Original Article

Results of the use of physical therapy for metabolic syndrome according to anthropometric studies

YULIYA KALMYKOVA[1] ✉, SERGEY KALMYKOV[1], HELEN BISMAK[2], OLHA BEZIAZYCHNA[1], DARIA OKUN[3]

[1]*Department of Physical Therapy, Kharkiv State Academy of Physical Culture, Kharkiv, Ukraine*
[2]*Department of Physical Therapy and Ergotherapy, National University of Ukraine on Physical Education and Sport, Ukraine*
[3]*Department of Sport Medicine, Biochemistry and Anatomy; Kharkiv State Academy of Physical Culture, Kharkiv, Ukraine*

ABSTRACT

Purpose: to investigate and determine anthropometric indicators (length and body weight, abdominal circumference, skin fold thickness, calculate body mass index and percentage of adipose tissue) of examined patients with metabolic syndrome, evaluate the effectiveness of our comprehensive physical therapy program based on the study of the dynamics of anthropometric indicators women with metabolic syndrome during the rehabilitation process. Material and methods: 28 women with metabolic syndrome were examined, the main group (MG) (n = 14) and the control group (CG) (n = 14), the average age was in MG – 31.49 ± 0.71 years, in the CG – 31.06 ± 0.57 years. Women of the main group studied according to the author's program of physical therapy, women of the control group - according to the program, used for metabolic syndrome according to the methods of S.M. Popova (2005, 2008), N.A. Beloy (2001). Results: allowed us to analyse the dynamics before the indicators were fully scrutinized by the programs of physical therapy and to separate the results from the main and control groups. Conclusions: the author's program of physical therapy is effective, was carried out in order to normalize body weight and reduce the manifestations of abdominal obesity. Keywords: anthropometry, author's program, women, physical therapy, metabolic syndrome.
Keywords: Body weight; Author's program; Women; Physical therapy; Metabolic syndrome.

Cite this article as:
Kalmykova, Y., Kalmykov, S., Bismak, H., Beziazychna, O., & Okun, D. (2021). Results of the use of physical therapy for metabolic syndrome according to anthropometric studies. *Journal of Human Sport and Exercise*, *16*(2), 333-347. https://doi.org/10.14198/jhse.2021.162.09

✉ **Corresponding author.** *Department of Physical Therapy, Kharkiv State Academy of Physical Culture, 61058, Klochkovskaya strit, 99, Kharkiv, Ukraine.* *https://orcid.org/0000-0002-6227-8046*
E-mail: yamamaha13@gmail.com
Submitted for publication December 03, 2019.
Accepted for publication February 07, 2020.
Published April 01, 2021 *(in press* February 24, 2020).
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202

doi:10.14198/jhse.2021.162.09

INTRODUCTION

Metabolic syndrome is a pathological condition characterized by the development of abdominal obesity, dyslipidaemia, arterial hypertension (Kalmykov, & Kalmykova, 2017) and impaired carbohydrate metabolism (the phenomenon of insulin resistance) (Kalmykov, 2012, Kirichenko, et al., 2012; Yuliya, et al., 2018). The main etiological factors of the metabolic syndrome are genetic predisposition, excessive intake of fats and lack of exercise.

In Ukraine, the prevalence of metabolic syndrome (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 (Mankovsky, 2016; Koliada, et al., 2017). 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 T.N. Sorvacheva, V.A. Peterkova, & L.N. Titova (2016), 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 D. M. Styne, S. A. Arslanian, et al., (2017) MS is becoming recognized not only as an important social, but also as a paediatric problem.

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. According to G. Reaven (1988), insulin resistance can be detected in 25% of people with a sedentary lifestyle. Hypodynamia is accompanied by a decrease in translocation of glucose transporters in muscle cells. The use of excess animal fats that contain saturated fatty acids leads to structural changes in the phospholipids of cell membranes and impaired expression of genes that control the insulin signal inside the cell, that is, to the development of insulin resistance (IR) (Reaven, Lithell, & Landsberg, (1996).

Further study of MS allowed us to associate its clinical manifestations not only with insulin resistance, but also with a special type of obesity - "*android*" or "*abdominal*" (Kalmykov, et al., 2015; Kalmykova, et al., 2018). In this case, the accumulation of subcutaneous or visceral fat was meant, it is considered the main component of MS as a reflection of visceral obesity, the degree of which in all classifications is proposed to be estimated by an indirect indicator - the size of the waist circumference (WC). In clinical practice, it is used as a marker for visceral obesity, as it correlates with the amount of visceral fat diagnosed by computed tomography (Ginzburg, 2010).

A study by Diabetes Epidemiology: Collaborative Analysis of Diagnostic Criteria in Europe (1999) 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 decreased 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, haemostasis system (Su, et al., 2015; Gurka, et al., 2016).

The main idea of creating the concept of MS is to highlight a population of patients with high cardiovascular risk (Reaven, 2002) where prophylactic measures, including lifestyle modification and the use of adequate medications, can significantly affect the prognostic characteristics of the cardiovascular system. The selection

of patients with MS is also of great clinical importance, since, on the one hand, this condition is reversible, that is, with appropriate treatment, it is possible to achieve the disappearance or at least a decrease in the severity of its main manifestations, on the other hand, it precedes the occurrence of such a pathology, like type 2 diabetes and atherosclerosis, which is inextricably linked to increased mortality in the population (Kalmykov, 2007; Melnichenko, et al., 2011; Boytsov, et al., 2013; Masterov, et al., 2017).

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. 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 (H von Bibra, et al., 2017).

It is extremely important that in patients with metabolic syndrome there are disorders of carbohydrate and lipid metabolism, high blood pressure, and also a high risk of developing coronary heart disease (Sergeeva, & Rodionova, 2018). Therefore, correction of all major pathogenetic disorders should be carried out. 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 (Chazova, et al., 2015).

METHODS

Participants

The study was conducted on the basis of the Kharkiv City Hospital No. 3. Under observation were 28 young women who were arbitrarily divided into two groups: the main group (MG) - 14 patients and the control group (CG) - 14 patients. The average age of MG patients was 31.49 ± 0.71 years, and of CG – 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 (Table 1).

Table 1. Distribution of patients of the main and control groups by concomitant pathology and manifestations of the metabolic syndrome.

Manifestations of the metabolic syndrome and concomitant pathology		**Groups of surveyed**			
		Control group n = 14		Main group n = 14	
		Abs.	%	Abs.	%
Type 2 diabetes		14	100	14	100
Hypertension stage I-II		10	71.4	9	64.3
Hypertensive neurocirculatory dystonia		2	14.3	3	21.4
Obesity	I degree	5	35.7	4	28.6
	II degree	9	64.3	10	71.4
Coronary heart disease. Stable angina pectoris I-II functional class		2	14.3	1	7.1
Heart failure I degree		5	35.7	6	42.9
Chronic pancreatitis		3	21.4	2	14.3
Dyskinesia of the biliary system		6	42.9	8	57.1
Chronic pharyngotracheitis		3	21.4	3	21.4
Chronic sinusitis		2	14.3	1	7.1

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" (World Medical Association, 2013), "*Universal Declaration on Bioethics and Human Rights*" (UNESCO, 2005), "*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 (1997).

Measurements

The 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).

Anthropometric studies have an important role in assessing the effectiveness of rehabilitation measures in patients with MS. There are a large number of instrumental methods that allow determining the content of adipose tissue (bioelectric impedance, dual-ray X-ray absorptiometry, determining the total water content in the body), but their use in wide clinical practice does not justify itself. A more practical and simple method of screening for obesity is to calculate body mass index, which reflects the relationship between weight and body length. It has been proven that even a moderately elevated body mass index (BMI) leads to the development of hyperglycaemia, arterial hypertension and dangerous complications. At the same time, the determination of BMI is a fairly simple manipulation that ensures the timely prevention of these conditions. In general, medical practice, it is recommended to determine the BMI in all patients, followed by measures to reduce or maintain a normal level (Martirosov, et al., 2004; Kalmykova, 2014). Body mass index was determined by indicators of length and body weight in Equation 1:

$$\textbf{BMI = weight (kg) / height}^2\ \textbf{(m}^2\textbf{)} \qquad \textbf{(Eq. 1),}$$

According to the BMI obtained, it is possible to assess the border deviation of the actual body weight from due (Table 2).

Table 2. Assessment of the limits of deviation of actual body weight from the appropriate BMI.

Body Mass Index (kg/m^2)	Body weight. kg
Less than 18.5	Underweight
18.5-24.9	Normal weight
25.0-29.9	Overweight
30.0-34.9	Obese class I
35.0-39.9	Obese class II
Over 40	Obese class III

In the process of monitoring patients, anthropometric indicators were monitored before the start of rehabilitation measures and at the end of their use. It is proved that physical activity leads to a moderate increase in energy consumption and contributes to a change in energy balance. But sometimes physical activity, with undoubted benefits, does not give a significant reduction in body weight, which is explained by the redistribution of fat content (it decreases) in the direction of increasing muscle mass (Martirosov, et al., 2004). However, despite a slight overall decrease in body weight with increased physical activity, the amount of visceral fat decreases, which is extremely important to reduce the risk of developing concomitant pathology and improve the prognosis of life in obese patients. The primary goal is to reduce body weight by 10% for 4-6 months (Petunina, 2007).

When determining the metabolic syndrome, the presence of abdominal obesity is the main criterion for the diagnosis of MS recommended by the International Diabetes Federation (IDF diabetes atlas), with normative parameters of waist size < 94 cm for men and < 80 cm for women; in addition to determining BMI, we used a method for determining the circumference of the abdomen (waist) in a standing position with calm breathing. The tape is applied in front - at the level of the navel, behind – at level III of the lumbar vertebra on the exhale and measure the circumference (Kalmykova, 2014).

In addition, we used a method for determining the thickness of the skin fold using a calliper - calliper. To assess fat deposition, we measured the thickness of the skin-fat folds: on the back of the shoulder - measured vertical skin fold between the shoulder and elbow joints; on the side - the thickness of the diagonal skin-fat fold between the ilium and the lower edge of the chest is measured; on the stomach - the thickness of the vertical skin-fat fold is measured away from the navel at a distance of about 2.5 cm (Kalmykova, 2014). The total result of adipose tissue in women body was evaluated by Table 3. The percentage of adipose tissue in the body was evaluated by Table 4 (Kalmykova, 2014).

Table 3. Average calculations of the content of adipose tissue in the body of men and women (%).

Skinfold thickness (mm)	**Men (age in years)**				**Women (age in years)**			
	17-29	30-39	40-49	50+	16-29	30-39	40-49	50+
15	4.8	-	-	-	10.5	-	-	-
20	8.1	12.2	12.2	12.6	14.1	17.0	19.8	21.4
25	10.5	14.2	15.0	15.6	16.8	19.4	22.2	24.0
30	12.9	16.2	17.7	18.6	19.5	21.8	24.5	26.6
35	14.7	17.7	19.6	20.8	21.5	23.7	26.4	28.5
40	16.4	19.2	21.4	22.9	23.4	25.5	28.2	30.3
45	17.7	20.2	23.0	24.7	25.0	26.9	29.6	31.9
50	19.0	21.5	24.6	26.5	26.5	28.2	31.0	33.4
55	20.1	22.5	25.9	27.9	27.8	29.4	32.1	34.6
60	21.2	23.5	27.1	29.2	29.1	30.6	33.2	35.7
65	22.2	24.3	28.2	30.4	30.2	31.6	34.1	36.7
70	23.1	25.1	29.3	31.6	31.2	32.5	35.0	37.7
75	24.0	25.9	30.3	32.7	32.2	33.4	35.9	38.7
80	24.8	26.6	31.2	33.8	33.1	34.3	36.7	39.6
85	25.5	27.2	32.1	34.8	34.0	35.1	37.5	40.4
90	26.2	27.8	33.0	35.8	34.8	35.8	38.3	41.2
95	26.9	28.4	33.7	36.6	35.8	36.5	39.0	41.9
100	27.6	29.0	34.4	37.4	36.6	37.2	39.7	42.6
105	28.2	29.6	35.1	38.2	37.1	37.9	40.4	43.3
110	28.8	30.1	35.8	39.0	37.8	38.6	41.0	43.9
115	29.4	30.6	36.4	39.7	38.4	39.1	41.5	44.5
120	30.0	31.1	37.0	40.4	39.0	39.6	42.0	45.1
125	31.0	31.5	37.6	41.1	39.6	40.1	42.5	45.7
130	31.5	31.9	38.2	41.8	40.2	40.6	43.0	46.2
135	32.0	32.3	38.7	42.4	40.8	41.1	43.5	46.7
140	32.5	32.7	39.2	43.0	41.3	41.6	44.0	47.2
145	32.9	33.1	39.7	43.6	41.8	42.1	44.5	47.7
150	33.3	33.5	40.2	44.1	42.3	42.6	45.0	48.2

155	33.7	33.9	40.7	44.6	42.8	43.1	45.4	48.2
160	34.1	34.3	41.2	45.1	43.3	43.6	45.8	49.2
165	34.5	34.6	41.6	45.6	42.7	44.0	46.2	49.6
170	34.9	34.8	42.0	46.1	44.1	44.4	46.6	50.0
175	35.3	-	-	-	-	44.8	47.0	50.4
180	35.6	-	-	-	-	45.2	47.4	50.8
185	35.9	-	-	-	-	45.6	47.8	51.2
190	-	-	-	-	-	45.8	48.2	51.6
195	-	-	-	-	-	46.2	48.5	52.0
200	-	-	-	-	-	46.5	48.9	52.4
205	-	-	-	-	-	-	49.1	52.7
210	-	-	-	-	-	-	49.4	53.0

Table 4. Content of the fatty tissue in the body.

Fat levels in the body	Men	Women
Competitive	3-6%	9-12%
Very low	< 10%	< 16%
Low	10-14%	16-20%
Average	15-19%	21-25%
Above the average	20-25%	26-30%
High	26-30%+	31-40%+

Procedures

Physical therapy of patients of the main group was carried out in order to normalize body weight and reduce the manifestations of abdominal obesity, achieve target levels of compensation for hyperglycaemia, 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 No. 1), the basic principles of which were developed by the American Heart Association (Ministry of Health of Ukraine, 2013; Nishimura, et al. 2017), therapeutic massage according to the method of P.B. Efimenko (2013) for patients with alimentary-constitutional obesity; medical gymnastics; morning hygienic gymnastics; self-study (SS) dosed walking.

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 autonomic nervous system (ANS); rest pauses and relaxation exercises. All physical exercises were performed from the initial positions "*sitting on the floor*", "*standing*". In the preparation of 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. For therapeutic gymnastics classes in the main group of patients, elements of sports-oriented aerobics were used, in which simple series of movements, as well as jumping and running in place, were used. When constructing the training program, we used methods of musical interpretation, namely rhythmic music in the style of "*foxtrot*", "*charleston*", "*tango*", Latin American rhythms ("*cha-cha-cha*", "*samba*", "*rumba*"), "*disco*", "*Rock and roll*", "*break-dance*", complications (with a change in pace, rhythm and direction of movement), blocks with repetition of exercises 4-6 times. Women of the main group were engaged in therapeutic walking during the day. Walking distance

- 3-4 km, walking pace - 110-120 steps / min After 1 month, the walking distance increased to 5-6 km per day, the pace of walking -120-140 steps / min.

In the control group of patients, a physical therapy program was used, which included diet therapy using a hypocaloric diet, therapeutic massage according to A.F. Verbov (2006), therapeutic gymnastics, morning hygienic gymnastics, self-study, dosed walking, running, walking, outdoor and sports games. Therapeutic physical culture was carried out according to the methods of S.M. Popov (2005, 2008), N.A. Belaya (2001) 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). Dosed walking was intended for patients in the control group, depending on the severity, concomitant pathology, age and physical performance of the patient. The first weeks of walking training, patients with CG used a short rest of 2-3 minutes. to perform breathing exercises. Distance - 3-4 km, walking pace - 70-90 steps. / min After 1-1.5 months, the walking distance increased to 5-6 km per day, the walking pace was 70-90 steps. / min.

The complexes of therapeutic gymnastics classes and therapeutic walking programs for women of the MG and CG were composed depending on the phases of the ovarian-menstrual cycle. During menstruation, static physical exercises associated with straining and increasing intra-abdominal pressure were excluded.

Statistical analysis

The processing of the results of the research was carried out using the "*Data Analysis*" package of Microsoft Excel spreadsheets. Indicators of descriptive statistics (mean arithmetic mean, standard deviation and error of average value) were determined. The statistical reliability of differences in mean values was estimated by the Student's test, the differences were considered reliable when ($p < .05$).

RESULTS

Table 5. Anthropometric indicators of women examined in the initial study ($\overline{X} \pm m$).

Indicators	Groups of surveyed			
	Main group n = 14 $\overline{X} \pm m$	Control group. n = 14 $\overline{X} \pm m$	t	p
Body length. m	163.43 ± 1.16	165.14 ± 1.71	0.83	> .05
Body weight. kg	86.59 ± 1.80	86.71 ± 2.06	0.05	> .05
Body mass index. kg / m^2	32.37 ± 0.55	32.77 ± 0.58	0.14	> .05
Abdominal circumference. cm	85.71 ± 1.41	84.64 ± 1.47	0.53	> .05
The total thickness of the skin fold: on the back of the shoulder. on the side. on the stomach. mm	63.29 ± 3.33	67.57 ± 2.98	0.96	> .05

From anthropometric indicators in the examined women of the main and control groups, we determined the length and body weight, abdominal circumference, skin fold thickness, calculated body mass index and percentage of adipose tissue. When comparing the anthropometric indices of patients of both groups, there were no statistically significant differences in the studied indices (Table 5). *Abdominal circumference in* patients of the main group was 85.71 ± 1.41 cm, and the control 84.64 ± 1.47 cm, which confirms the presence of a metabolic syndrome with abdominal type of obesity in patients of both groups according to the

criteria of the metabolic syndrome recommended by the International Diabetes Federation, IDF and WHO (p > .05) (WHO, 1999; Kahn, et al., 2005; WHO, 2006).

Total thickness of the skin fold: on the back of the shoulder, on the side, on the abdomen in women of the main group was 63.29 ± 3.33 mm, in the control group - 67.57 ± 2.98 mm (p > .05), which indicates The "*high*" content of adipose tissue in the body is more than 31% (Table 3, Table 4). Thus, the anthropometric study confirms the presence of alimentary obesity of the I-II degree in the examined patients (Martirosov, & Rudnev, 2004).

Body mass index in the MG was 32.37 ± 0.55 kg/m^2, in the CG – 31.77 ± 0.58 kg/m^2, which confirms the presence of obesity of the first degree. Thus, according to anthropometric studies in the main group with obesity of the first degree, we found 5 people (35.7%), with obesity of the second degree - 9 people (64.3%). In the control group of persons with grade I obesity there were 4 people (28.6%), with grade II obesity - 10 people (71.4%).

In a second study of anthropometric indicators in the examined patients, we determined positive dynamics, namely, a decrease in body weight, BMI, abdominal circumference and the total thickness of the skin fold (Table 6).

Table 6. Anthropometric indicators of the examined women of the main (n = 14) and control (n = 14) groups before and after experiment ($\overline{X} \pm m$).

Indicators	Group	Before experiment $\overline{X} \pm m$	After experiment $\overline{X} \pm m$	t-criterion of Student	p
Body weight. kg	Main	86.59 ± 1.80	79.75 ± 1.44	2.97	< .05
	Control	86.71 ± 2.06	81.58 ± 1.90	1.47	> .05
Body mass index. kg / m^2	Main	32.37 ± 0.55	29.98 ± 0.48	5.50	< .05
	Control	32.77 ± 0.58	31.13 ± 0.45	1.02	> .05
Abdominal circumference. cm	Main	85.71 ± 1.41	79.68 ± 1.01	4.31	< .05
	Control	84.64 ± 1.47	82.18 ± 1.20	1.21	> .05
The total thickness of the skin fold: on the back of the shoulder. on the side. on the stomach. mm	Main	63.29 ± 3.33	56.52 ± 2.08	2.18	< .05
	Control	67.57 ± 2.98	62.52 ± 2.01	1.55	> .05

In women of the main group, we observed a decrease in body weight of 6,84 kg (7,9%) compared with the initial study. In the control group, body weight decreased by 5.13 kg (5.90%).

Body mass index in the MG decreased from 32.37 ± 0.55 kg/m^2 to 29.9 ± 0.48 kg/m^2 - by 7.40% and corresponded to "*excess body weight*" (p < .05). In the CG, BMI decreased from 32.77 ± 0.58 kg/m^2 to 31.13 ± 0.45 kg/m^2 - by 5.0% and responded to "*obesity of the first degree*", and the dynamics of BMI in the CG was statistically insignificant (p > .05).

Abdominal circumference in the main group decreased from 85.71 ± 1.41 cm to 79.68 ± 1.01 cm - by 7.1%, which is less than the diagnostic standards for the diagnosis of metabolic syndrome (p < .05) in the control group - from 84.64 ± 1.47 cm to 82.18 ± 1.20 cm - by 2.9%, which confirms the presence of metabolic

syndrome in patients of the control group, and in the CG the dynamics of this indicator was statistically insignificant.

Total thickness of the skin fold in the MG decreased by 10.7% and amounted to 56.52 ± 2.08 cm, which indicates the content of adipose tissue in the body is "*above average*"; in CG - decreased by 7.5% and amounted to 62.52 ± 2.01 cm, which indicates a "*high*" content of adipose tissue in the body - more 31% (Martirosov, & Rudnev, 2004).

Comparing anthropometric indices in patients of the main and control groups, we came to the conclusion that during repeated examination in the main group of patients, as a result of the use of the author's physical rehabilitation program, the BMI, abdominal circumference, total thickness of the skin fold were statistically significantly better, the difference in body weight in MG and CG was statistically insignificant (Table 7).

Table 7. Comparative characteristics of anthropometric indicators of patients during the re-examination ($\overline{X} \pm m$).

Indicators	Groups of surveyed			
	Main group n = 14 $\overline{X} \pm m$	Control group. n = 14 $\overline{X} \pm m$	t	p
Body weight. kg	79.75 ± 1.44	81.58 ± 1.90	1.15	> .05
Body mass index. kg / m^2	29.98 ± 0.48	31.13 ± 0.45	1.78	< .05
Abdominal circumference. cm	79.68 ± 1.01	82.18 ± 1.20	1.81	< .05
The total thickness of the skin fold: on the back of the shoulder. on the side. on the stomach. mm	56.52 ± 2.08	62.52 ± 2.01	2.08	< .05

DISCUSSION

The primary task facing medicine is the 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 (Korchinskiy, 2014). Initial measures should be aimed at reducing body weight and normalizing metabolic disorders. The effect of weight loss on blood pressure was demonstrated in a number of large multicentre studies, such as Tonren-1, TASH, Tomshi, XENDOS. It was noted that non-drug therapy associated with lifestyle correction improves metabolic control; self-observation improves glycaemic control; peripheral blood glucose control, provides a level of normoglycemia (HЬA1c = 6.5%), reduces the incidence of micro- and macrovascular complications; intensive insulin therapy for type 1 diabetes reduces morbidity and mortality; early intensification of therapy to achieve established treatment goals improves the combined indicator of morbidity and mortality in type 2 diabetes; in patients with type 2 diabetes mellitus, in an unsuccessful attempt to achieve the target glucose level, the possibility of early administration of insulin therapy should be considered; metformin is recommended as a first-line drug in patients with overweight and type 2 diabetes (Kalmykov, 2013; Spanidis, et al., 2016; Kalmykova, et al., 2018).

Korchinskiy V.S. (2014) claims that, under the influence of dosed physical activity, hyperglycaemia and glucosuria decrease in patients, the action of insulin increases, visceral obesity decreases, blood pressure

normalizes, and manifestations of heart failure decrease. The therapeutic effect of exercise therapy on the body is carried out by nervous and humoral regulation of motor-visceral reflexes. Any muscle contraction irritates the numerous nerve endings in them and the flow of impulses from them, as well as from the proprioceptors of other formations of the musculoskeletal system, are sent to the central nervous system. They change its functional state and, through vegetative centres, provide regulation and restructuring of the activity of internal organs. At the same time, the humoral system is involved in this regulation process, in which the metabolic products that appear in the muscles enter the bloodstream and act on the nervous system (directly on the centres and through the chemoreceptors) and the endocrine glands, causing the release of hormones. Thus, information on the work of muscles along the nerve and humoral pathways enters the central nervous system (CNS), is integrated, and then these systems regulate the function and trophism of internal organs and endocrine glands (Korchinskiy, 2014).

According to Popov, S.N. et al. (2008), Milyukov I.V. and Evdokimova T.A. (2004), 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.

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 (Verbov, 2006; Vakulenko, 2006). According to the recommendations of P.B. Efimenko (2013) for a complete solution of the tasks set is achieved not by direct action on individual areas of excessive accumulation of adipose tissue during obesity, but by 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. With metabolic syndrome with the phenomena of arterial hypertension according to the recommendations of L.A. Kunichev (1979) shows the effect on the paravertebral zones of the cervical and upper thoracic spinal segments C7-C2 and D5-D1.

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, hyperglycaemia, arterial hypertension) (Kalmykov, 2009, 2010; Kalmikov, 2012), 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 classes of physiotherapy (Zeman, & Valaskova, 2017). 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 physiotherapy (Kazakov, et al. 2003; Epifanov, et al. 2006; Popov, et al. 2008), herbal medicine (Kalmikov, 2010; Kalmykov, & Kalmykova, 2016), massage (Efimenko, 2013), physiotherapeutic treatment (Bisset, & Vicenzino, 2015; Probst, 2017), diet therapy (Kalmykova, 2013), 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 parameters, will improve adaptation to physical activity; will keep patients working.

CONCLUSIONS

To analyse the effectiveness of physical rehabilitation in patients with metabolic syndrome, we used the conduct, analysis and generalization of the results of studies of body length and weight, BMI, abdominal circumference, and skin fold thickness. When comparing the anthropometric indicators of patients of both groups in the initial study, we did not find statistically significant differences in the studied parameters. Abdominal circumference in patients of the main and control groups confirmed the presence of a metabolic syndrome with abdominal type of obesity according to the criteria of the metabolic syndrome recommended by the International Diabetes Federation (IDF) and WHO ($p > .05$). The total thickness of the skin fold: on the back of the shoulder, on the side, on the abdomen in women of the main and control groups testified to a "*high*" content of adipose tissue in the body - more than 31%. Thus, the anthropometric study confirms the presence of alimentary obesity of the I-II degree in the examined patients.

In order to normalize body weight and reduce the manifestations of abdominal obesity, we have developed, justified and applied for 4 months a comprehensive program of physical therapy for the main patients (rehabilitation measures were carried out according to the author's physical therapy program), and control (according to the program, is used for metabolic syndrome in the indicated treatment and prevention institution) of the groups where, during the second study, the anthropometric parameters of patients with metabolic syndrome changed significantly.

Comparing anthropometric indices in patients of the main and control groups, we came to the conclusion that during repeated examination in the main group of patients, the BMI, abdominal circumference, total thickness of the skin fold were statistically significantly better as a result of the use of the author's physical therapy program, the difference in body weight in MG and CG was statistically insignificant. All of the above is also confirmed by mathematical and statistical processing of the obtained data.

AUTHOR CONTRIBUTIONS

Yuliya Kalmykova. Collected data, conceived and designed the analysis, performed the analysis, wrote the paper. Sergey Kalmykov. Collected data, conceived and designed the analysis, performed the analysis. Helen Bismak. Collected data. Olha Beziazychna. Collected data. Daria Okun. Collected data, performed the analysis.

SUPPORTING AGENCIES

No external financial support to be declared.

DISCLOSURE STATEMENT

The authors declare that there are no conflicts of interest regarding the publication of this article.

ACKNOWLEDGEMENTS

The work was carried out in accordance with the priority thematic area 76.35. "*Medico-biological justification for the implementation of recovery measures and the appointment of physical rehabilitation to young people of different levels of preparedness.*" Number of state registration - 0116U004081.

REFERENCES

Belaya, N.A. (2001). Physical therapy and massage. Moscow: Sovetskiy sport, 83-85.

Bisset, L. M., & Vicenzino, B. (2015). Physiotherapy management of lateral epicondylalgia. Journal of physiotherapy, 61(4), 174-181. https://doi.org/10.1016/j.jphys.2015.07.015

Boytsov S.A., Goloshchapov A.V. (2013). The relationship of the main parameters of metabolic cardiovascular syndrome with the degree of carbohydrate metabolism and the severity of abdominal obesity. Arterial hypertension. Vol. 9 (2), 47-50.

Chazova I.E., Mychka V.B. (2015). Prevention, diagnosis and treatment of metabolic syndrome. Moscow: Eksmo, 48.

Convention for the protection of Human Rights and Dignity of the Human Being with regard to the Application of Biology and Medicine: Convention on Human Rights and Biomedicine. Council of Europe. Oviedo, 04.04.1997 r. URL: http://conventions.coe.int/treaty/rus/Treaties/Html/164.htm

Efimenko, P.B. (2013). Technique and methodology of classical massage. Kharkiv: KhNADU, 256-258.

Epifanov, V.A. (2006). Therapeutic Physical Culture. GEOTAR-Media. 249-262.

Ginzburg M.M. (2010). Obesity and metabolic syndrome. Impact on health, prevention and treatment. Samara: Parus, 160.

Gurka, M. J., Vishnu, A., Santen, R. J., & DeBoer, M. D. (2016). Progression of metabolic syndrome severity during the menopausal transition. Journal of the American Heart Association, 5(8), e003609. https://doi.org/10.1161/jaha.116.003609

H von Bibra, Ströhle, A., Sutton, M. S. J., & Worm, N. (2017). Dietary therapy in heart failure with preserved ejection fraction and/or left ventricular diastolic dysfunction in patients with metabolic syndrome. International journal of cardiology, 234, 7-15. https://doi.org/10.1016/j.ijcard.2017.01.003

IDF diabetes atlas. Electronic resource. Available at: https://www.idf.org/diabetesatlas

Kahn, R., Buse, J., Ferrannini, E., & Stern, M. (2005). The metabolic syndrome: time for a critical appraisal: joint statement from the American Diabetes Association and the European Association for the Study of Diabetes. Diabetes Care, 28, 2289-2304. https://doi.org/10.2337/diacare.28.9.2289

Kalmikov, S. (2012). Dynamics of indexes of carbohydrate exchange at patients by saccharine diabetes of 2th type on a background application of facilities of physical rehabilitation. Slobozhanskiy herald of science and sport, 5-1 (32), 102-105.

Kalmikov, S. A. (2010). Fitoterapiya [Phytotherapy], Kharkiv: KhDAFK, 205 p.

Kalmykov, S. A. (2013). Features of method of medical physical culture at insufficiency of aortic valve. Pedagogics, psychology, medical-biological problems of physical training and sports, 17(1), 25-29.

Kalmykov, S., & Kalmykova, J. (2016). The characteristics of the medicinal plants used in the herbal medicine of type 2 diabetes. Slobozhanskyi herald of science and sport, 3 (53), 26-30.

Kalmykov, S., & Kalmykova, Y. (2017). Dynamics of cardiovascular parameters in combined aortic malformations under the influence of a physical therapy program during the rehabilitation process. Slobozhanskyi herald of science and sport, no. 6 (62), 43-47.

Kalmykov, S.A. (2007). Topical issues of therapeutic physical culture in the rehabilitation of patients with type II diabetes mellitus. Slobozhanskiy herald of science and sport, Issue 12, 171-174.

Kalmykov, S.A. (2009). Evaluation of the effectiveness of the program of integrated physical rehabilitation for patients with type 2 diabetes mellitus. Medical perspectives, 14(2), 114-118.

Kalmykov, S.A. (2010). Study of the state of physical workability in patients with insulin-dependent diabetes mellitus under the influence of a program of physical rehabilitation. Health-saving technologies, physical rehabilitation and recreation in higher education institutions, 3, 82-86.

Kalmykov, S.A. (2012). Complex physical rehabilitation of persons of mature age, patients with type 2 diabetes mellitus, at the polyclinic stage: Dissertation of the candidate of medical sciences; Dnipropetrovsk Medical Academy of Health Ministry of Ukraine, 240.

Kalmykov, S.A., Kalmykova, Y.S. & Bezyazichnaya, O.V. (2015). Study of variability of antropometric and hemodynamic parameters in patients with alimentary obesity on the background of application of physical rehabilitation technique. News of science and education, 15(39), 38-46.

Kalmykova, Y., Kalmykov, S., & Bismak, H. (2018). Dynamics of anthropometric and hemodynamic indicators on the condition of young women with alimentary obesity in the application of a comprehensive program of physical therapy. Journal of Physical Education and Sport, 18(4), 2417-2427. https://doi.org/10.7752/jpes.2018.04364

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/10.15391/snsv.2018-5.004

Kalmykova, Yu.S. (2014). Metody doslidzhennya u fizychniy reabilitatsiyi: doslidzhennya fizychnoho rozvytku [Methods of research in physical rehabilitation: research on physical development], KhSAPC, Kharkiv, 104.

Kalmykova, Y.S. (2013). Features of medical feed at saccharine diabetes. Pedagogics, psychology, medical-biological problems of physical training and sports, 17(1), 30-33.

Kazakov, V. N., Sokrut, V. N. & Povazhnaya, Ye.S. (2003). Meditsinskaya reabilitatsiya v terapii [Medical rehabilitation in therapy]. Donetskiy GMU, Donetsk.

Kirichenko, M. P., Kalmykov, S.A. and Kalmykova, Yu.S. (2012). Features of cardiovascular reaction on physical exertion in patients with diabetes mellitus 2nd type under influence of physical rehabilitation means. Experimental and Clinical Medicine, 4, 71-73.

Koliada, A., Syzenko, G., Moseiko, V., Budovska, L., Puchkov, K., Perederiy, V., ... & Sineok, L. (2017). Association between body mass index and Firmicutes/Bacteroidetes ratio in an adult Ukrainian population. BMC microbiology, 17(1), 120. https://doi.org/10.1186/s12866-017-1027-1

Korchinskiy, V.S. (2014). The effectiveness of physical rehabilitation in metabolic syndrome. Biomedical and biosocial anthropology, 23, 200-201.

Kunichev, L.A. (1979). Therapeutic massage: a guide for nurses. L: Medicine, 216.

Mankovsky, B.R. (2016). Metabolic syndrome – an independent disease or a set of symptoms? Therapia, 4, 29-31.

Martirosov, E.G., & Rudnev, S.G. (2004). Anthropometric methods for the determination of fat and lean body mass. Problems of modern anthropology (a collection dedicated to the 70th anniversary of the birth of Professor BA Nikityuk), 40-62.

Masterov, O.S. & Kalmykov, S.A. (2017). Analysis of the results of correction of hyperglycemia in type 2 diabetes mellitus by means of physical therapy. Physical rehabilitation and recreation and health technologies, 1, 44-52.

Melnichenko, G.A., & Pyshkina, E.A. (2011). Obesity and insulin resistance are risk factors and an integral part of the metabolic syndrome. Therapeutic archive, 12, 5-8.

Methodical recommendations on counseling patients on the basic principles of healthy eating (in accordance with the order of the Ministry of Health of Ukraine No. 16 of 14.01.2013). (2013). International Endocrinology Journal, 5 (53), 138-147.

Milyukova, I.V., & Evdokimova, T.A. (2004). Physiotherapy. SPb.: Sova; M.: EKSMO, 862.

News and Information: WHO global database on body mass index (BMI): an interactive surveillance tool for monitoring nutrition transition. Public Health Nutrition, Vol 9, 5, 658-660, August 2006. https://doi.org/10.1079/PHN2006967

Nishimura, R.A., Otto, C.M., Bonow, R.O. et al. (2017). AHA/ACC Focused Update of the 2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease A Report of the American College of Cardiology. American Heart Association Task Force on Clinical Practice Guidelines. Circulation. Vol. 135, e1159-e1195. https://doi.org/10.3410/f.727426955.793533368

Petunina, N.A. (2007). The role of weight loss in obese patients in preventing the development of type 2 diabetes. Obesity and metabolism, 1, 3-7.

Popov, S.N. (2005). Physical rehabilitation. Rostov n/D: Feniks, 608.

Popov, S.N., Valeev, N.M. & Garaseeva, T.S. (2008). Therapeutic physical culture. Moscow: Akademiya, 416.

Probst, M. (2017). Physiotherapy and Mental Health. Clinical Physical Therapy, 230.

Reaven, G. (2002). Metabolic syndrome: pathophysiology and implications for management of cardiovascular disease. Circulation, 106(3), 286-288. https://doi.org/10.1161/01.cir.0000019884.36724.d9

Reaven, G. M. (1988). Role of insulin resistance in human disease. Diabetes, 37(12), 1595-1607. https://doi.org/10.2337/diab.37.12.1595

Reaven, G. M., Lithell, H., & Landsberg, L. (1996). Hypertension and associated metabolic abnormalities – the role of insulin resistance and the sympathoadrenal system. New England Journal of Medicine, 334(6), 374-382. https://doi.org/10.1056/nejm199602083340607

Sergeeva, V.V., & Rodionova, A.U. (2018). Hypertension associated with metabolic syndrome: clinical expert parameters, disability and aspects of rehabilitation. Aterial'naya Gipertenziya (Arterial Hypertension), 24 (3), 321–330.

Sorvacheva, T.N., Peterkova, V.A., & Titova, L.N. (20016). Obesity in adolescents. Alternative approaches to diet therapy. Attending doctor, 4, 50-54.

Spanidis, Y., Mpesios, A., Stagos, D., Goutzourelas, N., Bar Or, D., Karapetsa, M., ... & Kouretas, D. (2016). Assessment of the redox status in patients with metabolic syndrome and type 2 diabetes reveals great variations. Experimental and therapeutic medicine, 11(3), 895-903. https://doi.org/10.3892/etm.2016.2968

Styne, D. M., Arslanian, S. A., Connor, E. L., Farooqi, I. S., Murad, M. H., Silverstein, J. H., & Yanovski, J. A. (2017). Pediatric obesity – assessment, treatment, and prevention: an Endocrine Society Clinical Practice guideline. The Journal of Clinical Endocrinology & Metabolism, 102(3), 709-757. https://doi.org/10.1210/jc.2016-2573

Su, M. C., Lin, H. R., Chu, N. F., Huang, C. H., & Tsao, L. I. (2015). Weight loss experiences of obese perimenopausal women with metabolic syndrome. Journal of clinical nursing, 24(13-14), 1849-1859. https://doi.org/10.1111/jocn.12806

The DECODE Study Group. (1999). Glucose tolerance and mortality: comparison of WHO and American Diabetes Association diagnostic criteria. Lancet, Vol. 354, 617-621. https://doi.org/10.1016/s0140-6736(98)12131-1

Universal Declaration on Bioethics and Human Rights (Adopted on 10/19/2005 at the 33rd session of the General Conference of UNESCO). United Nations Educational, Scientific and Cultural Organization, availably at: http://www.un.org/ru/documents/decl_conv/declarations/bioethics_and_hr.shtml

Vakulenko, L.O. (2006). Therapeutic massage. Ternopil: TDMU Ukrme-dkniga, 346-357.

Verbov, A.F. (2006). Alphabet of massage. Moscow: Polyglot, 415.

World Health Organization: Definition, Diagnosis and Classification of Diabetes Mellitus and Its Complications: Report of a WHO Consultation. (1999). Geneva, World Health Org.

World Medical Association (2013). Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects. JAMA, 310 (20), 2191-2194. https://doi.org/10.1001/jama.2013.281053

Yuliya, K., & Sergey, K. (2018). Physical exercise application for the correction of carbohydrate metabolism in diabetes mellitus. Journal of Physical Education and Sport, 18(2), 641-647. https://doi.org/10.7752/jpes.2018.02094

Zeman, M., & Valaskova, L. (2017). Application of physiotherapy in persons at risk of metabolic syndrome development. Neuro endocrinology letters, 38(7), 484-487.