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Correction of Carbohydrate Metabolism by Means of Physical Therapy of Patients with Metabolic Syndrome

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Abstract

Purpose: to investigate the characteristics of carbohydrate metabolism indicators in patients with metabolic syndrome before the beginning of rehabilitation effects as well as to trace the dynamics of indicators in the process of application of our physical therapy comprehensive program.
Material and methods. The survey involved 70 women with metabolic syndrome, who were divided into the main (MG) (35 women) and control (CG) (35 women) groups with the average age in the MG 31.49±0.71-year-olds, in the CG – 31.06±0.57 year-old. In the main group, a physical therapy program was applied for patients with metabolic syndrome, which includes a hypo caloric diet with a hypolipidemic focus; therapeutic massage according to the method of patients alimentary-constitutional obesity; medical gymnastics using elements of sports-oriented aerobics and special physical exercises based on Pilates gymnastics using fitballs and expanders; morning hygienic gymnastics; limited walking in combination with breathing exercises, taking into account the activity of the autonomic nervous system.
Result. As a result of a comprehensive and developed physical therapy program that was justified and applied for 4 months for patients with metabolic syndrome, the studied carbohydrate metabolism parameters changed significantly. Main group women showed significantly improved indicators of glycemia on empty stomach: from 8.85±1.54 to 5.98±0.81 mmol·l^{-1}, glycemia after eating: from 11.47±1.85 to 7.68±0.86 mmol·l^{-1} and reached the target levels of diabetes compensation and diagnostic criteria for the metabolic syndrome.
Conclusions: physical exercises contribute to the improvement and normalization of carbohydrate metabolism. They restore adaptation to physical exertion and normalize the function of the cardiovascular system, motor activity and psychoemotional state as well.
Key words: glycemia, metabolic syndrome, efficiency, women, physical therapy program

Анотація

Калмикова Ю.С., Бісмак О.В., Перебійніс В.Б., Калмиков С.А. Корекція вуглеводного обміну хворих на метаболічний синдром засобами фізичної терапії

Мета: дослідити особливості показників вуглеводного обміну хворих на метаболічний синдром перед початком реабілітаційних впливів, та прослідити динаміку показників в процесі застосування нами комплексної програми фізичної терапії.

Матеріал і методи. В дослідженні приймали участь 70 жінок, хворих на метаболічний синдром, вони були розділені на основну (35 жінок) і контрольну (35 жінок), середній вік складав в ОГ 31,49±0,71 років, в КГ – 31,06±0,57 років. В основній групі застосовувалась програма фізичної терапії для хворих на метаболічний синдром, яка включає гіпокалорійну дієту з гіполіпідемічною спрямованістю; лікувальний масаж для хворих на аліментарно-конституціональне ожиріння; лікувальну гімнастику із застосуванням елементів спортивно-орієнтованої аеробіки та спеціальних фізичних вправ на основі гімнастики Пілатес з використанням фітболів та еспандерів; ранкову гігієнічну гімнастику; дозовану ходьбу в поєднанні з дихальними вправами з урахуванням активності вегетативної нервової системи.

Результати. В результаті розробленої, обґрунтованої та застосованої протягом 4 місяців комплексної програми фізичної терапії для хворих на метаболічний синдром суттєво змінились досліджувані показники вуглеводного обміну – у жінок основної групи статистично значуще покращилися показники глікемії натще: з 8,85±1,54 до 5,98±0,81 ммоль·л$^{-1}$, глікемії після їди: з 11,47±1,85 до 7,68±0,86 ммоль·л$^{-1}$ і досягли цільових рівнів компенсації цукрового діабету та діагностичних критеріїв метаболічного синдрому.

Висновки: заняття фізичними вправами сприяють поліпшенню і нормалізації вуглеводного обміну; відновлюють адаптацію організму до фізичних навантажень; нормалізують функцію серцево-судинної системи, рухову активність і психоемоційний стан.

Ключові слова: глікемія, метаболічний синдром, ефективність, жінки, програма фізичної терапії.

Аннотация

Калмыкова Ю.С., Бисмак Е.В., Перебейнос В.Б., Калмыков С.А. Коррекция углеводного обмена больных метаболическим синдромом средствами физической терапии

Цель: исследовать особенности показателей углеводного обмена больных на метаболический синдром перед началом реабилитационных воздействий, и проследить динамику показателей в процессе применения нами комплексной программы физической терапии.

Материал и методы: В исследовании принимали участие 70 женщин, больных на метаболический синдром, они были разделены на основную (35 женщин) и контрольную (35 женщин), средний возраст составлял в ОГ 31,49±0,71 лет, в КГ – 31,06±0,57 лет. В основной группе применялась программа физической терапии для больных на метаболический синдром, которая включает гипокалорийную диету с гиполипидемической направленностью; лечебный массаж для больных алиментарно-конституциональным ожирением; лечебную гимнастику с применением элементов спортивно-ориентированной аэробики и специальных физических упражнений на основе гимнастики Пилатес с использованием фитболов и эспандеров; утреннюю гигиеническую гимнастику; дозированную ходьбу в сочетании с дыхательными упражнениями с учетом активности вегетативной нервной системы.

Результаты. В результате разработанной, обоснованной и применяемой в течение 4 месяцев комплексной программы физической терапии для больных на метаболический синдромом существенно изменились исследуемые показатели углеводного обмена – у женщин основной группы статистически значимо улучшились показатели гликемии натощак: с 8,85±1,54 до 5,98±0,81 ммоль·л$^{-1}$, гликемии после еды: с 11,47±1,85 к 7,68±0,86 ммоль·л$^{-1}$ и достигли целевых уровней компенсации сахарного диабета и диагностических критериев метаболического синдрома.

Выводы: занятия физическими упражнениями способствуют улучшению и нормализации углеводного обмена; восстанавливают адаптацию организма к физическим нагрузкам; нормализуют функцию сердечно-сосудистой системы, двигательную активность и психоэмоциональное состояние.

Ключевые слова: гликемия, метаболический синдром, эффективность, женщины, программа физической терапии

Introduction

Metabolic syndrome is a significant clinical and epidemiological problem in the population of industrialized countries. It is characterized by the presence of abdominal obesity, insulin resistance, type 2 diabetes mellitus, dyslipidemia, arterial hypertension. Epidemiological data on metabolic syndrome is not optimistic. Observations by scientists and clinicians around the world confirm that today there is a growing epidemic of metabolic syndrome. Its frequency in populations depends on ethnicity, age and gender [1].

Epidemiological data indicate a fairly high prevalence of metabolic syndrome, which averages about 24% and exceeds 40% in the age group after 60 years. From literary sources it is known [2] that in industrialized countries among the population older than 30 years, the prevalence of this pathology ranges from 14 to 24%. It was established that there are age and gender characteristics of the development of metabolic syndrome. In particular, with age, the proportion of patients with this pathology increases [3]. So, in age groups from 20 to 49 years, metabolic syndrome is more often observed in men aged 50-69 years - almost the same in men and women, and in people over 70 years old - more often diagnosed in women. In women of older age groups, metabolic syndrome is more likely to be associated with the onset of menopause.

In Ukraine, the prevalence of MS varies from 20 to 35%, and in women it also occurs 2.5 times more often and with age the number of patients only increases [4, 5]. It is alarming that, according to epidemiological studies conducted in our country, about 12% of adolescents aged 12 to 17 years are overweight, of which 2,3% are obese, while every third adolescent with obesity shows signs of metabolic syndrome. According to Sorvacheva et.al. [6], MS is diagnosed in half of children with adolescent obesity. It is proved that the formation of MS begins in childhood long before the manifestation of type 2 diabetes mellitus and coronary heart disease and for a long time is almost asymptomatic. In this regard, according to Styne et al. [7] MS is becoming recognized not only as an important social, but also as a pediatric problem [40].

An important role in the development of the metabolic syndrome is given to a genetic predisposition, excessive consumption of high-calorie foods and reduced physical activity. It is generally accepted that the current MS, called Syndrome X, was described by Gerald Reaven in 1988. According to Reaven [8,54], insulin resistance can be detected in 25% of people with a sedentary lifestyle. It is important to emphasize that his main merit lies in the fact that he named the common reason for the development of arterial hypertension (AH) in one patient, dyslipidemia with an increase in triglycerides (TG), a decrease in high density lipoproteins (HDL), as well as impaired glucose tolerance (IGT) – insulin resistance [9]. Also in the study of this syndrome, studies of Lang [10], Lang et al. [11] and later Avogaro [12] can be noted, Kaplan [13] and many other domestic and foreign scientists [14, 15].

It should be noted that a single concept of the metabolic syndrome for males and females does not exist, since the formation of MS in men is directly dependent on the severity of abdominal obesity, and in women this dependence on obesity appears only with the onset of menopause and hypoestrogenemia in 50% of patients with hypertension make up women during menopause, the frequency of detection of type 2 diabetes mellitus (type 2 diabetes) [16] in women 40-50 years old is 3-5%, and in women over 60 years old - 10-20%, that is, disorders of carbohydrate metabolism progress with age [17–19].

The difference in the risk of fatal cardiovascular diseases was reflected in the SCORE system [20, 21], presented back in 2003 at the Congress of the European Society of Cardiology [22, 23], which shows that in men, cardiovascular diseases begin to progress with the age of 40, while in women this regularity occurs only with the age of 50-55 years and the onset of menopause [24].

A study by Diabetes Epidemiology: Collaborative Analysis of Diagnostic Criteria in Europe [25] showed that increased blood pressure and impaired insulin sensitivity increase the risk of developing cardiovascular disease in postmenopausal women even with minor changes in blood pressure and insulin sensitivity. The most vulnerable period of women's transitional age is Premenopause, that is, the initial period of a decrease in ovarian function (mainly after 45 years and before menopause), which is accompanied by a critical decrease in estrogen levels. The implementation of estrogen deficiency during menopause includes an effect on the metabolism of lipoproteins, a direct effect on the biochemical processes in the vessel wall through specific estrogen receptors, as well as an indirect effect through the metabolism of glucose, insulin, homocysteine, hemostasis system [26, 27].

It is also extremely important that patients with metabolic syndrome have abnormalities in carbohydrate and lipid metabolism, high blood pressure, and a high risk of developing coronary heart disease [28]. Therefore, all major pathogenetic disorders should be corrected. The choice of therapeutic effects and their combinations should be differentiated, taking into account pathogenetic, clinical features, stage of the disease and personal characteristics of the patient [29].

Non-drug measures to improve the health status of patients with metabolic syndrome include: a low-calorie diet, training patients in a proper lifestyle with a change in eating habits, keeping a nutrition diary, and exercise to increase physical activity [30-32]. The effect of an increase in physical activity is manifested in such a way that even a slight increase in overall physical fitness leads to a significant reduction in the risk of premature death and an improvement in the overall health of people with a sedentary lifestyle [33, 40].

Purpose: to investigate the characteristics of indicators of carbohydrate metabolism in patients with metabolic syndrome before the beginning of rehabilitation effects, and to trace the dynamics of indicators in the process of using our comprehensive program of physical therapy.

Material and methods

Participants

The study was conducted on the basis of the Kharkiv City Hospital No. 3. Under observation were 70 young women who were arbitrarily divided into two groups: the main group (MG) - 35 patients and the control group (CG) - 35 patients. The mean age of patients with MG was 31.49–0.71 years, and that of CG was 31.06–0.57 years. By the number of patients, age, and the presence of concomitant pathology, the main and control groups of women were homogeneous. Patients of the main group underwent rehabilitation measures according to the author's program of physical therapy, to patients of the control group - according to the program, they are used for metabolic syndrome in the specified medical institution.

Procedure

Examination of patients was carried out before the use of physical rehabilitation means (initial examination) and after 4 months of the introduction of comprehensive physical rehabilitation programs (re-examination).

The studies were carried out in accordance with international documents on the regulation of biomedical research: "Helsinki Declaration" adopted by the General Assembly of the World Medical Association "on the" ethical principles of medical research involving a person as a subject" [34]; "Universal Declaration on Bioethics and Human Rights" [35]; "Convention for the Protection of Human Rights and Dignity of the Human Being with regard to the Application of Biology and Medicine" adopted by the Council of Europe [36].

An important role in assessing the effectiveness of rehabilitation measures in MS patients is played by the study of carbohydrate metabolism, which was carried out according to the results of fasting glycemia and 2:00 after a meal in the clinical diagnostic laboratory of the Kharkiv City Hospital No. 3 in the apparatus of the densitometer scanning DM 2120 (manufacturer – PLC Solar, Republic of Belarus, passport SOL 2.840.001 PS, certificate of verification of the working means of measuring equipment No. 394/3 of January 25, 2008 and № 83409/3 dated March 30, 2009) using complex diagnostic reagent kits (manufacturer - HUMAN Gesellschaft fur Biochemica und Diagnostika mbH (Germany), PSRN No. 4321/2010). Current monitoring of blood glucose levels was carried out during kinesitherapy classes with the Super Glucocard II (GT-1640) glucometer (manufacturer – ARKRAY Inc. KDK CORPORATION (Japan), registration certificate No. 932/14) using GLUCOCARDTM Test Strip II test strips (manufacturer – ARKRAY Inc. KDK CORPORATION (Japan). Fasting venous glucose of ≤66.0-6.1 mmol·l^{-1} was used as criteria for compensating for diabetes mellitus, and 3.9-5.0 mmol·l^{-1} for fasting self-monitoring.

In the process of kinesitherapy training and pedagogical observation was carried out - it was carried out with the aim of optimizing dosing of physical activity, preventing the development of hypoglycemic conditions and fatigue in MS patients with an external examination, determining the level of glycemia before, during and after kinesitherapy classes.

Physical therapy program

Physical therapy of patients of the main group at the outpatient stage was carried out in order to normalize body weight and reduce the

manifestations of abdominal obesity, achieve target levels of compensation for hyperglycemia, normalize blood pressure and increase the tolerance of the cardiovascular system to dosed physical activity. The physical therapy program for sick women of the main group included: a hypocaloric diet with a lipid-lowering orientation (lipid-lowering diet № 1) (Table 1), the basic principles of which were developed by the American Heart Association [37, 38], therapeutic massage according to the method of P.B. Efimenko [39] for patients with alimentary-constitutional obesity; medical gymnastics; morning hygienic gymnastics; self-study (SS) dosed walking.

Table 1

Hypolipidemic diet №1

Parameters	Restrictions
Fat in the diet – less than 30% of total calories Correlation SFA / MSFA / PSFA = 1:1:1 Cholesterol in the diet - less than 300 mg per day	
Protein products	– consumption of meat no more than 200 g per day, except for meat with fat layers and offal; – permissible only lean varieties of beef, pork and young lamb; – better consumption of fish and poultry (chicken, turkey meat), and without skin; – permissible consumption of salmon and other types of fatty fish, except for fish roe
Fatty foods	– consumption of eggs up to 2 per week, including those used for cooking; – consume 1% fat milk, avoiding whole milk; – low fat yogurt, cottage cheese and cheese; – "hard fats" (butter), processed cheese, coconut, palm oil, chocolate are excluded; – only vegetable oils, olive oil or soft margarines are used
Carbohydrate products	– bread, cereal products, potatoes, rice and pastry cooked without egg yolks; – avoid the use of confectionery products in the preparation of which solid fats and yolks are used, and heavy desserts

Notes: SFA – saturated fatty acids; MSFA – monounsaturated fatty acids; PSFA – polyunsaturated fatty acids

Physical exercises were used for the muscles of the upper extremities and the shoulder girdle, neck, torso with elements of sports-oriented aerobics with full amplitude, medium and fast pace; special physical exercises based on Pilates gymnastics using fitballs and expanders; exercises for coordination and training of the vestibular apparatus at an average pace, with a maximum amplitude depending on the capabilities of the patient; regulated breathing exercises when walking, taking into account the activity of the ANS; rest pauses and relaxation exercises. All physical exercises were performed from the initial positions "sitting on the floor", "standing". When making LH complexes, the emphasis was on combining various previously learned exercises into choreographic connections; during the course of the lesson, the tempo, rhythm, direction and amplitude of movements. Aerobics classes used rhythmic music in the style of "foxtrot", "charleston", "tango", Latin rhythms ("cha-cha-cha", "samba", "rumba"), "disco", "rock and roll","Break Dance" [40].

In the control group of patients used physical therapy program, which included diet therapy using a hypocaloric diet, therapeutic massage by the method of Verbov [41, 42], therapeutic gymnastics, morning hygienic gymnastics, self-study, metered walking, jogging, walking, moving and sports games. Therapeutic physical education was carried out according to Popov [43, 44], Belaya [45] for patients with alimentary-constitutional obesity and diabetes mellitus with the exception of exercises, are contraindicated in arterial hypertension (static exercises, accompanied by an increase in intra-abdominal pressure, torso).

Statistical analysis

The duration of the study was 4 months. The initial study was performed before (1-2 days) and after (last days of the month) the application of physical therapy. In the initial study, there was no statistically significant difference between the levels of glycemia in the capillary blood on an

empty stomach and 2 hours after a meal, and in the second study, the indicators improved statistically significantly. Statistical data processing was performed using the analysis package Statistica 6.0 for Windows. Assessment of compliance with the law of normal distribution was performed using the Shapiro-Wilk test (W). Since all the studied indicators corresponded to the law of normal distribution, we determined the arithmetic mean ($\overline{x}$) and the standard deviation (S). The significance of the difference was assessed using Student's t-test. Differences not exceeding the probability level $p<0.05$ at a given number of degrees of freedom were considered statistically significant.

Results

The main criteria for the diagnosis of metabolic syndrome is to determine the level of glycemia in capillary blood on an empty stomach and 2 hours after a meal, the level of glycated hemoglobin [46–47]. Therefore, we determined the initial values of the above indicators. As can be seen from Table 2, the level of fasting glucose in patients of the main and control groups was 8.85±1.54 and 8.61±1.69 mmol·l^{-1}, respectively, there was no statistically significant difference between these indicators. The results obtained confirm the presence of metabolic syndrome in patients of both groups.

Table 2

Indicators of carbohydrate metabolism in women
of the main (n = 35) and control (n = 35) groups in the initial study

Indicators	Norm	Surveyed group		t	p
		main group n=35	control group n=35		
		$\overline{x} \pm S$	$\overline{x} \pm S$		
Glucose in capillary blood fasting mmol·l^{-1}	3.3-5.5	8.85±1.54	8.61±1.69	0.63	>0.05
Glucose in capillary blood 2 hours after a meal, mmol·l^{-1}	to 7.5	11.47±1.85	11.49±1.19	0.06	>0.05
Glycosylated hemoglobin (HbA1$_c$), %	4.0-6.1	9.80±1.23	9.97±1.36	0.54	>0.05

In women of both the main and control groups, an increase in the level of glycemia was observed 2 hours after eating in 11.47±1.85 and 11.49±1.19 mmol·l^{-1}, respectively ($p>0.05$), which may indicate for insulin resistance, endogenous insulin deficiency or prolonged release in response to increased blood glucose.

The HbA1$_c$ level in women in the study and control groups was at the level of 9.80±1.23 and 9.97±1.36%, respectively ($p>0.05$), which indicates a long-term increase in blood glucose concentration during the previous 6 – 12 months and unsatisfactory compensation of diabetes mellitus in the examined patients.

As a result of the use of complex programs of physical therapy at the outpatient stage for 4 months in patients of the main and control groups, the studied parameters of carbohydrate metabolism significantly changed: the glucose content in the capillary blood on an empty stomach and after meals, the level of glycated hemoglobin.

As shown in table 3, in the main group of patients there was a normalization of the parameters of carbohydrate metabolism. Thus, in MG women there was a statistically significant improvement (decreased) in fasting blood glucose indices: from 8.85±1.54 to 5.98±0.81 mmol·l^{-1}, post-meal glycemia: from 11.47±1.85 to 7.68±0.86 mmol·l^{-1}, glycosylated hemoglobin - from 9.80±1.23 to 9.07±1.25% (by 0.73%) ($p<0.05$) and reached the target levels of diabetes mellitus compensation and diagnostic criteria for metabolic syndrome.

In patients with CG, there was also a statistically significant improvement in the parameters of carbohydrate metabolism: the level of glucose in the capillary blood on an empty stomach decreased from 8.61±1.69 to 6.97±1.09 mmol·l^{-1}, the level of glycemia 2 hours after eating decreased from 11.49±1.18 to 8.73±1.18 mmol·l^{-1}, the level of HbA1$_c$ decreased from 9.97±1.36 to 9.63±1.39% (by 0.34%), and these changes were statistically insignificant, but did not reach the criteria for determining MS in accordance with the recommendations of various expert organizations: WHO [48], International Diabetes Federation [49] and American Association of Clinical Endocrinologists [50].

Table 3

Dynamics of carbohydrate metabolism in women of both groups during the initial and repeated studies

Indicators	Norm	Group	Before experiment	After experiment	t	p
			$\overline{x} \pm S$	$\overline{x} \pm S$		
Glucose in capillary blood fasting mmol·l^{-1}	3.3-5.5	Main Control	8.85±1.54 8.61±1.69	5.98±0.81 6.97±1.09	9.70 4.81	<0.01 <0.05
Glucose in capillary blood 2 hours after a meal, mmol·l^{-1}	to 7.5	Main Control	11.47±1.85 11.49±1.19	7.68±0.86 8.73±1.18	11.59 7.47	<0.01 <0.01
Glycosylated hemoglobin (HbA1$_c$), %	4.0-6.1	Main Control	9.80±1.23 9.97±1.36	9.07±1.25 9.63±1.39	2.48 1.05	<0.05 >0.05

Comparing the indicators of carbohydrate metabolism in patients of the main and control groups, we came to the conclusion that during the second examination in the main group of patients after applying the author's physical therapy program, they were the best ($p<0.05$) (Table 4).

Table 4

Indicators of carbohydrate metabolism in women of the main (n = 35) and control (n = 35) groups during the repeated study

Indicators	Norm	Surveyed groups		t	p
		main group n=35	control group n=35		
		$\overline{x} \pm S$	$\overline{x} \pm S$		
Glucose in capillary blood fasting mmol·l^{-1}	3.3-5.5	5.98±0.81	6.97±1.09	4.26	<0.05
Glucose in capillary blood 2 hours after a meal, mmol·l^{-1}	to 7.5	7.68±0.86	8.73±1.18	4.23	<0.05
Glycosylated hemoglobin (HbA1$_c$), %	4.0-6.1	9.07±1.25	9.63±1.39	1.75	<0.05

Discussion

In the complex of medical and rehabilitation measures for metabolic syndrome, an important place is given to means of physiotherapy. Under the influence of dosed physical activity in patients, hyperglycemia and glucosuria decrease, the action of insulin increases, visceral obesity decreases, blood pressure normalizes, and manifestations of heart failure decrease [51–54].

Treatment of the metabolic syndrome is aimed at preserving life, ensuring a sufficiently high quality of life and independence in controlling the course of the disease. Less important purpose are the prevention of late complications of diabetes, obesity, hypertension, dyslipoproteinemia and a reduction in mortality in the early stages of the disease. The primary task facing medicine is timely treatment of the metabolic syndrome, including non-drug and drug methods for the correction of metabolic disorders and obesity, and when choosing drugs, it is necessary to take into account their metabolic effects and organ protective effect. The main objectives of the treatment of metabolic syndrome are: normalization of body weight, increased physical activity, antihypertensive therapy, the use of lipid-lowering drugs and disaggregation therapy. Considering that the pathological condition that initiates insulin resistance and the entire metabolic cascade is most often obesity, which, in turn, leads to the development of arterial hypertension and can cause a decrease in the sensitivity of peripheral tissues to insulin and further accumulation of excess body weight, the use of therapeutic physical culture aids for metabolic syndrome should take into account the features of physical training techniques for insulin resistance, diabetes mellitus, obesity and hypertension [55–57].

According to Popov et al., Milyukova [44], Evdokimova [58], the regular use of dosed physical training contributes to the formation of a new dynamic stereotype, which eliminates or weakens the pathological stereotype, which helps eliminate the disease or functional abnormalities in the internal systems. Physical training can be considered as a factor enhancing the mobility of physiological processes. Thus, the main mechanism of action of physical exercises on the human body is the neuro-reflex and neuro-humoral mechanism. There are four main mechanisms of the therapeutic effect of physical exercises on the patient's body: tonic, trophic effect, the formation of compensations and normalization of functions [43, 59].

Korchinskiy [51] claims that, under the influence of dosed physical activity, hyperglycemia and glucosuria decrease in patients, the action of insulin increases, visceral obesity decreases, blood pressure normalizes, and manifestations of heart failure decrease.

In the treatment of *hyperglycemia and diabetes mellitus* in the metabolic syndrome, therapeutic massage is used to improve blood circulation and lymph flow, improve the activity of the nervous system, to normalize sleep and psychoemotional state, to improve metabolic processes [41, 42, 60].

With a metabolic syndrome with the phenomena of arterial hypertension according to the recommendations of Kunicheva [61] shows the effect on the paravertebral zones of the cervical and upper thoracic spinal segments C7-C2 and D5-D1.

With metabolic syndrome, therapeutic massage is an effective component of complex treatment. Its effectiveness is based on mechanical, neuro-reflex and humoral factors affecting the human body. The action of the mechanical factor is manifested in loosening of fatty tissue during obesity, and neuro-reflex and humoral – in stimulating the function of the whole organism and general metabolism. All this together will help reduce adipose tissue deposition [62, 63].

According to the recommendations of [39] for a complete solution of the tasks achieved is not achieved by direct action on individual areas of excessive accumulation of adipose tissue during obesity, but with massage of the whole body. Therefore, the best result is obtained during a general massage, using all massage techniques in a certain sequence and a variety of manipulations. The intensity and duration of massage of individual parts of the body is directly dependent on the location and amount of deposition of adipose tissue. According to Mukhin [64] therapeutic massage is prescribed to improve the general tone of the body; activation of peripheral blood and lymph flow, redox and metabolic processes; counteraction to impaired intestinal motor-evacuation function; eliminate fatigue and increase muscle tone and performance. Apply general massage, underwater shower massage, self-massage.

Diet therapy (DT) is one of the main means of complex treatment of metabolic syndrome. In order to reduce glycemia and serum lipids, to reduce excess body weight, a diet with a moderate restriction of carbohydrates and the complete exclusion of refined sugars with a sufficient protein content that meets the physiological needs of humans and fats was used [17, 31, 65].

According to the recommendations of Kazakov et.al. [66], physiotherapeutic treatment is prescribed taking into account the patient's clinical syndromes.

Physiotherapy for metabolic syndrome is used to stimulate redox and metabolic processes; normalization of carbohydrate metabolism; improving the function of the cardiovascular, respiratory, digestive, endocrine and other body systems; prevention or inhibition of the development of concomitant diseases; increase in general tone, increased energy consumption and hardening of the body [67].

Thus, among a large number of works on the problem of rehabilitation in the metabolic syndrome, no therapeutic physical culture methods were found that take into account the presence of the components of the metabolic syndrome (abdominal obesity, hyperglycemia, arterial hypertension), there are conflicting data on methods of monitoring and regulating physical activity in accordance with the state patients, that is, optimal pedagogical control is not carried out during group exercises of physical therapy. In addition, the recommendations on the use of diet therapy, massage and physiotherapy are quite contradictory but not individualized. Therefore, treatment of the metabolic syndrome should be comprehensive, and include physical therapy, herbal medicine, massage, physiotherapeutic treatment, diet therapy, drug therapy and many other means of physical therapy, which will contribute to more stable stabilization of blood sugar levels, restoration of the cardiovascular system, normalization of blood pressure and anthropometric indicators, will improve adaptation to physical activity; will keep patients working.

Conclusions

1. To analyze the effectiveness of physical therapy for patients with metabolic syndrome, we used the analysis and generalization of the results of the study of fasting glycemia and 2 hours after eating, current monitoring of the level of glycemia in capillary blood before and after the use of physical rehabilitation. So, the fasting glucose level in women of the main and control groups according to the results of the initial pre-dormancy did not differ, there was no significant difference between these indicators. The obtained results confirm the presence of metabolic syndrome in women of both groups. In women, both the main and control groups, an increase in glycemia was observed 2 hours after eating (11.47±1.85 and 11.49±1.19 mmol·l^{-1}, respectively) ($p>0.05$).

2. As a result of a comprehensive physical therapy program that was developed and used for 4 months for patients with metabolic syndrome, the studied carbohydrate metabolism parameters changed significantly - patients of the main group were engaged in the original physical therapy program, patients of the control group were involved in the program used for metabolic syndrome in the specified treatment and prevention institution.

3. After the use of physical therapy in the main group of patients, normalization of carbohydrate metabolism occurred, in women of the main group statistically significantly improved fasting glycemia: from 8.85±1.54 to 5.98±0.81 mmol·l^{-1}, glycemia after eating: from 11.47±1.85 to 7.68±0.86 mmol·l^{-1} and reached the target levels of diabetes compensation and diagnostic criteria for the metabolic syndrome [68]. In patients with CG, there was also a statistically significant improvement in carbohydrate metabolism: fasting capillary blood glucose decreased from 8.61±1.69 to 6.97±1.09 mmol /l, glycemia after 2 hours. after eating, decreased from 11.49±1.19 to 8.73±1.18 mmol·l^{-1}, but did not reach the criteria for determining MS in accordance with the recommendations of various expert organizations: WHO, International Diabetes Federation and American Association of Clinical Endocrinologists. Comparing the indicators of carbohydrate metabolism in patients of the main and control groups, we came to the conclusion that during the second examination in the main group of women after applying the author's physical rehabilitation program, they were the best ($p<0.05$).

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Conflict of interest

The authors declare that there is no conflict of interest.

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