

Dynamics of hemodynamic parameters and tone of the autonomic nervous system in the rehabilitation of patients with neurocirculatory dystonia

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Abstract

Purpose: to substantiate, develop and evaluate the effectiveness of a physical therapy program for young women with hypertensive neurocirculatory dystonia at the outpatient stage.

Material & Methods: under our supervision there were 28 women with a diagnosis of neurocirculatory dystonia of hypertonic type; they were randomly divided into two groups: main (14 patients) and control (14 patients); the average age of patients in the main group was $20,1 \pm 0,35$ years, in the control group – $20,6 \pm 0,23$ years. The course of physical therapy for patients of the main and control groups lasted for 5 months. The patients of the main group underwent rehabilitation measures according to the program of physical therapy, which included kinesiotherapy using therapeutic exercises based on dance aerobics in combination with regulated breathing exercises, taking into account the tone of the ANS and autogenic training, patients of the control group were engaged in the E.V. Doliger physical therapy program for patients with NCD.

Results: the functional indicators of the cardiovascular and autonomic nervous system obtained during the primary study indicated the absence of economization of the work of the cardiovascular system, the presence of dysfunction of the autonomic nervous system in the direction of the predominance of the activity of the sympathetic department. After 5 months of using physical therapy programs, when re-examined, patients in both groups showed a decrease in heart rate and a decrease in blood pressure; stroke volume in the main group was within normal limits, in the control group, a decrease in stroke volume indicated a reduced myocardial contractility; the decrease in the minute volume of blood in the main group was due to a decrease in heart rate, in the control group – due to a decrease in heart rate and stroke volume. The value of the Kerdo index in the main group corresponded to the state of eutonia, in the control group – sympathicotonia.

Conclusions: in the course of the study, we came to the conclusion that a physical therapy program was developed, which included kinesiotherapy using therapeutic exercises based on dance aerobics in combination with regulated breathing exercises, taking into account the tone of the parasympathetic and sympathetic divisions of the autonomic nervous system and autogenic training, is effective and contributes to the normalization of hemodynamic parameters and the tone of the autonomic nervous system, which improves the quality of life of NCD patients. The conducted studies have confirmed the need for the use of physical therapy, including kinesiotherapy using therapeutic exercises based on dance aerobics in combination with regulated breathing exercises, taking into account the tone of the ANS and autogenous training.

Key words: neurocirculatory dystonia, physical therapy, dance aerobics, hemodynamic parameters, indicators of the functional state of the autonomic nervous system.

Анотація

Динаміка гемодинамічних показників та тону вегетативної нервової системи в реабілітації хворих на нейро-циркуляторну дистонію. **Мета:** обґрунтувати, розробити і оцінити ефективність програми фізичної терапії для жінок молодого віку, хворих на нейро-циркуляторну дистонію по гіпертонічному типу, на поліклінічному етапі. **Матеріал і методи:** під нашим спостереженням перебували 28 жінок з діагнозом: Нейро-циркуляторна дистонія по гіпертонічному типу; вони були довільно розділені на дві групи: основну (14 хворих) і контрольну (14 хворих); середній вік хворих основної групи склав $20,1 \pm 0,35$ років, контрольної – $20,6 \pm 0,23$ років. Курс фізичної терапії хворих основної і контрольної груп тривав протягом 5 місяців. Пацієнтам основної групи проводилися реабілітаційні заходи за програмою фізичної терапії, яка включала кінезотерапію з використанням терапевтичних вправ на основі танцювальної аеробіки в поєднанні з регламентованими дихальними вправами з урахуванням тону ВНС та автогенне тренування, пацієнти контрольної групи займалися за програмою фізичної терапії для хворих на НЦД Є.В. Долігер. **Результати:** отримані при первинному дослідженні функціональні показники серцево-судинної та вегетативної нервової системи свідчили про відсутність економізації роботи серцево-судинної системи, наявність дисфункції автономної нервової системи у бік переважання активності симпатичного відділу. Через 5 місяців застосування програм фізичної терапії при повторному дослідженні у хворих обох груп спостерігалось зменшення частоти серцевих скорочень та зниження артеріального тиску; ударний об'єм в основній групі знаходився в межах нормальних значень, в контрольній групі зменшення ударного обсягу свідчив про знижену скорочувальну здатність міокарду; зменшення хвилинного об'єму крові в основній групі відбулося за рахунок зменшення частоти серцевих скорочень, в контрольній групі – за рахунок зменшення частоти серцевих скорочень і ударного обсягу. Величина індексу Кердо в основній групі відповідала стану еутонії, в контрольній групі – симпати-котонії. **Висновки:** в ході проведеного дослідження ми прийшли до висновку, що розроблена програма фізичної терапії, яка включала кінезотерапію з використанням терапевтичних вправ на основі танцювальної аеробіки в поєднанні з регламентованими дихальними вправами з урахуванням тону парасимпатичного та симпатичного відділів вегетативної нервової системи й автогенне тренування, є ефективною і сприяє нормалізації гемодинамічних показників та тону вегетативної нервової системи, що

сприяє підвищенню якості життя хворих на НЦД. Проведені дослідження підтвердили необхідність застосування фізичної терапії, що включає кінезотерапію з використанням терапевтичних вправ на основі танцювальної аеробіки в поєднанні з регламентованими дихальними вправами з урахуванням тону ВНС та автогенне тренування.

Ключові слова: нейро-циркуляторна дистонія, фізична терапія, танцювальна аеробіка, гемодинамічні показники, показники функціонального стану вегетативної нервової системи.

Introduction

Neurocirculatory dystonia (NCD) is a polyetiological functional disease, which is manifested by numerous cardiovascular, respiratory and vegetative disorders, asthenia, poor tolerance of stressful situations and physical activity (Grigus & Hrushevskaya, 2017). Functional disorders of the cardiovascular system are widespread, especially among young and middle-aged people. According to numerous epidemiological studies, in the population they are noted in 25-80% of cases. In the general structure of cardiovascular diseases, NCD is 32-50%. They get sick more often at a young and mature age (18-40 years), mostly women. NCD in the structure of cardiovascular diseases in adolescents is 75% (Bentsa, 2018).

Goldstein et al. (2002), Rafanelli et al. (2019), Napalkova & Krivyca (2019), Mathias & Bannister (2013) note that vegetative disorders are one of the most urgent problems of modern science, which is primarily due to their significant prevalence (Goldstein et al., 2002; Rafanelli et al., 2019; Napalkova & Krivyca, 2019; Mathias & Bannister, 2013).

NCD is a functional pathology and is not the result of an organic lesion of the heart. However, about 50% of patients note a deterioration in the quality of life, and clinical manifestations of the disease, such as autonomic crises, rhythm and conduction disturbances, in the absence of adequate treatment, persist up to 20 years.

The issues of complex treatment of patients with vegetative dysfunctions are covered in the works of many domestic and foreign specialists. However, recommendations for the use of physical exercises during the rehabilitation treatment of patients with NCD are of a general nature. Require further improvement recommendations for independent physical exercises, insufficiently clear criteria for assessing the effectiveness of rehabilitation measures (Grigus & Hrushevskaya, 2017).

According to the International Classification of Diseases 10th revision, neurocirculatory dystonia is called somatoform dysfunction of the autonomic nervous system and is recognized as a symptom complex, which is caused by an imbalance in the interaction of the sympathetic, parasympathetic

and metasympathetic divisions of the autonomic nervous system (Murzhak-Chub & Kuts-Burdeina, 2018).

Comprehensive treatment of NDC should include psychotherapeutic methods, an individual approach to prescribing medication, the use of preformed physical factors, and kinesitherapy. Rational psychotherapy and auto-training are carried out in order to reduce stress, achieve psychological comfort and normalize the psychological state of the patient. Various relaxation techniques (diaphragmatic breathing, muscle relaxation), as well as psychological trainings with elements of rational psychotherapy (creating visual images, acquiring problem-solving skills) have a significant therapeutic effect. A significant positive effect in case of psycho-emotional overwork is an increase in physical activity: walking, dosed physical activity, swimming, despite the possible temporary increase in symptoms (Bentsa, 2018).

According to the results of the study Nikolenko (2018); Murzhak-Chub & Kuts-Burdeina (2018), with mild and moderate degrees of the disease, preference is given to non-drug methods, including adherence to the daily regimen with sufficient night sleep and daytime rest, kinesitherapy classes, rational nutrition (depending on the initial vegetative tone, the nature of nutrition has its own characteristics), psychotherapy (individual, group, family) to correct the relationship of the patient with the environment, hydro- and balneotherapy (use of fresh water for douching, rubbing, showers and baths with the addition of various aromatic compounds, herbal remedies, as well as mineral waters, different in composition, application of preformed physical factors, massage, reflexology, herbal medicine).

As noted Yezhova et al. (2021), during physical activity, physiological indicators of the work of the heart change. The heart rate (HR), stroke volume or cardiac output (SV), minute volume of blood circulation (MVC), blood pressure (BP) increase. For therapeutic exercises of low and medium intensity, adaptation to the load and the growth of MVC is carried out mainly due to the SV, which is positive for the work of the heart, in the case of high-intensity exercise, due to the increase in heart rate. The direct relationship between exercise intensity and heart rate helps to dose aerobic exercise and determine the patient's response to it. Changes in blood pressure components can have different directions. Thus, systolic blood pressure (SBP) increases during exercise, and diastolic blood pressure (DBP) may remain unchanged, slightly increase (up to 10 mm Hg) or decrease. Changes in blood pressure during therapeutic exercise should be taken into account when dosing exercise, especially strength exercise, for patients with NCD.

But, according to the results of scientific studies, the long-term effects of therapeutic exercises on the physiological parameters of the cardiovascular system may not appear, which is associated with

insufficient intensity of physical activity. These effects are more commonly observed in patients who have been doing therapeutic endurance exercise for years or in endurance athletes. First, there is a decrease in heart rate at rest (bradycardia) and compensatory – an increase in the value of SV, which is positive for the functioning of the heart and its energy supply. Secondly, moderate myocardial hypertrophy develops, which is a manifestation of the strengthening of the heart, and positively affects its contractile function. For patients, important long-term effects of therapeutic exercises are strengthening the myocardium, increasing the strength of its contraction, improving its blood supply due to an increase in the number of coronary capillaries, elasticity of the walls of blood vessels. The condition of the walls of the main arteries improves due to the training of their muscle layer. Therefore, vessels respond faster and more, respectively, to changes in SBP. An increase in the number of capillaries in skeletal muscles contributes to the normalization of DBP changes during exercise (Yezhova et al., 2021).

According to the Grigus & Hrushevskaya (2017), for a faster restoration of physiological balance in the work of the cardiovascular system, it is necessary to use the whole range of therapeutic measures, including physical therapy. Physical factors do not have side effects, do not cause intoxication, allergic reactions, there is no cumulative effect and addiction.

Under the influence of physical exercises, notes Olchovik (2015), venous pressure indicators normalize, blood circulation speed increases both in the coronary and peripheral vessels, which is accompanied by an increase in the minute volume of blood circulation and a decrease in the total peripheral resistance in the vessels. According to the author, the degree of tonic effect of therapeutic exercises depends on the mass of the contracting muscles and the intensity of the exercises. Exercises that involve large muscle groups performed at a fast pace have a significant effect. The alternation of exercises that enhance the processes of excitation in the central nervous system (exercises for large muscle groups, with pronounced muscle effort, at a fast pace), with exercises that enhance the processes of inhibition (breathing exercises, muscle relaxation exercises), contribute to the restoration of normal mobility of nervous processes. Under the influence of physical exercises, the author claims, indicators of venous pressure normalize, the speed of blood circulation in the coronary and peripheral vessels increases, which is accompanied by an increase in the minute volume of blood circulation and a decrease in peripheral resistance in the vessels. Under the influence of muscle activity, metabolic processes in the myocardium improve, the functional state of the vegetative centers is rebuilt, which leads to an increase in its contractile function. The degree of impact of exercise on metabolism depends on the number of muscles involved in the movement, and on the

intensity of its implementation (Olchovik, 2015; Kalmykova et al., 2021).

According to Bentsa (2018), treatment of NCD should begin with the formation of a proper lifestyle, the normalization of work and rest. Patients need a balanced diet, normal sleep, avoidance of alcohol and smoking. In the presence of harmful factors and intoxications associated with professional work, their complete exclusion is necessary. Comprehensive treatment for NCD should include psychotherapeutic action, drug treatment, physiotherapy, kinesiotherapy. The main non-drug treatment measure is rational psychotherapy and auto-training to reduce stress, achieve psychological comfort and facilitate the return to normal psychological functioning of the patient. Various relaxation techniques (diaphragmatic breathing, muscle relaxation), as well as psychological trainings with elements of rational psychotherapy (building visual images, teaching problem-solving skills) have a pronounced therapeutic effect. A positive effect in case of psycho-emotional overwork is an increase in physical activity: regular walking, dosed physical training in the gym, swimming. Respiratory syndrome responds well to treatment with breathing exercises. If an infectious factor is identified, foci of chronic infection are treated, as well as restorative therapy (multivitamins, adaptogens of plant origin: ginseng tincture, eleutherococcus extract, aralia tincture, zamanihi tincture) (Bentsa, 2018).

According to Grigus & Hrushevska (2017), kinesiotherapy is prescribed for the purpose of: normalizing the processes of excitation and inhibition in the central nervous system, motor-vascular reflexes of vascular tone, impaired regulation of blood pressure; increasing the regulatory role of the central nervous system in coordinating the activities of the most important organs and systems involved in the pathological process; strengthening motor-visceral and visceromotor connections; general strengthening of the body and the emotional state of the patient; stimulation of the activity of the cardiovascular and muscular systems and an increase in muscle and vascular tone; reducing the need for medicines.

The means of physical rehabilitation for diseases of the cardiovascular system, namely neurocirculatory dystonia, are corrective physical exercises, general developmental exercises, breathing exercises, exercises with resistance for the muscles of the lower leg and thigh, therapeutic walking and walking barefoot, wiping with cold water, therapeutic massage, physiotherapy procedures (Kalmykov et al., 2020; Kalmykova & Rakcheeva, 2016).

Particular attention deserves the appointment of special physical exercises during conservative treatment, which are selectively combined with restorative and breathing exercises, means and hardening and preformed physical factors and taking into account: the clinical course of the disease, comorbidities, as well as taking into account the individual characteristics of the organism (gender,

age), functional abilities of the main life support systems, the state of protective systems, the level of physical fitness and tolerance to physical neoplasms at different stages of physical rehabilitation. The intensity and volume of classes depend on the general physical fitness and the functional state of the cardiovascular system, which is determined during dosed tests with a load (Murzhak-Chub & Kuts-Burdeina, 2018; Grigus & Hrushevska, 2017).

The basis for building a program of physical therapy by means of recreational aerobics Dolgier (2015), became a sanogenetic approach, in which the choice and scope of rehabilitation methods is determined taking into account the level of physical performance, the characteristics of the course of the disease. Wellness aerobics classes are held twice a week for 60 minutes. Three times a week, self-healing walks in a park or seaside area are recommended, combined with general developmental exercises. To obtain the maximum healing effect, patients are offered daily morning hygienic exercises using self-massage of the head, cervical-collar zone and reflexogenic zones of the feet, which are also included in the recovery part of recreational aerobics classes, and self-performing autogenic training according to the Schultz method which is an active psychotherapy method. An important place in the rehabilitation of patients with NCD is given to rational nutrition. The physical therapy program includes three periods: introductory, which is a sparing regimen; the main one, which consistently combines sparing training and training modes, and the final one, which provides for a training mode. The rehabilitation course is six months (24 weeks). The method of conducting health-improving aerobics classes is group. The lesson consists of three parts: preparatory, main and final. To calculate the intensity of overload, the method for determining the heart rate reserve is used. The peak (maximum) load was in the middle or end of the second third of the main part. According to the calculations, the heart rate for 10 seconds should be 20-26 beats during the session. The lesson is based on low-intensity therapeutic exercises, characterized by the performance of low-amplitude movements. In addition, attention is drawn to the signs and symptoms of overwork on the modified scale of the experienced Borg effort, with a digital gradation in the range from 0 to 10 points. The tempo of musical accompaniment for women with NCD should not exceed 118-122 accents per minute (Dolgier, 2015).

Material and methods of research

Participants

Under observation were 28 women with a diagnosis of neurocirculatory dystonia of hypertonic type. They were randomly divided into two groups: main (14 patients) and control (14 patients). The average age of patients in the main group was $20,1 \pm 0,35$ years, in the control group – $20,6 \pm 0,23$ years. The duration of the disease is from 1 to 3

years. The course of physical therapy in patients of the main (MG) and control groups (CG) lasted for 5 months. The patients of the main group underwent rehabilitation measures under the program of physical therapy, which included kinesiotherapy using therapeutic exercises based on dance aerobics in combination with regulated breathing exercises, taking into account the tone of the ANS and autogenic training, patients in the control group were engaged in the E.V. Doliger physical therapy program for patients with NCD.

Methods

To analyze the effectiveness of the physical therapy program for neurocirculatory dystonia, we carried out the determination and analysis of hemodynamic parameters and indicators of the functional state of the autonomic nervous system. Examination of patients was carried out for the use of physical therapy (initial examination) and after 5 months of using physical therapy programs (re-examination). In order to obtain complete information about the functional state of the cardiovascular system in patients with hypertensive neurocirculatory dystonia, as well as to determine the amount of physical activity in the preparation of an individualized physical therapy program, we determined and analyzed the values of systolic, diastolic pressure, stroke volume and minute blood volume. Due to the fact that in neurocirculatory dystonia the level of blood pressure depends to a large extent on the activity of the central nervous system (cortical and subcortical sections) and the autonomic (vegetative) nervous system, we considered it appropriate to study the functional state (tonus) of the sympathetic and parasympathetic sections of the ANS.

To study the state of the ANS, we used the definition of the vegetative Kerdo index (V.I.) according to the formula (Kérdö, 1966; Kalmykova et al, 2018):

$$V.I. = (1 - d/p) \times 100,$$

where V.I. – vegetative Kerdo index; d/p – diastolic pressure/pulse rate ratio.

Procedure

In the main group of patients, we applied a program of physical therapy, which included kinesiotherapy using therapeutic exercises based on dance aerobics in combination with regulated breathing exercises, taking into account the tone of the ANS; autogenous training.

The global goal of the physical therapy program was: increasing adaptive capacity, general endurance, fitness of the body and general physical performance; adaptation of the body to physical stress of a domestic and labor nature. Short-term goals were: normalization of blood pressure and autonomic regulation of vascular tone; improvement of blood circulation and trophic processes in the myocardium; normalization of the psycho-emotional state and a decrease in the body's reaction to adverse external actions.

The basis of the kinesitherapy complexes was therapeutic exercises for medium and large muscle groups of the limbs and trunk based on dance aerobics, alternating with relaxation of the muscle groups of the upper and lower extremities and dynamic breathing exercises performed from the initial positions of "standing" and "walking", on average and at a fast pace, with a large range of motion in the joints Hawley & Franks (2000). In order to have a positive effect on the vegetative centers with a subsequent depressor reaction, we used regulated breathing exercises, taking into account the tone of the ANS. In order to stop the neurotic syndrome that accompanies the course of hypertensive type NCD, normalize the processes of excitation and inhibition in the central nervous system and normalize the emotional tone and mood of patients in the main group, we used musical accompaniment of kinesitherapy classes, as well as autogenous training according to the method of I. Schultz, which we conducted in the end of the final part of the kinesitherapy complex (Schultz, 1985). Patients were engaged in autogenous training for 15-20 minutes.

The course of physical therapy was divided into three periods: preparatory, basic, training.

In the preparatory period, general developmental exercises for all muscle groups were used in combination with exercises for strength and flexibility training in order to prepare the musculoskeletal apparatus and the cardiovascular system for physical exertion; exercises for training the vestibular apparatus; to balance with incomplete, and then – with full amplitude, at an average pace, from the initial positions "standing", "when walking", "sitting on the floor" on the basis of aerobic gymnastics. The number of repetitions of each exercise is 10-14 times. The emphasis was on exercises for the muscle group of the upper shoulder girdle and torso.

After 0,5 months of training, with a sufficient increase in the tolerance of the cardiovascular system to physical activity, the patients began to exercise according to the program of the main mode.

In the main period, physical exercises were used for the muscles of the upper limbs and shoulder girdle, neck, torso with elements of aerobics with full amplitude, at an average pace, the number of repetitions was 8-16 times; exercises for coordination and training of the vestibular apparatus; regulated breathing exercises while walking, taking into account the activity of the ANS divisions; rest breaks and relaxation exercises; running, jumping, and hopping.

During the training period, physical exercises were used for the muscles of the upper limbs and shoulder girdle, neck, torso with aerobic elements with maximum amplitude, at an average and fast pace, the number of repetitions was 12-16-30 times; exercises for coordination and training of the vestibular apparatus; regulated breathing exercises while

walking, taking into account the activity of the ANS divisions; rest pauses and relaxation exercises. All physical exercises were performed from the initial positions "sitting on the floor", "standing".

During therapeutic gymnastics, we recommended the use of regulated breathing when performing therapeutic exercises based on dance aerobics, taking into account the activity of the ANS. A differentiated approach to the appointment of regulated breathing, taking into account the tone of the sympathetic and parasympathetic divisions of the autonomic nervous system, based on the results of research, was as follows: breathing exercises with forced inspiration and holding the breath on inspiration activate mainly the sympathetic division of the autonomic nervous system; breathing exercises with an increase in the duration of exhalation and holding the breath on exhalation cause a more pronounced effect on the parasympathetic division of the autonomic nervous system (Goldstein et al., 2002; Rafanelli et al., 2019; Mathias & Bannister, 2013)

In the aerobics lesson, rhythmic music was used in the style of "foxtrot", "charleston", "tango", Latin American rhythms - "cha-cha-cha", "samba", "rumba", "disco", "rock and roll", "brakedance".

To correct the internal picture of the disease, relieve emotional overstrain, form an adequate assessment of the disease in the patient and maintain it throughout the rehabilitation treatment, we used autogenic training according to the method of I. Schultz, which we carried out at the end of the final part of the kinesitherapy session (Schultz, 1985). Patients were engaged in autogenous training in the "Shavasana" position - relaxation in the "dead body" position at the end of the final part of the kinesitherapy complex for 15-20 minutes.

In the control group of patients, the Dolgier (2015), physical therapy program was used, which included kinesitherapy using health-improving aerobics and daily morning hygienic gymnastics using self-massage of the head, neck-collar zone and reflexogenic zones of the feet, as well as self-performing autogenic training (Yushkovska & Dolgier, 2012).

The study was carried out in accordance with the research plan "Theoretical and methodological foundations of physical therapy and occupational therapy for organic and functional disorders of the organs and systems of the human body in health-

care practice", 2021-2025. (state registration number 0121U110141).

Statistical analysis

Statistical data processing was carried out using the Statistica 13 analysis package. Since all the studied indicators corresponded to the normal distribution law. The significance of the difference was assessed using Student's t-test. Differences that did not exceed the probability level $p < 0,05$ for a given number of degrees of freedom were considered statistically significant.

Results of the study

The hemodynamic parameters obtained during the initial study indicated the absence of economization of the cardiovascular system, the presence of ANS dysfunction in the direction of the predominance of the activity of the sympathetic department (Table 1).

Thus, in patients of the main and control groups, an increase in SBP to $141,07 \pm 1,42$ mm Hg was observed and $141,21 \pm 0,89$ mm Hg respectively ($p > 0,05$). DBP in both groups was at the upper limit of normal and in the MG was $84,57 \pm 3,57$ mm Hg, in the CG - $90,21 \pm 2,56$ mm Hg ($p > 0,05$). We found an acceleration of heart rate in both groups: in the main group it was $92,43 \pm 2,05$ bpm, in the control group it was $95,14 \pm 1,68$ bpm ($p > 0,05$). The data obtained confirm the presence of hypertensive NCD in the examined patients. The acceleration of heart rate indicates the presence of arterial hypertension and low adaptive capacity of the cardiovascular system in patients of both groups ($p > 0,05$). Stroke volume was recorded at the lower limit of normal in the main and control groups: $64,12 \pm 2,25$ ml and $60,51 \pm 2,17$ ml, respectively. MBV in both groups were determined within the normal range ($p > 0,05$).

The data obtained in the study of the ANS indicate a shift in the vagal-sympathetic balance towards a weakening of the vagal and dominance of the sympathetic tone in patients of both groups. Thus, the Kerdo index in the MG was at the level of $(8,94 \pm 2,22$ c.u.), in the CG - $(5,33 \pm 1,59$ c.u.) ($p > 0,05$) (Figure 1).

On re-study, which was conducted after 5 months of using physical rehabilitation programs, the majority of patients in both groups showed the dynamics of functional indicators of the cardiovascu-

Table 1. Hemodynamic parameters and Kerdo index in patients of both groups during the initial study (M \pm m)

Indicators	Norm	Groups of examined patients		t	p
		MG, n=14	CG, n=14		
Heart rate, bpm	60-84	92,43 \pm 2,05	95,14 \pm 1,68	1,03	>0,05
SAT, mm Hg	100-139	141,07 \pm 1,42	141,21 \pm 0,89	0,09	>0,05
DBP, mm Hg	60-89	84,57 \pm 3,57	90,21 \pm 2,56	1,28	>0,05
SV, ml	60-120	64,12 \pm 2,25	60,51 \pm 2,17	1,16	>0,05
MBV, ml/min	3000-7000	5887,90 \pm 153,32	5731,48 \pm 176,87	0,67	>0,05
Kerdo index, c.u.	0 \pm 0,15	8,94 \pm 2,22	5,33 \pm 1,59	1,32	>0,05

lar system and ANS (Table 2).

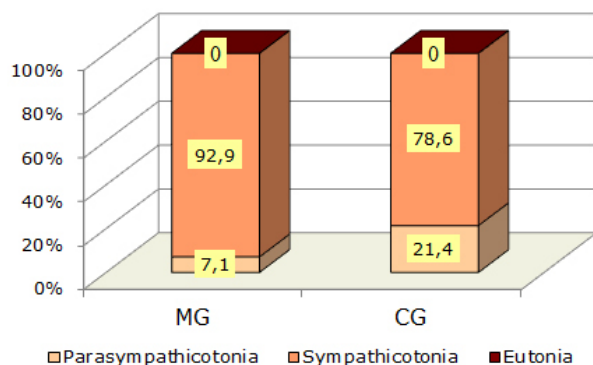
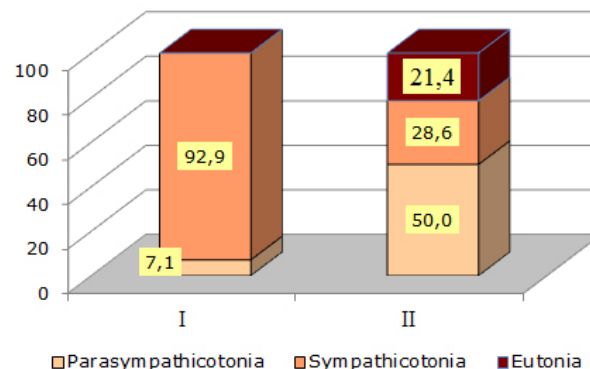


Figure 1. Functional state of the ANS in patients with MG and CG during the initial study (%)

In the second study in the main group, there was a decrease in heart rate by 20,3%, in the control group – by 8,0%, which indicates an increase in the physiological reserves of the cardiovascular system. In both groups, there was a decrease in blood pressure. In the MG, the figures of SBP and DBP reached normal values and were in accordance with $126,36 \pm 0,94$ and $73,64 \pm 2,00$ mm Hg ($p > 0,05$), in the control: SBP – $136,43 \pm 0,94$ mm Hg, DBP – $85,21 \pm 1,88$ mm Hg, moreover, the decrease in DBP in the control group was statistically insignificant. Stroke volume in the main group was within the normal range and amounted to $68,90 \pm 1,10$ ml, in the control group, SV decreased to $59,66 \pm 2,13$ ml, which may indicate a reduced myocardial contractility. We observed a decrease MBV in the main group from $5887,90 \pm 153,32$ to $5064,71 \pm 145,38$ ml/min. by decreasing heart rate. In CG, MBV also decreased from $5731,48 \pm 176,87$ to $5217,71 \pm 190,75$ ml/min. due to a decrease in heart rate and SV.

When determining the vegetative Kerdo index, we found in the main group 3 patients with eutonia, 4 with sympathicotonia and 7 with parasympathicotonia. In the control group, 2 patients had eutonia, 10 patients had sympathicotonia, and 2 patients had parasympathicotonia (Figure 2).

Main group



Control group

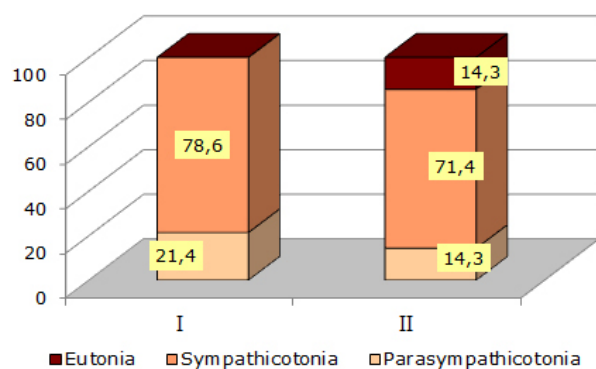


Figure 2. The functional state of the ANS in patients with OH and CG during the initial and repeated study (%)

Table 2. Dynamics of functional parameters of the cardiovascular and autonomic nervous system in patients of the main and control groups during the initial and re-examination ($M \pm m$)

Indicators	Norm	Study periods		t	p
		Initial study	Re-study		
Main group (n=14)					
Heart rate, bpm	60-84	$92,43 \pm 2,05$	$73,71 \pm 2,32$	6,05	<0,001
SAT, mm Hg	100-139	$141,07 \pm 1,42$	$126,36 \pm 0,94$	8,65	<0,001
DBP, mm Hg	60-89	$84,57 \pm 3,57$	$73,64 \pm 2,00$	2,67	<0,05
SV, ml	60-120	$64,12 \pm 2,25$	$68,90 \pm 1,10$	1,91	<0,05
MBV, ml/min.	3000-7000	$5887,90 \pm 153,32$	$5064,71 \pm 145,38$	3,90	<0,05
Kerdo index, c.u.	$0 \pm 0,15$	$8,94 \pm 2,22$	$-0,14 \pm 1,04$	3,70	<0,05
Control group (n=14)					
Heart rate, bpm	60-84	$95,14 \pm 1,68$	$87,57 \pm 1,24$	3,63	<0,05
SAT, mm Hg	100-139	$141,21 \pm 0,89$	$136,43 \pm 0,94$	3,63	<0,05
DBP, mm Hg	60-89	$90,21 \pm 2,56$	$85,21 \pm 1,88$	1,57	>0,05
SV, ml	60-120	$60,51 \pm 2,17$	$59,66 \pm 2,13$	0,28	>0,05
MBV, ml/min.	3000-7000	$5731,48 \pm 176,87$	$5217,71 \pm 190,75$	1,98	<0,05
Kerdo index, c.u.	$0 \pm 0,15$	$5,33 \pm 1,59$	$2,73 \pm 1,45$	1,20	>0,05

Table 3. Comparative characteristics of the functional parameters of the cardiovascular and autonomic nervous systems in patients of the main and control groups during a repeated study (M±m)

Indicators	Norm	Groups of examined patients		t	p
		MG, n=14	CG, n=14		
Heart rate, bpm	60-84	73,71±2,32	87,57±1,24	5,26	<0,001
SAT, mm Hg	100-139	126,36±0,94	136,43±0,94	7,47	<0,001
DBP, mm Hg	60-89	73,64±2,00	85,21±1,88	4,21	<0,05
SV, ml	60-120	68,90±1,10	59,66±2,13	3,86	<0,05
MBV, ml/min.	3000-7000	5064,71±145,38	5217,71±190,75	0,64	>0,05
Kerdo index, c.u.	0±0,15	-0,14±1,04	2,73±1,45	1,61	>0,05

The Kerdo index in the MG was at the level of (-0.14 ± 1.04 units), which corresponds to the state of eutonia, in the CG - ($2,73 \pm 1,45$ c.u.), which corresponds to a pronounced predominance of the sympathetic division VNS, and changes V.I. in the control group were statistically insignificant.

Comparing the performance of the cardiovascular and autonomic nervous system in patients of both groups, we came to the conclusion that the repeated study showed a statistically significant improvement in heart rate, SBP, DBP, SV in the main group compared to the control group, which indicates a more positive the influence of the author's program of physical therapy on the functional state of the cardiovascular and autonomic nervous system (table 3).

Discussion

The use of rehabilitation programs for neurocirculatory dystonia is given much attention in the modern scientific literature. Neurocirculatory dystonia is a polyetiological functional disease, which is manifested by numerous cardiovascular, respiratory and vegetative disorders, asthenia, poor tolerance of stressful situations and physical exertion (Grigus & Hrushevskaya, 2017). Functional disorders of the cardiovascular system are common, especially among young and middle-aged people. According to numerous epidemiological studies, in the population they are noted in 25-80% of cases. In the general structure of cardiovascular diseases, NCD is 32-50%. They get sick more often at a young and mature age (18-40 years), mostly women. NCD in the structure of cardiovascular diseases in adolescents is 75%. Patients with NCD represent a risk group for diseases of the circulatory system – they subsequently often develop organic diseases of the cardiovascular system, such as hypertension and coronary heart disease (Bentsa, 2018).

There is no doubt that the treatment of neurocirculatory dystonia is based on the use of physical therapy programs. Therefore, for a faster restoration of physiological balance in the work of the cardiovascular system, it is necessary to use the entire complex of therapeutic measures, including kinesitherapy. Physical factors do not have side effects, do not cause intoxication, allergic reactions, there is no cumulative effect, addiction (Grigus & Hrushevskaya, 2017).

The use of recreational aerobics in NCD disease has recently received much attention. According to the rehabilitation program of E.V. Dolgier, health-improving aerobics classes are held twice a week. Third time a week, independent health-improving walks in a park or seaside area are recommended in combination with general developmental exercises. To obtain the maximum healing effect, patients are offered daily morning hygienic gymnastics with the use of self-massage of the head, neck-collar zone and reflexogenic zones of the feet, which are also included in the recovery part of health-improving aerobics classes, and self-execution of autogenic training according to the method of J. Schulz, which is an active method of psychotherapy (Dolgier, 2015).

Considering the pathogenesis of NCD, Bentsa, T.M. (2018) notes that functional disorders are realized in the form of dysfunctions of the autonomic nervous system, which regulates the activity of the circulatory system through the sympathetic and parasympathetic divisions of the autonomic nervous system. Under the influence of etiological factors, there is a disintegration of neuro-hormonal-metabolic regulation at the level of the cerebral cortex, limbic zone and hypothalamus, which leads to dysregulation of the function of the autonomic nervous system in general and the hypothalamic-pituitary-adrenal system in particular, changes in neuroendocrine reactivity, microcirculation system and endothelial function, which leads to the development of NCD (Bentsa, 2018). Sustained vegetative dysfunction in the regulation of the cardiovascular system in NCD is accompanied by a violation of the vegetative support of activity, an increase in vegetative reactivity, and an inadequate response to physical activity from the cardiovascular system. (Murzhak-Chub & Kuts-Burdeina, 2018).

Given the above, we have developed a program of physical therapy, which included kinesitherapy using therapeutic exercises based on dance aerobics in combination with regulated breathing exercises, taking into account the tone of the ANS and autogenous training. The global goal of the physical therapy program was: increasing adaptive capacity, general endurance, fitness of the body and general physical performance; adaptation of the body to physical stress of a domestic and labor nature. Short-term goals were: normalization of

blood pressure and autonomic regulation of vascular tone; improvement of blood circulation and trophic processes in the myocardium; normalization of the psycho-emotional state and a decrease in the body's reaction to adverse external actions.

The basis of the kinesitherapy complexes was therapeutic exercises for medium and large muscle groups of the limbs and trunk based on dance aerobics, alternating with relaxation of the muscle groups of the upper and lower extremities and dynamic breathing exercises performed from the initial positions of "standing" and "walking", on average and at a fast pace, with a large range of motion in the joints. In order to stop the neurotic syndrome that accompanies the course of hypertensive NCD, normalize the processes of excitation and inhibition in the central nervous system and normalize the emotional tone and mood of patients in the main group, we used musical accompaniment of kinesitherapy classes, as well as autogenous training according to the method of I. Schultz, which we carried out at the end the final part of the kinesitherapy complex (Hawley & Franks, 2000; Schultz, 1985).

In order to have a positive effect on the vegetative centers with a subsequent depressor reaction, we used regulated breathing exercises, taking into account the tone of the ANS. Moreover, the activity of the departments of the autonomic nervous system was determined immediately before each session of kinesitherapy with subsequent refinement of the methodology for the use of regulated breathing exercises. A differentiated approach to the appointment of regulated breathing, taking into account the determination of the tone of the sympathetic and parasympathetic divisions of the autonomic nervous system, was as follows. Breathing exercises with forced inspiration and breath-holding on inspiration activate the predominantly sympathetic part of the autonomic nervous system. Breathing exercises with an increase in the duration of exhalation and holding the breath on exhalation cause a more pronounced effect on the parasympathetic division of the autonomic nervous system. The prerequisite for the introduction of the concept of the specific action of regulated breathing exercises was the data that during forced inspiration and holding the breath on inspiration, the sympathetic nervous system is activated, followed by the release of the neurotransmitters norepinephrine and adrenaline, and exhalation and holding the breath on expira-

tion excite mainly the vagus nerve receptors, accompanied by the release of the neurotransmitter acetylcholine.

Such use of breathing exercises leads to a shift in the vagal-sympathetic balance towards a weakening of the vagal and dominance of the sympathetic tone of the ANS, which further leads to the normalization of blood pressure, an increase in the economization of the work of the heart and the adaptive capabilities of the cardiovascular system.

Conclusions

In the course of the study of the effectiveness of physical therapy programs for neurocirculatory dystonia, we came to the conclusion that the developed physical therapy program, which included kinesitherapy using therapeutic exercises based on dance aerobics in combination with regulated breathing exercises taking into account the tone of the parasympathetic and sympathetic parts of the autonomic nervous system and autogenous training, it is effective and contributes to the normalization of hemodynamic parameters and the tone of the autonomic nervous system, which improves the quality of life of patients with NCD. The conducted studies have confirmed the need for the use of physical therapy, including kinesitherapy using therapeutic exercises based on dance aerobics in combination with regulated breathing exercises, taking into account the tone of the ANS and autogenous training.

Author's contribution

Conceptualization, S.K. and Yu.K.; methodology, S.K., Yu.K. and V.K.; software, S.K. and Yu.K.; check, S.K. and Yu.K.; formal analysis, S.K.; investigation, S.K., Yu.K.,; resources, S.K., Yu.K. and I.S.; data curation, S.K.; writing – rough preparation, S.K. and Yu.K.; writing – review and editing, S.K. and Yu.S.; visualization, S.K. and Yu.S.; supervision, V.P.-M.; project administration, S.K. and Yu.S. All authors have read and agreed with the published version of the manuscript.

Conflict of Interest Statement

The author declares no conflict of interest

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References

- Bentsa, T.M. (2018). Rational approaches to the diagnosis and treatment of neurocirculatory dystonia. *Medicine of Ukraine*, 3(219), 29-35. [https://doi.org/10.37987/1997-9894.2018.3\(219\).198447](https://doi.org/10.37987/1997-9894.2018.3(219).198447)
- Dolgier, E. (2015). The Effect of Physical Rehabilitation Programs, Means Aerobics on Physical Work Capacity of Women with Neurocirculatory Dystonia. *Youth Scientific Journal Lesya Ukrainka Eastern European National University*, (18), 124-127. <http://sport-visnyk.vnu.edu.ua/index.php/sportvisnyk/article/view/426>
- Goldstein, D.S., Robertson, D., Esler, M., Straus, S.E., & Eisenhofer, G. (2002). Dysautonomias: clinical disorders of the autonomic nervous system. *Annals of internal medicine*, 137(9), 753-763. <https://doi.org/10.7326/0003-4819-137-9-200211050-00011>
- Grigus, I., & Hrushevska, A. (2017). Complex physical re-

- habilitation of patients with neurocircular dystonia. *Rehabilitation and Recreation*, 2(2), 18-22. <https://health.nuwm.edu.ua/index.php/rehabilitation/article/view/3>
- Hawley, E.T., & Franks, B.D. (2000). *Wellness fitness*. BD Frenks, Olymp. lit.
- Kalmykov, S., Kharchenko, Ya., & Kalmykova, Yu. (2020). Characteristics of the main means of physical therapy for neuro-circulatory dystonia, physical rehabilitation and recreational health technologies, 5(1), 84-87. http://journals.uran.ua/frir_journal/article/view/207582
- Kalmykova, Y., Kalmykov, S., Polkovnyk-Markova, V., & Reutska, A. (2018). Application and influence of the complex program of physical therapy on the state of the cardiovascular and autonomic nervous system of young women, patients with alimentary obesity. *Slobozhanskyi herald of science and sport*, (5 (67)), 22-27. <https://doi.org/10.5281/zenodo.2536287>
- Kalmykova, Yu, Danova, O., & Kalmykov, S. (2021). The modern problem of diseases of the cardiovascular system in students of special medical groups and ways to solve it by means of physical therapy. *Physical rehabilitation and recreational health technologies*, 6(4), 16-21. http://journals.uran.ua/frir_journal/article/view/260957/257383
- Kalmykova, Yu.S., & Rakcheeva, O.V. (2016). Actual issues of therapeutic physical culture in neurocirculatory dystonia, *Physical rehabilitation and recreational recreational technologies*, 2, 24-30. http://journals.uran.ua/frir_journal/article/download/89947/pdf
- Kérdő, I. (1966). Ein aus Daten der Blutzirkulation kalkulierter Index zur Beurteilung der vegetativen Tonuslage. *Acta neurovegetativa*, 29(2), 250-268. <https://doi.org/10.1007/BF01269900>
11. Mathias, Christopher, J., & Bannister, R. (eds) (2013) *Autonomic Failure: A Textbook of Clinical Disorders of the Autonomic Nervous System*, 5 edn (Oxford, 2013; online edn, Oxford Academic, 1 July 2013). <https://doi.org/10.1093/med/9780198566342.001.0001>
- Murzhak-Chub, T.I., & Kuts-Burdeina, O.O. (2018). Physical rehabilitation for vegetosudinal distonia. Collection of articles by participants of twenty other All-Ukrainian practical and educational conference, 34-36. <http://naukam.triada.in.ua/images/files/zbirnik22.pdf#page=35>
- Napalkova, T., & Krivyca, R. (2019). Actuality of application of physical therapy of women of 18-20 years with vegetovascular dystonia in mixed type at the sanatorium stage. *Scientific journal National Pedagogical Dragomanov University*, 4(112), 95-97. <http://enpuir.npu.edu.ua/handle/123456789/25464>
- Nikolenko, O. (2018). Theoretical bases of application of means of physical rehabilitation to patients with vegetative-vascular dystonia. *Bulletin of the Carpathian University. Physical Education*, 29, 53-56. <https://doi.org/10.15330/fcult.29.53-57>
- Olchovik, A.V. (2015). Physical development and physical preparedness of students of special medical group with the disease of vegetative-vascular dystonia of mixed type. *Pedagogics, psychology, medical-biological problems of physical training and sports*, 19(3), 38-45. <https://doi.org/10.15561/18189172.2015.0306>
- Rafanelli, M., Walsh, K., Hamdan, M.H., & Buyan-Dent, L. (2019). Autonomic dysfunction: diagnosis and management. *Handbook of Clinical Neurology*, 167, 123-137. <https://doi.org/10.1016/B978-0-12-804766-8.00008-X>
- Schultz, I.G. (1985). *Autogenic training*. Translated from German.
- Yezhova O., Tymruk-Skoropad K., Tsyzh L., Sytnyk O. (2021). *Therapeutic exercises: study guide*. Zhytomyr. ISBN 978-617-7972-19-5
- Yushkovska, O.G., & Dolgier, E.V. (2012). Physical rehabilitation of women of the juvenile period, patients with neurocirculatory dystonia, using various directions of health aerobics. *Theory and Methods of Physical Education and Sports*, 1, 101-106. <https://repo.odmu.edu.ua:443/xmlui/handle/123456789/8931>