

Substantiation of the developed program of physical rehabilitation of physically prepared persons with essential arterial hypertension of the I degree

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Purpose: scientifically substantiate the developed complex physical rehabilitation program aimed at accelerating the recovery process at different rehabilitation periods for people with essential hypertension of the first and second adulthood who have been engaged in fitness for more than three years.

Material & Methods: in the patients of the main and control groups, the functional state was determined using the analysis of the heart rate variability on the Poly-Spectrum apparatus © Neurosoft, blood pressure measurement by the method of N. S. Korotkov, bioimpedance study of the body composition, and the quality of life according to the MOS SF-36. The main group consisted of 31 people (24 men and 7 women), the control group was 31 (23 men and 8 women).

Results: program of physical rehabilitation has been developed, which includes kinesitherapy (training on simulators, independent exercises, dosed aerobic exercise, morning hygienic gymnastics), thermo-contrast agents and nutrition correction and was introduced in the sports and recreational complex "Monitor" in the main group.

Conclusion: use of the developed program of physical rehabilitation helped to normalize blood pressure, improve the functional state and the level of quality of life to a greater extent than in the control group in which the standard program of the institution was applied.

Keywords: arterial hypertension, physical rehabilitation, sauna, strength exercises, orthostatic exercises, flexibility, coordination, heart rate variability, integral body rheography.

Introduction

Arterial hypertension (AH) is the most common disease of the cardiovascular system in industrially developed countries [3]. Among all AH patients, 95% of people are classified as essential hypertension (EG) [11; 13]. In most countries of the world, including in Ukraine, there is a clear tendency towards an increase in the number of patients with arterial hypertension [2]. It is a factor that worsens the quality of life, and one of the main factors of early disability and mortality due to a high risk of complications such as stroke, coronary heart disease, cardiac and renal insufficiency, etc. [3]. Arterial hypertension, despite significant achievements in studying the mechanisms of its development, improvement of diagnostic methods, therapy, primary and secondary prevention, remains one of the most important problems of modern cardiology [5].

Since long-term use of antihypertensive drugs is required to maintain the necessary therapeutic effect, the role of non-drug methods, including therapeutic physical factors, in the prevention, treatment and rehabilitation of patients with cardiovascular diseases is increasing. Physical factors do not have side effects, do not cause intoxication, allergic reactions, do not lead to cumulating, addictive, and are also able to enhance the action of medications; it helps to reduce their dosage [2].

However, for people who have changed their way of life and are engaged in sports, physical rehabilitation is not presented in accessible scientific literature. Parts of persons engaged in fitness and lead a healthy lifestyle, generally accepted recommendations for physical rehabilitation is not enough to nor-

malize blood pressure, which requires the development of a special comprehensive rehabilitation program.

In order for the physical rehabilitation program to be effective, it needs to be developed on the basis of the mechanisms for regulating blood pressure: a decrease in cardiac output, a decrease in the activity of the sympathetic nervous system, a reduction in the overall resistance of peripheral vessels, an increase in the sensitivity of the baroreceptors, decreased plasma volume [1; 12].

Well-proven programs of physical rehabilitation, including cyclic and strength exercises. Intensive physical activity can stimulate the activity of the sympathetic nervous system and renin-angiotensin-aldosterone to such an extent that the hypotensive effect of physical exertion of less intensity is increased. In a complex of rehabilitation tools with the use of a sauna as a thermo-contrast means of rehabilitation, one can achieve a more pronounced effect of reducing catecholamines and the volume of blood plasma [4; 6; 9; 10].

A powerful adaptive stimulus for training the sympathetic nervous system is endowed with means of physical rehabilitation that require increased concentration and neuro-emotional tension. Therefore, the physical rehabilitation program should be supplemented by complex coordination forms of physical activity. And to increase the sensitivity of baroreceptors it is advisable to use physical exercises with different initial positions for training orthostatic mechanisms of vascular response [1; 12].

Analyzed data of the literature testify to the need to use ther-

mal-contrast effects (sauna, shower, bath, hardening) on the body of patients with essential hypertension, as a powerful factor for training the functional system of regulation of blood pressure in the process of restoring their health [7; 8].

Relationship of research with scientific programs, plans, themes. The research was carried out in accordance with the "Consolidated Scientific Research Plan in the field of physical rehabilitation and sports for 2012–2016". On the topic 4.4. "Improving the organizational and methodological foundations of programming the process of physical rehabilitation for dysfunctional disorders in different body systems" (state registration number 0111U001737).

The purpose of the research: scientifically substantiate the developed complex physical rehabilitation program aimed at accelerating the recovery process at different rehabilitation periods for people with essential hypertension of the first and second adulthood who have been engaged in fitness for more than three years.

Research tasks: on the basis of the literature analysis, to select the methods of physical rehabilitation, which have a powerful effect on the mechanisms of blood pressure regulation, to develop and implement a physical rehabilitation program and to evaluate its effectiveness.

Material and Methods of the research

The contingent of patients consists of 62 physically trained people (47 males at the age of $39,5 \pm 4,8$ years and 15 women at the age of $41,7 \pm 5,5$ years); they were engaged in fitness for more than three years with essential hypertension of the first stage without concomitant diseases and complications that would contribute to the development of secondary hypertension. In the main and control groups of 31 persons.

Patients were conducted: blood pressure measurement for Korotkoff method, determination of heart rate variability (HRV), bioimpedance analysis and integral body rheography.

The main group was involved in the physical rehabilitation program developed by us for six months (kinesitherapy, thermo-contrast methods and diet therapy). The control group was engaged in accordance with generally accepted recommendations on physical rehabilitation of persons with arterial hypertension (medical gymnastics, therapeutic massage, physiotherapy).

Results of the research and their discussion

Physical rehabilitation of persons with essential hypertension was carried out at the dispensary stage in three periods: preparatory, basic and fixing.

The program lasted six months and began with a training motor regimen, as the selected contingent of patients consisted of those people who had already been engaged in fitness for more than three years, but could not achieve normalization of blood pressure.

The complex program of physical rehabilitation of patients with essential hypertension contained information and practical component:

– *information component* of the program consists of personal consultation, instrumental monitoring and assessment of the patient's condition, provision of theoretical knowledge about the etiology, pathogenesis of the disease, as well as the impact of the means and the importance of observing the principles of physical rehabilitation.

– *practical component* of the program is based on the mastery and use of physical rehabilitation, as well as educational and motivational conversations to maintain a healthy lifestyle after the completion of the physical rehabilitation program.

Kinesitherapy exercises for persons with arterial hypertension had an elongated opening part (30–20 minutes), the main part shortened to 20–30 minutes, and the final part increased to 10 minutes. This kind of occupation is very important because it allows you to gradually increase the load without the risk of hypertensive crisis or loss of consciousness. In the process of increasing the patient's tolerance to physical exertion on the main and fixing the periods of rehabilitation, the duration of the introductory and final part decreased, and the main one increased. The volume and intensity of the exercises experienced the same changes. Intensity was increased due to weight gain, the combination of exercises in groups and by changing the initial position (lying, sitting, standing, upside down), which allowed to dose the load on the vascular centers from a small one – recumbent, to the very – upside down).

In the classes of kinesitherapy, physical exercises on the simulators were designed in a circular method with medium and moderate intensity in large and maximum amplitude. The exercises were necessarily performed with diaphragmatic breathing, and alternating not only the working muscles, but also the original position, the frequency of the change increased according to the patient's adaptation.

Carrying out complex co-ordination exercises allowed to expand the feeling of one's own body and the ability to control tight muscles (for example, the neck muscles were often stressed when doing leg exercises).

Dosed aerobic load was intended after kinesitherapy, or another day in the form of therapeutic walking, swimming or running.

Thermo-contrast agents were intended for patients one month after the onset of rehabilitation. With the disappearance or a significant decrease in orthostatic reactions, patients were assigned a contrast shower. The first two weeks the temperature difference was small – warm-cool water, and then the temperature range increased to hot-cold water. The number of repetitions increased to two or three contrasts. If the patient did not have complaints after the contrast shower, then he was assigned a sauna.

Psychorelaxation was integrated into motor activity. At all exercises, patients were taught to deliberately strain and relax the working muscles. This made it possible to learn to control the level of muscle tension during exercise and to transfer this skill to everyday life and, as a consequence, not be in a state of chronic muscle and mental stress.

Educational and motivational conversations to change the way of life were present at all stages of rehabilitation during the sessions of kinesitherapy in the form of counseling during

exercise and in breaks between them. During the interviews, the following tasks were set:

- mastering the basic knowledge of anatomy and physiology of the musculoskeletal system and the cardiovascular system;
- mastering knowledge about the mechanisms of therapeutic action of physical exercises;
- detailed explanation of the mechanisms of reduction and mechanisms of increasing blood pressure;
- mastering the methodology of independent studies.

For a better understanding of the program, the tools and their application for six months are presented in Table 1.

Analysis of blood pressure after rehabilitation showed positive changes in the main group. In 87% of patients the pressure was normalized. The mean systolic pressure dropped from 144,6 to 128,2 Mmhg, and the diastolic value from 87,8 to 81,5 Mmhg That is, the systolic pressure decreased by 16.5,

and the diastolic pressure by 6.3 mm, while in the control group the systolic pressure decreased by 2,1 Mmhg, and the diastolic pressure by 0,7 Mmhg The parameters of the auscultative pressure measurement method are shown in Table 2.

Parameters of cardiac rhythm variability in the control group for physical rehabilitation were better than in the main group, as evidenced by the best functional state (3,4 versus 0,03), and the ratio of high frequency oscillations to low frequency oscillations was 2,5 versus 3,2. The total power of the spectrum of the control group was 3263 msl/Hz versus 2341 msl/Hz in the baseline.

Upon completion of rehabilitation, in the main group, the percentage of low frequency waves, indicating the activity of the sympathetic system, decreased by 12%, while in the control group it increased by 4,9%, which led to a worsening of the sympathetic parasympathetic ratio by 12% in the control and an improvement of 2,5 times in the main group (from 3,2 to 1,2). In the main group, the total power of the spectrum doubled, while in the control group the total power of the spectrum decreased by 26,2%. There was an improvement in the level of functional status of the main group, increased by seven units.

Table 1
Filling the rehabilitation program for physically trained individuals with essential hypertension

Period	Month	ME	Kinesitherapy	Self-study	Nutrition correction	Aerobic load	Thermo-contrast agents	Educational-motivational conversations to change the way of life
Preparatory	1–2 weeks	Mastering	3 hour/week 10 exercises for 10–20 repetitions. Intensity: 40–60%	Repeat warm-up at home	Establishment of existing nutrition	–	–	
	I month		3 hour/week 20 exercises for 15–20 repetitions. Intensity: 60–80%	Warm-up during the day, diaphragms. breath.	Normalization of the regime (3–5 times/day)	20 minutes. 3 times a week.	–	
Main	II month	Every morning	3 hour/week. up to 25 exercises for 15–20 repetitions. Intensity: 60–80% Co-coordinating exercises are added	Warm-up during the day, diaphragms. breathing, walking or running	Nutrition 3–5 times/day, normalization of the volume (deficit 200–500 kcal.)	1-2 hours per week	Contrast shower in 2–3 temperature contrasts ($\Delta t=10-20^{\circ}\text{C}$)/sauna one set up to 3 minutes	
	III month		3 hour/week Intensity is increased due to the combination of exercises in 2–3 groups, which are performed on 2–3 approaches	To remove psychoemotional and physical stress several times a day with breathing, exercises for flexibility, therapeutic walking or running	Nutrition 3–5 times/day, shortage of 500 kcal./Day	3 hours per week	Sauna 3 times/ weeks first event in the sauna – 3 min. Second and third call – up to 5 minutes. Cooling in the waiting room – 5 min.	
Fixing	IV month	Maintain volume and intensity				Intensity + 10–20%	Sauna 3 times/ week First event in the sauna – 5 min. Second and third call – up to 7 minutes. Cooling with cold water	
	V month				List the caloric content, respectively, physical. load, create a deficit of 200 kcal./day	Maintain volume and intensity	Sauna 1–2 times a week 3–5 events for 5–7 minutes, cooling with water, rest in the waiting room 5 min.	
	VI month					Sauna once a week 3–5 events for 5–7 minutes, cooling with water, rest in the waiting room 5 min.		
	Testing						Summing up of the program, analysis of the received indicators of diagnostics, comparison with the ascending state. Calorie counting according to the future physical activity is already without a calorie deficit.	

Remark. ME – morning exercises.

Table 2

Indices of blood pressure in patients of the main and control groups before and after rehabilitation, MmHg.

Sex	Main group before rehabilitation		Main group after rehabilitation		Control group before rehabilitation		Control group after rehabilitation	
	BP syst.	BP diast.	BP syst.	BP diast.	BP syst.	BP diast.	BP syst.	BP diast.
Men	145±6,4	89±7,6	129±8,9	82±4,1	143±6,9	86±6,7	139±9,4	85±6,5
Women	143±4,3	85±6,7	127±10,8	80±4,9	141±1,8	84±5,2	142±2,2	84±3,6

Remark. BP syst. – systolic blood pressure, BP diast. – diastolic blood pressure; the indicators of the main group are statistically significant ($p < 0,01$), the control group's performance is not statistically significant ($p > 0,05$).

In the control group, the functional status level decreased by 1,5 units. The deterioration in the parameters of the control group indicates the incorrectness of the dosage of exercise, disregard for the work and rest regime, and the lack of effective methods of psycho-relaxation. Parameters of cardiac rhythm variability in patients of the main and control groups before and after rehabilitation are presented in Table 3.

The study of integral body rheography made it possible to evaluate and analyze important parameters of hemodynamics and respiratory system, on the basis of which we can objectively evaluate the effectiveness of the rehabilitation program.

According to the received data, the majority of hemodynamic parameters in patients of both groups were above the norm. Thus, the parameters of the minute volume of circulation (MVC) were higher than normal in 75% of the patients in the main group and in 55.5% in the control group. The respiratory rate was higher than normal in 75% of the patients and 74% in the control group.

Upon completion of the rehabilitation program, the indices of integral body rheography showed positive changes in the main group and negative changes in the control group. In the main group, the shock volume of blood circulation (SVB) decreased from 100 to 93,2 ml, in the control group the shock volume of blood circulation increased from 95,3 to 96,6 ml and exceeded the index of the main group by 3,4 ml. These data coincided with the indices of cardiac rhythm variability,

and indicate a decrease in the influence of the sympathetic system in the persons of the main group.

Under the influence of rehabilitation exercises, the heart rate (HR) decreased from 68,9 to 64,7 beats min^{-1} in the main group, and in the control group it did not differ much from the initial parameters (66,7 at the beginning and 67,1 beats min^{-1} on completion). These data coincided with the indices of cardiac rhythm variability, and indicate an increase in the influence of the parasympathetic system in individuals of the main group.

Changes in heart rate along with changes in stroke volume (SV) led to a decrease in the minute volume of blood circulation (MVB) in the main group by 0,8 liters, while in the control group it remained unchanged.

The obtained data of the IRGPB of the patients of the main and control groups are presented in Table 4.

The physical rehabilitation program we developed improved the bio-impedance study of body composition more than twice as much as the standard program (Table 5).

Thus, the data obtained from the integral rheography of the body coincided with the dynamics of heart rate variability and bioimpedance examination of the body, and indicate an improvement in the state of the cardiovascular system, as well as a decrease in sympathetic activity and an increase in activity of the parasympathetic system, which led to a decrease in

Table 3

Characteristics of parameters of variability of heart rhythms of patients of the main and control groups before and after rehabilitation

Indicators	Main group		Control group		Difference before and after	
	Before rehabilitation	After rehabilitation	Before rehabilitation	After rehabilitation	Main group	Control group
TP	2341	4671	3264	2409	2330	-855
25%; 75%	1255; 2623	2170; 5854	1617; 4147	1354; 2579		
LF/HF	3,2	1,2	2,5	2,8	2	-0,3
25%; 75%	1,5; 4,4	0,8; 1,3	1,0; 3,2	1,4; 4,1		
% VLF	50	47,8	46,3	41,9	2,2	4,4
25%; 75%	36,5; 59	33; 61,5	34,5; 56,5	28; 52		
% LF	38	26	33,4	38,3	12	-4,9
25%; 75%	25;43	18; 31,5	27,5; 40	29; 42		
% HF	14	26,4	19,7	19,4	12,4	-0,3
25%; 75%	8; 20	16; 36	9,5; 26	12; 25		
FS	0,03	7,1	3,4	1,9	7,07	-1,5
25%; 75%	-5; 3,5	4,3; 11,8	-1,5; 8,0	-3,3; 7,3		

Remark. TP – the total activity of neurohumoral effects on the heart rhythm (msl Hz), LF/HF – the balance between activity of the sympathetic and parasympathetic divisions (c. u.), % VLF, % LF and % HF – percentage ratio of very low, low and high frequency heart waves rhythm, FS – functional state (c. u.), Indicators, deteriorated, have a negative value. Indices of the main group are statistically significant ($p < 0,05$), the parameters of the control group are not statistically significant ($p > 0,05$).

Table 4

Indices of integral rheography of the patient's body of the main and control groups before and after rehabilitation

Indicators	Main group		Control group		Difference before and after	
	Before rehabilitation	After rehabilitation	Before rehabilitation	After rehabilitation	Main group	Control group
VSV	100	93,2	95,3	96,6		
25%; 75%	90,1; 107,7	86,5; 100,9	86,5; 100,1	83,9; 103,1	6,8	-1,3
MVB	6,8	6	6,3	6,3		
25%; 75%	6,2; 7,4	5,6; 6,7	5,8; 6,7	5,9; 6,9	0,8	0
SI	53,5	51,2	49,1	54,1		
25%; 75%	45,9; 61,5	44,7; 53,1	42,9; 55,8	45,2; 59,8	2,3	-5
CI	3,6	3,3	3,2	3,6		
25%; 75%	3,2; 3,8	2,9; 3,6	2,9; 3,8	3,2; 3,8	0,3	-0,4
KP	128,8	117,2	116,4	122,1		
25%; 75%	116,4; 134,2	103,9; 128,5	99,6; 135	109,9; 131,4	11,6	-5,7
HR	68,9	64,7	66,7	67,1		
25%; 75%	65,8; 73,3	60; 70	60; 73,5	67; 72	4,2	-0,4
KIT	77,5	78,2	78,2	76,8		
25%; 75%	76,7; 79,3	74,5; 81,4	76,3; 80,5	74,5; 79,6	-0,7	1,4
RR	18	16,4	17,7	17,2		
25%; 75%	15,8; 20	14; 19	16; 19	15; 19	1,6	0,5

Remark. VSV – value of the shock volume of the left ventricle (ml), MVB – minute volume of blood circulation (l min), SI – shock index (ml m⁻²), CI – cardiac index (l·min⁻¹·m⁻²), KP – the ratio of the MVB to the required value of the MVB (%), KIT – characterizes the state of the tone of the arterial system (c. u.), heart rate – heart rate (beat min⁻¹), RR – respiratory rate (breathing min⁻¹). Indices of the main group are statistically significant (p<0,01), the parameters of the control group are not statistically significant.

the left ventricular stroke volume and decrease in heart rate.

Conclusions

Despite the existence of various programs of rehabilitation for persons with essential hypertension, blood pressure is not always normalized.

For physically trained persons with arterial hypertension Physical rehabilitation programs have not been found based on the data of the analyzed scientific-methodical literature. People need a program with large adaptive stimuli and a wide range of physical rehabilitation facilities, since standard recommendations are not enough to normalize blood pressure.

Having learned from the experience of other authors, we believe that the physical rehabilitation program will be effective if it includes kinezotherapy (training on simulators with targeted alternation of starting positions, dosed aerobic exercise, independent exercises, morning hygienic gymnastics), thermal contrast media (contrast shower and sauna), psychocorrection (psycho-relaxation, educational-motivational conversations) and nutrition correction. These funds will affect the mechanisms of regulation of blood pressure.

The combination of the theoretical and practical component of the program helped to develop the right habits and adjust the lifestyle of people with essential hypertension, so they consciously controlled the level of psychological and physical activity, as well as rest and diet, which led to lower blood

Table 5

Indices of bioimpedance study of the body of patients in the main and control groups before and after rehabilitation

Indicators	Main group		Control group		Difference before and after	
	Before rehabilitation	After rehabilitation	Before rehabilitation	After rehabilitation	Main group	Control group
BMI	28,3	26,7	27,6	27		
25%; 75%	26,8; 30	25,2; 29,2	25,1; 30	25,2; 29,7	1,6	0,6
Body weight	90	85,3	87,1	85,1		
25%; 75%	79,7; 99,2	75; 94,7	74,3; 96	71,9; 91,6	4,7	2
Fat mass	25,1	21,5	23,7	22,1		
25%; 75%	20,4; 29	17,8; 24,3	19,3; 28,5	18,4; 26,3	3,6	1,6
% of fat mass	27,6	25,1	26,7	25,6		
25%; 75%	24; 31	23; 27,5	23; 30	23; 28	2,5	1,1
Non-fat mass	64,9	63,7	63,4	62,9		
25%; 75%	57,7; 72,3	55,7; 71,6	55,5; 69,2	53; 69,2	-1,2	-0,5

Remark. Indicators that have improved are of positive significance. Indicators have deteriorated, have a negative value. Parameters of the main and control groups are not statistically significant (p>0,05).

pressure.

In accordance with the effectiveness criteria (normalization of blood pressure, improvement of heart rate variability and integral rheography of the body), a comprehensive program of physical rehabilitation is effective for people with essential arterial hypertension.

Use of the means given in the article is easily accessible for the majority of persons, contributes to the greater dissemination of this program of physical rehabilitation.

The prospect of further research is the introduction of a rehabilitation program for physically trained individuals with essential hypertension in rehabilitation and sports complexes and the adaptation of a program for physically unprepared persons with essential hypertension, as well as the development of information and propaganda programs for the prevention of cardiovascular diseases among children and students.

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