all tests improved from 23.5% to 66.7% ($p<0.05$). Thus, the experimental technique is more effective in the treatment of cervical osteochondrosis than the generally accepted technique.Conclusions: Systematic physical education with the use of special physical exercises aimed at eliminating problems in the cervical spine give a significant effect in the rehabilitation of cervical osteochondrosis. The indicators of the static strength of the abdominal and back muscles will improve, the flexibility and endurance of the cervical spine will also increase, and the speed and strength capabilities of the arm muscles will increase.
Keywords: School children's health, Lifestyle, Rehabilitation, Joint mobility, Physical therapy.

Resumen. Antecedentes. El problema de la rehabilitación de niños con osteocondrosis cervical se puede resolver creando una técnica especial y realizando ejercicios adicionales en casa. El objetivo del estudio es la rehabilitación de estudiantes de secundaria con osteocondrosis de la columna cervical.Métodos: participaron en la investigación niños y niñas de 15 a 17 años diagnosticados de osteocondrosis de la columna cervical. Un total de 38 escolares participaron en el estudio. El estudio se realizó del 28 de febrero al 26 de mayo de 2023 sobre la base de varias escuelas secundarias de la ciudad de Kirov. Todos los estudiantes de ambos grupos estudiaron de acuerdo con el programa estándar 3 veces por semana. Los niños del grupo experimental B realizaron adicionalmente series de ejercicios físicos de la metodología experimental. El estudio utilizó pruebas que evalúan la fuerza estática de los músculos abdominales y de la espalda, la flexibilidad y resistencia de la columna cervical y las capacidades de velocidad y fuerza de los músculos de los brazos. Al analizar los resultados, se realizó su procesamiento estadístico utilizando la media aritmética, desviación cuadrada, error y diferencia. Confianza a $p<0,05$. Resultados: Según los resultados de la investigación, se encontró que los niños del grupo control lograron mejorar ligeramente los indicadores estudiados hasta el 10,6%, el aumento de los indicadores desde el inicio hasta el final del estudio en todas las pruebas resultó poco confiable ($p > 0,05$). En el grupo experimental, al final del estudio, los indicadores de todas las pruebas mejoraron del 23,5% al 66,7% ($p < 0,05$). Por lo tanto, la técnica experimental es más efectiva en el tratamiento de la osteocondrosis cervical que la técnica generalmente aceptada. Conclusiones: La educación física sistemática con el uso de ejercicios físicos especiales destinados a eliminar problemas en la columna cervical tiene un efecto significativo en la rehabilitación de la osteocondrosis cervical. Los indicadores de la fuerza estática de los músculos abdominales y de la espalda mejorarán, la flexibilidad y resistencia de la columna cervical también aumentarán y las capacidades de velocidad y fuerza de los músculos del brazo aumentarán.
Palabras clave: Salud de los escolares, Estilo de vida, Rehabilitación, Movilidad articular, Fisioterapia.

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Introduction

One of the urgent health problems of the younger generation today is the increase in the number of children and adolescents suffering from diseases of the musculoskeletal system. Osteochondrosis literally translates as a pathological change in bone and cartilage tissues of a destructive nature. Recently, osteochondrosis of the spine, which is diagnosed from the age of 9-11, has become much younger. According to some authors, only 8% of graduates of grades 9-11 are recognized as healthy. In recent years, the number of children with various functional disorders and diseases of the spine has increased to 67% (Kabisheva & Naumenko, 2013). This is due to the fact that modern man is characterized by a sedentary, sedentary lifestyle. At the same time, the muscles of the trunk and neck perform a constant load, which, with their small but constant static tension, support working and household poses. When they get tired, the entire load falls on the spinal column and, first of all, on the intervertebral discs. In addition, excessive static muscle tension contributes to the obstruction of venous outflow and accelerates the processes of fibrosis, sclerosis and secondary degenerative changes in the spine (Ma et al., 2020; Yin et al., 2022; Wilhite et al., 2023).

Osteochondrosis is a degenerative-dystrophic lesion of the spinal tissues, characterized by damage to the intervertebral discs, adjacent articular surfaces and vertebral bodies, ligamentous apparatus of the spine. With this pathology, changes occur both in the soft tissues surrounding the spine and in the bone tissue of the vertebra itself, however, there

is no unified theory of the development of spinal osteochondrosis in children and adolescents today. Therefore, the tasks of both health-improving physical culture and physical rehabilitation in this pathology are not fully defined (Fonseca et al., 2022).

In medicine, it is customary to distinguish the following types of osteochondrosis: cervical, lumbar, thoracic, combined. With cervical osteochondrosis, aching pains appear in the back of the head, side and back of the neck. Pain can radiate to the arm, forearm or fingers, and sensitivity is impaired. The pain can be aching, pulling, or stabbing. Head movements are difficult. Cervical osteochondrosis is a very dangerous disease, since in the affected part of the spine, in addition to the spinal cord, there are arteries that feed the brain, and their pinching is fraught with the most severe consequences, because the nutrition of the brain is disrupted. That is why with cervical osteochondrosis, headaches, dizziness, fainting, numbness of the tongue, tinnitus, hearing impairment, vision, laryngeal diseases, increased blood pressure are observed. Headache with cervical osteochondrosis worries in the back of the head, then passes to the parietal lobes and temples (König et al., 2015; Khan et al., 2020).

There are many theories of the origin of intervertebral osteochondrosis (infectious, rheumatoid, autoimmune, traumatic, muscular, endocrine, hereditary and other theories). Nevertheless, the main attention in the occurrence of the disease is given to the improper load on the intervertebral discs (Sitte et al., 2012; Fonseca et al., 2022).

Intervertebral discs, along with ligaments, connect the vertebrae to each other. The disc itself is a fibrous-cartilaginous plate, in the middle of which there is a nucleus surrounded by a fibrous ring (Fig. 1) (Sitte et al., 2012).

The intervertebral disc does not have its own vascular system and therefore feeds at the expense of other tissues. An important source of nutrients for the disc are the back muscles, the good condition of which is an important condition for ensuring the normal functioning of the discs. Intervertebral discs play the role of shock absorbers that soften the pressure on the spine under stress (Heyde et al., 2006; König et al., 2015; Khan et al., 2020).

Cervical osteochondrosis can be caused by systematic muscular overstrain during labor operations associated with prolonged fixation of the working posture. Of particular importance in this regard for knowledge workers (including schoolchildren and students) is the long-term maintenance of a posture associated with reading, writing, working on a computer, in which the head is tilted forward and, consequently, the cervical lordosis is smoothed, and the entire trunk is slightly tilted forward. In all these cases of lordosis smoothing, pressure increases on the anterior segment of the intervertebral disc, whose nutrition is limited due to the many hours and daily maintenance of this position, and degenerative changes develop in this particular area. Therefore, it is the cervical-brachial and lumbar localization of osteochondrosis that are the most diagnosed (König et al., 2015; Khan et al., 2020; Fonseca et al., 2022).

Prevention of osteochondrosis should begin from early childhood. Proper physical education, prevention of sudden overloads and posture disorders are an important aspect of it. Reducing injuries, static and dynamic overloads of the spine is important in preventing osteochondrosis (Heyde et al., 2006; Nguyen et al., 2021; Fonseca et al., 2022).

In the prevention and treatment of osteochondrosis, systematic exercises in therapeutic physical gymnastics are essential. When practicing therapeutic gymnastics, blood circulation in the muscles improves, as well as develops a muscular corset and has a tonic effect on the human psyche (Garzonio et al., 2022; de Zoete, 2023).

Physical exercises used in physical therapy classes enhance the functional "restructuring" of all parts of the nervous system, exerting a stimulating effect on both effective and affective systems (Garzonio et al., 2022; Chen et al., 2023; Teichert et al., 2023).

Some authors propose a method of therapeutic physical culture consisting of several stages, the exercises of each subsequent stage require a little more physical strength from those involved. The method of using physical exercises is based on the principle of controlling one's feelings and physical condition (de Zoete, 2023; Ling et al., 2023).

In several studies, the authors propose orthopedic treatment for patients with osteochondrosis of the spine, which consists in the use of breathing exercises aimed at unloading the spine. This weakens reflex-painful muscle spasm and compression of the intervertebral discs. By increasing the intervertebral space and reducing pressure on the discs and nerve roots, exercises with these gymnastics will help relieve an acute pain attack (Moon et al., 2016; Chen et al., 2023; Mastromarchi et al., 2023).

Some techniques consist in the use of special simulators that allow you to put a load on the muscles surrounding the affected area. This contributes to the flow of blood to this place, and therefore useful substances that will help a speedy recovery without medication and wearing supportive corsets (Sterling et al., 2019; Ling et al., 2023).

With osteochondrosis of the spine, the use of physical exercises allows to normalize the pressure on the spine and relieve the affected spinal cord roots, as well as reduce the hypertonicity of the muscles involved in the pathological process, which in itself improves blood circulation in the muscles and nerve roots, thereby preventing the development of muscle atrophy and tight joint mobility (Moon et al., 2016; Teichert et al., 2023).

It is known that childhood and adolescent osteochondrosis, as well as radicular syndrome, should indicate the presence of curvature of the spine in a child, which should be a serious reason for an immediate visit to a specialist doctor. Improper load distribution on the spine inevitably leads to its curvature, and then, in turn, to disorders in the intervertebral disc system. In the early stages of the disease, it is much easier to bring everything back to normal through a special muscle corset (Sterling et al., 2019; Nguyen et al., 2021; Teichert et al., 2023).

Physical education for cervical osteochondrosis, like

other physical activities, requires the right approach and compliance with certain rules. Of course, following these rules will allow you to get the maximum positive effect from exercise and help your health (Mastromarchi et al., 2023).

Thus, the analysis of scientific and methodological literature has shown that the prevention of osteochondrosis should begin at an early age. Proper physical education, prevention of sudden overloads and posture disorders are an important point of it. Reducing injuries, static and dynamic overloads of the spine is important in preventing osteochondrosis. In the prevention and treatment of osteochondrosis, systematic exercises in therapeutic physical gymnastics are essential.

The objective of the study is rehabilitation of high school students with osteochondrosis of the cervical spine.

Tasks

1) To study the causes of osteochondrosis, their types and effects on humans.

2) To determine effective means of physical rehabilitation for osteochondrosis of the cervical spine.

3) To develop a methodology for using physical rehabilitation tools to restore the musculoskeletal system, improve the indicators of physical development and physical fitness in children of senior school age in non-urgent forms of classes and additional individual classes at home.

The hypothesis of the study: it is assumed that the use of special physical exercises in physical education classes at school and at home will contribute to the effective rehabilitation of older students with the problem of osteochondrosis.

Methods

Study participants:

The research involved boys and girls aged 15-17 who were diagnosed with osteochondrosis of the cervical spine. A total of 38 schoolchildren participated in the study. Diagnosis of cervical osteochondrosis was carried out by a pediatrician specializing in problems of the musculoskeletal system.

Inclusion criteria

• Children aged 15-17 years attending secondary schools in Kirov (Russia).

• Children who do not have severe or acute diseases that prevent participation in the research.

Exclusion criteria

• Children who did not agree to participate in the research unless their parent or legal guardian signed an informed consent.

• Children who have not been admitted by a doctor to physical education classes at school.

Organization of the study

The study was conducted from February 27 to May 26, 2023 on the basis of several secondary schools №42, №46, №54, №60 and No. 66 of the city of Kirov.

2 groups were formed to conduct the study:

The control group consisted of schoolchildren from school No. 42 (7 children), from school No. 46 (5 children), from school No. 54 (7 children). There are 19 children in total.

The experimental group consists of schoolchildren from school No. 60 (11 children), from school No. 66 (8 children). There are 19 children in total.

In all schools of the city of Kirov in Russia, physical education classes are held 3 times a week for 40 minutes. All students in both groups studied according to the standard curriculum of educational institutions (Kainov & Kuryerova, 2019). The children from the control group did not perform any special physical exercises, adhering to the standard program. It is important to note that children who are diagnosed with cervical osteochondrosis, as a rule, do not participate in outdoor games and sports games with their peers. This is a recommendation of medical organizations. Therefore, more often at this moment, children from the control group watched their peers who participate in outdoor games or had the opportunity to repeat previously passed material. As a rule, this is 7-9 minutes of the total duration of the lesson in some classes. At that time, children from the experimental group performed sets of physical exercises based on the developed methodology. Also, students from the experimental group received homework in the form of a set of exercises that had to be done at home before the next physical education lesson. An example of a physical education lesson in both groups is shown in table 1.

Table 1.
Physical education lesson in control and experimental groups

Parts of the lesson	The control group	The experimental group
Preparatory (5 minutes)	To prepare the body for the upcoming load: pulse check, general warm-up.	
Main (30 minutes)	Fulfilling the main purpose and objectives of the lesson, for example, studying the high jump using the "scissors" method. Improving the skill of throwing a tennis ball at a distance.	
	Outdoor or sports games	A set of exercises from an experimental technique
The final (5 minutes)	To reduce the emotional background of those involved and bring the body into a calm state: pulse measurement and breathing exercises	

The requirements that were imposed on the experimental method

1. Compliance of the exercises used with the age characteristics of the students;

2. Accessibility of the exercises used to perform them;

3. When performing exercises with objects, observe the principle of consistency from simple to complex;

4. Increasing interest in the classes being held.

The main means of the proposed technique are self–massage, general developmental exercises without objects, general developmental exercises with a gymnastic stick,

with a stuffed ball, breathing exercises, coordination exercises, special complexes of therapeutic gymnastics, which gradually increased the load on the cervical spine and contributed to improving mobility in the cervical spine, thereby preventing the exacerbation of osteochondrosis of the cervical spine.

The complexes used exercises in which students learned proper breathing, exercises were used to increase the vertical size of the intervertebral openings, exercises for muscle relaxation were used to increase the mobility of the vertebrae in the cervical region, as well as special exercises to strengthen the muscles of the shoulder girdle. A separate complex consisted of tasks that the students completed at home.

An approximate set of exercises that allows you to teach proper breathing when performing exercises:

The starting position is standing, arms along the body.

1. Raise your arms up, pull up – inhale; return to the starting position – exhale.

2. Tilt to the left side with your right hand raised up while inhaling.

3. The same exercise, but during exhalation.

4. Raise your hands up – inhale, sit down slowly, exhaling, and wrap your arms around your knees.

5. Raise your arms up through the sides, rising on your toes – inhale, lean forward freely, lowering your arms – exhale

6. Starting position – standing, hands on the belt. Circular movements of the pelvis to the right and left. Breathing is arbitrary.

7. Easy running (3-4 minutes); follow your breathing – inhale for 3 steps, exhale for 4 steps.

An approximate set of exercises that allows you to increase the mobility of the vertebrae in the cervical spine:

The starting position is standing, arms along the body.

1. Turn your head to the far right position, try to turn your head a little further with light springy movements, then the same thing to the left.

2. Lower your head down, trying to press your chin to your chest as much as possible. Try to lower your head even lower with light springy movements.

3. Pull your head back while retracting your chin. Try to move your head a little further back with light springy movements.

4. The palm of one hand on the forehead. Tilting your head forward, while pressing your palm on your forehead, counteracting the movement of the head, for about 10-15 seconds, then rest for the same amount of time.

5. The same thing, but the palm is in the temple area. Tilting the head to the side, simultaneously press on it with the palm of your hand, counteracting the movement of the head for about 10-15 seconds. Rest.

6. Raise your shoulders as much as possible and hold them in this position for 10-15 seconds. Relax, lower your shoulders and take a deep breath.

7. The starting position is lying on the gym mat. Lying on your side, lift your head 1-3 cm, hold it in this position for 10-15 seconds

8. The same thing, but lying on your stomach, lift your head 1-3 cm, hold it in this position for 10-15 seconds.

An approximate set of exercises that allows you to strengthen the muscles of the shoulder girdle:

The starting position is standing, arms along the body.

1. Lower and raise your shoulders: left – up, right – down. Then both shoulders are up. Perform slowly at first, then increase the tempo.

Raise your arms up, spread them apart and lower them down. Repeat 10-15 times standing and sitting, first at a slow pace, then at a fast pace.

Raise your arms up to shoulder height, spread them apart, lift them over your head and return to the starting position. Let go of your hands. Do the same thing while sitting.

Raise your arms to the sides at shoulder height and make rotational movements with them. Do the same thing while sitting at a slow and then fast pace.

An approximate set of exercises for homework:

1. Starting position – lying on the gym mat, spread your arms apart, slightly turning your torso to the left, reach your left palm with your right hand. Do the same thing the other way. Repeat 7-8 times.

2. Starting position – lying on your back with your knees bent, take hold of the edge of the sofa or the headboard with your hands. Slowly raise the torso, trying to reach the hands with the feet of the feet. Repeat the exercise 7-8 times.

3. Starting position – sitting on a chair, slowly raise your head up, lower it, then tilt your head to the right, to the left (the amplitude of movements is small) repeat 7-8 times.

4. Starting position – sitting on a chair. Slowly bend forward (back straight, head stretches forward); return to the starting position.

To assess the effectiveness of the experimental exercise technique, control tests were used, which were conducted before and after the research (Kainov &Kuryerova, 2019)

1. The static endurance of the abdominal muscles was measured by holding the legs at a 90-degree angle on the Swedish wall.

2. The static strength of the back muscles was measured by holding the "boat" position while lying on your stomach.

3. The strength of the arm muscles was assessed by the number of flexion and extension of the arms in the prone position.

4. The flexibility of the cervical spine was evaluated to the right and left sides so that the chin was turned to the side as much as possible.

5. The strength of the muscles of the cervical spine was assessed by holding the head lying on the back, on the stomach (the head must be lifted).

The main indications for the use of therapeutic gymnastics are

1) lack of sufficient physical activity;

2) osteochondrosis of the cervical, thoracic, lumbar spine at any stage;

3) scoliosis and other diseases of the spine;

4) diseases of the cardiovascular system;

5) respiratory and digestive diseases.

Despite the wide therapeutic effect, the use of therapeutic physical culture is undesirable in the following cases

1) for any diseases occurring in an acute form;

2) in case of exacerbation of existing chronic diseases;

3) within a month after the viral infection;

4) within a year after a myocardial infarction;

5) in the presence of malignant neoplasms;

6) with a tendency to bleeding;

7) in the case of an aortic aneurysm;

8) with tachycardia over 100 beats per minute;

9) in case of violation of the heart rhythm and conduction of the heart muscle;

10) in case of hypertension, blood pressure is over 160/100;

11) in severe form of diabetes mellitus.

Methods of mathematical statistics

A Student's t-test is a ratio that quantifies how significant the difference is between the 'means' of two groups while taking their variance or distribution into account (Wadhwa & Marappa-Ganeshan, 2023).

When using this research method, data is obtained confirming or refuting the hypothesis put forward in the study. The Biostatistics 2019 program was used in the study.

Results

To evaluate the effectiveness of the experimental exercise technique, various functional tests and tests were used, which were conducted before and after the research. The average results of both groups, which were obtained before the start of the research, are presented in Table 2.

Table 2.
Indicators of the control and experimental groups before the start of the study

Types of abilities	The control group			The experimental group			T	P
	Mn	Qn	mn	Mn	Qn	mn		
Static strength of the abdominal muscles	47,0	9,7	5,7	54,0	7,2	4,2	t=0,98	p>0,05
Static strength of the back muscles	64,0	4,8	3,6	53,0	9,7	5,7	t=1,63	p>0,05
Flexibility of the cervical spine to the left side	6,0	1,4	0,8	6,0	1,4	0,8	t=0	p>0,05
Flexibility of the cervical spine to the right side	6,0	1,4	0,8	6,0	0,9	0,5	t=0	p>0,05
Speed and strength abilities of the arm muscles	46,0	14,5	6,5	42,0	9,7	5,7	t=0,39	p>0,05
Endurance of the cervical spine lying on your back	59,0	9,7	5,7	56,0	22,8	13,4	t=0,20	p>0,05
Endurance of the cervical spine lying on your stomach	76,0	4,8	2,8	83,0	7,2	4,2	t=1,38	p>0,05

*Mn – The arithmetic mean; Qn – The mean square deviation; mn – Average error.

The results of testing at the beginning of the research showed that the studied students in the control and experimental groups did not differ in static endurance of the muscles of the trunk and legs, flexibility and endurance of the cervical spine. This indicates that the groups are homogeneous according to these indicators. This fact allows us to objectively verify the effectiveness of the experimental technique.

After the end of the research, all students took control tests again, the test results are shown in Table 3.

Table 3.
Indicators of the experimental and control groups after the study

Types of abilities	The experimental group			The control group			T	P
	Mn	Qn	mn	Mn	Qn	mn		
Static strength of the abdominal muscles	71,0	9,7	5,7	52,0	10,7	6,3	t=2,23	p>0,05
Static strength of the back muscles	72,0	7,3	4,2	69,0	2,4	1,4	t=0,68	p>0,05
Flexibility of the cervical spine to the left side	10,0	0,9	0,5	6,0	1,4	0,8	t=4,25	p<0,05
Flexibility of the cervical spine to the right side	10,0	0,9	0,5	6,0	1,4	0,8	t=4,25	p<0,05
Speed and strength abilities of the arm muscles	64,0	12,1	7,1	47,0	2,4	1,4	t=2,35	p>0,05
Endurance of the cervical spine lying on your back	80,0	12,1	7,1	61,0	3,2	1,5	t=2,38	p<0,05
Endurance of the cervical spine lying on your stomach	102,5	9,7	5,7	83,0	4,8	2,8	t=3,07	p<0,05

*Mn – The arithmetic mean; Qn – The mean square deviation; mn – Average error.

Table 3 shows changes in the studied indicators with positive dynamics in both groups. However, not all indicators are reliable ($p>0.05$). For example, the indices of flexibility and endurance between the control and experimental groups in the cervical spine significantly improved ($p<0.05$).

Table 4 shows the changes in the indicators in the control group from the beginning to the end of the research.

Table 4.
The indicators of the control group at the beginning and at the end of the study

Types of abilities	At the beginning of the study			At the end of the study			T	P
	Mn	Qn	mn	Mn	Qn	mn		
Static strength of the abdominal muscles	47,0	9,7	5,7	52,0	10,7	6,3	t=0,58	p>0,05
Static strength of the back muscles	64,0	4,8	3,6	69,0	2,4	1,4	t=0,87	p>0,05
Flexibility of the cervical spine to the left side	6,0	1,4	0,8	6,0	1,4	0,8	t=0	p>0,05
Flexibility of the cervical spine to the right side	6,0	1,4	0,8	6,0	1,4	0,8	t=0	p>0,05

Speed and strength abilities of the arm muscles	46,0	14,5	8,5	47,0	2,4	1,4	t=0,10	p>0,05
Endurance of the cervical spine lying on your back	59,0	9,7	5,7	61,0	2,4	1,4	t=0,66	p>0,05
Endurance of the cervical spine lying on your stomach	76,0	4,8	2,8	83,0	4,8	2,8	t=1,77	p>0,05

*Mn – The arithmetic mean; Qn – The mean square deviation; mn – Average error.

Table 4 shows that the average group indicators of various types of abilities in the control group at the end of the pedagogical experiment do not have significant differences and are unreliable (p>0.05).

At the same time, table 5 shows changes in indicators in the experimental group from the beginning to the end of the research.

Table 5.
Indicators of the experimental group at the beginning and at the end of the study

Types of abilities	At the beginning of the study			At the end of the study			T	P
	Mn	Qn	mn	Mn	Qn	mn		
Static strength of the abdominal muscles	54,0	7,2	4,2	71,0	9,7	5,7	t=5,27	p<0,05
Static strength of the back muscles	53,0	9,7	5,7	82,0	7,3	4,2	t=4,09	p<0,05
Flexibility of the cervical spine to the left side	6,0	1,4	0,8	10,0	0,9	0,5	t=4,94	p<0,05
Flexibility of the cervical spine to the right side	6,0	0,9	0,5	10,0	0,9	0,5	t=5,71	p<0,05
Speed and strength abilities of the arm muscles	42,0	9,7	5,7	64,0	12,1	7,1	t=3,41	p<0,05
Endurance of the cervical spine lying on your back	56,0	22,8	13,4	80,0	12,1	7,1	t=3,58	p<0,05
Endurance of the cervical spine lying on your stomach	83,0	7,2	4,2	102,5	9,7	5,7	t=2,79	p<0,05

*Mn – The arithmetic mean; Qn – The mean square deviation; mn – Average error.

Table 5 shows that in the experimental group, the indicators of the static strength of the abdominal muscles increased from 54.0 to 71.0, the static strength of the back muscles increased from 53.0 to 82.0, the flexibility of the cervical spine in the right side increased from 6.0 to 10.0. Changes in the indices of flexibility of the cervical spine to the left (from 6.0 to 10.0), speed and strength abilities of the hands (from 42.0 to 64.0), endurance of the cervical spine lying on the back (from 56.0 to 80.0), endurance of the cervical spine lying on the stomach (from 83.0 to 102.0). All these indicators have changed significantly and are of a reliable nature (p<0.05). Such results indicate the sufficient effectiveness of the experimental technique.

In order to visually assess the effectiveness of the experimental technique in comparison with the standard program, we determined the percentage increase in indicators in each test from the beginning to the end of the research and presented the results in the form of a diagram (Figure 2).

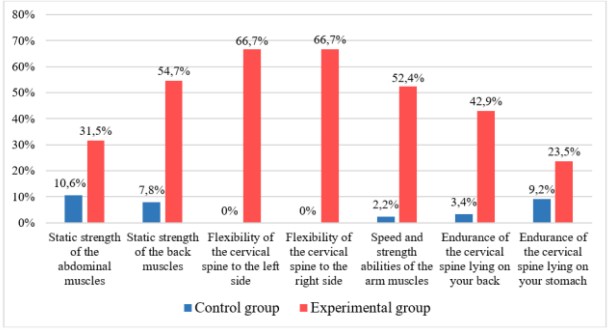

Figure 2. The increase in indicators in both groups from the beginning to the end of the study

Figure 1 shows that the experimental method, in comparison with the standard program, gives the best result in all indicators. Therefore, it can be concluded that it is more effective in the treatment of cervical osteochondrosis.

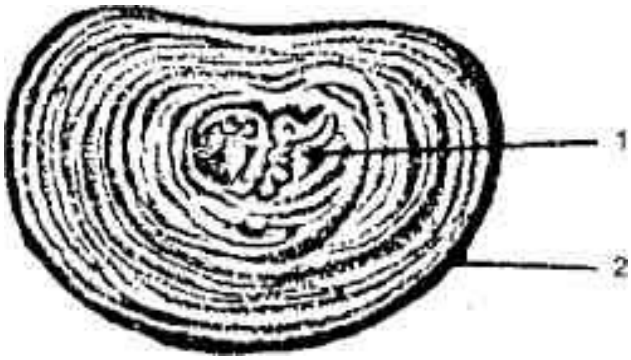

Figure 1. The structure of the intervertebral disc
1 – fibrous ring, 2 – pulpous nucleus destroyed by degenerative processes

Discussion

The research topic is one of the urgent problems of improving the health of the younger generation and is associated with an increase in the number of children and adolescents suffering from diseases of the musculoskeletal system (Weaver et al., 2020; Kåks & Målqvist, 2021; Requejo et al., 2022). At the same time, the main role of physical exercises in restoring impaired spinal functions is noted today by all leading scientists (Connolly et al., 2020; García-Hermoso et al., 2020; Rodríguez-Rodríguez et al., 2020; de Jesus et al., 2022). This problem needs to be solved, since it is in childhood that all the main pathological motor stereotypes are formed, which only become fixed with age and lead to a deterioration in the functioning of the entire musculoskeletal system (Stich et al., 2015; Krasin et al., 2022).

An analysis of the scientific and methodological literature on the studied problem has shown that the main cause of osteochondrosis is systematic muscle tension during labor operations associated with prolonged fixation of the working posture. Of particular importance in this regard for knowledge workers (including schoolchildren and students) is the long-term holding of a pose associated with

reading, writing, working on a computer, in which the head is tilted forward and, consequently, cervical lordosis is smoothed. Provokes the development of cervical osteochondrosis, the reclining position familiar to many people. Therefore, it is the cervical-brachial and lumbar localization of osteochondrosis that are the most diagnosed (Sitte et al., 2012).

To solve this problem, a methodology has been developed for using various means of physical rehabilitation to restore the musculoskeletal system, improve the indicators of physical development and physical fitness in children of senior school age in regular forms of classes and additional individual classes at home

According to the results of the research, it was found that children from the control group who studied according to the usual method were able to slightly improve the studied indicators. The data improved to 10.6%, the increase in indicators from the beginning to the end of the study for all tests turned out to be unreliable ($p>0.05$). Such data indicate that the standard procedure for children with cervical osteochondrosis is not a contraindication, but it does not have a significant impact on the development of schoolchildren's abilities.

In the experimental group, children performed special tasks during the lesson and some tasks were performed at home. At the end of the study, the indicators for all tests improved from 23.5% to 66.7% ($p<0.05$). This indicates that the application of the complex of physical exercises developed by us gives a positive dynamic for the development of static strength of the abdominal and back muscles, flexibility and endurance of the cervical spine and speed-strength abilities of the arm muscles. Therefore, it can be concluded that the method we have developed is more effective in the treatment of cervical osteochondrosis than the generally accepted method.

During classes with school-age children, physical exercises should be available for performance and correspond to the prevention stage, they should be regular and constant in order to ensure the growth or maintenance of an optimal level of fitness of the body. It is necessary to gradually increase the intensity, complexity and duration of training sessions – the main condition for increasing the fitness of the body (Moon et al., 2016; Sterling et al., 2019; Garzonio et al., 2022). It is also important to take into account the individual characteristics of schoolchildren (height, weight and physiological characteristics) (Weaver et al., 2020; Kåks & Målqvist, 2021; Requejo et al., 2022).

The issue of osteochondrosis is quite relevant (Polevoy, 2024). The problem of many diseases can be partially solved by physical exercise and physical culture in general. (Sarroeira et al., 2022; Septianto et al., 2024). This is especially important in modern living conditions, as the problems of insufficient activity of children in early school age (Marambio Miranda et al., 2020; Galán-Arroyo et al., 2023) are significantly increasing. Of course, scientific research could be improved by expanding some aspects. The problem is relevant and promising for further research in this direction.

The theoretical significance of the study is to supplement and expand knowledge in the field of adaptive physical rehabilitation on the use of exercise complexes for high school children with osteochondrosis in the cervical spine. The practical significance lies in the fact that the data obtained can be used in organizing the process of physical rehabilitation of high school children with musculoskeletal disorders in other educational institutions.

The scientific novelty lies in the fact that for the first time special complexes of physical exercises were presented, which are aimed at restoring the functional parameters of the musculoskeletal system in osteochondrosis of the cervical spine, which will increase the effectiveness of the process of physical rehabilitation of children in general. A set of physical exercises is performed during physical education lessons at school, as well as at home. Of course, the effectiveness of the study could be improved by supplementing it with additional physical exercises or control tests. In the following studies, it is planned to disclose the issue of the dosage of physical activity and the time allotted for performing sets of exercises during the lesson at school and at home.

Limitations of the study

Only children aged 15 to 17 years participated in the study. In the future, children with cervical osteochondrosis at primary and secondary school age could be studied, and various other informative tests could be used.

Conclusion

The standard procedure for children diagnosed with cervical osteochondrosis has a minor but positive effect on the development of some physical qualities of schoolchildren.

Systematic physical education with the use of special physical exercises aimed at eliminating problems in the cervical spine give a significant effect in the rehabilitation of cervical osteochondrosis. The indicators of static strength of the abdominal and back muscles, flexibility and endurance of the cervical spine and the speed and strength abilities of the arm muscles will significantly improve.

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Conflict of interest

None. The author declares no conflict of interest

Author contributions

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