

Effect of physical therapy on the oxidative homeostasis state in women with metabolic syndrome

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Abstract

Particular importances have pathological conditions, formation of which is based on a complex of metabolic disorders. The metabolic syndrome is a classic representative picture of such conditions. The current approach in the treatment of patients is based on the correction of body weight, impact on insulin resistance, normalization of blood pressure, achievement of the better metabolic control. Meanwhile, the therapeutic solutions are not always effective, and pharmacotherapy, especially aimed at a weight loss, does not give positive results. Common factor all components of the metabolic syndrome is oxidative stress, i.e. a condition which is characterized by increasing content of free radical molecules due to the imbalance between production and inactivation active forms of oxygen with cell damage. It is underlies a number of pathological processes such as inflammation, hypoxia, reperfusion of tissues and organ. **Aim of research:** to improve state of oxidative homeostasis in the patients with metabolic syndrome through application of physical therapy. **Materials and methods.** On the basis of medical centre for outpatient services for children and adults "Doctrine" (city Dnipro) 27 women with metabolic syndrome at the age of (50.1±1.9) years were examined. Metabolic syndrome is confirmed by increasing of a body mass index (BMI), waist circumference (WC) more than 80 cm, hyperglycemia, changes of the serum lipid profile, persistent arterial hypertension, reduced glucose tolerance, presence of insulin resistance according to HOMA-IR index. **Results.** The program is based on a phased application of aerobic exercise and training with weight loading and resistance during 16 weeks. The basic principles of the given program are the following: individuality of loads, specificity and reversibility. The implementation of proposed program had a significant positive effect, contributing to the weakening intensity processes of a free radical oxidation of lipids. Such results are possible due to the enhancement of protective properties of antioxidant protection system. Significant positive effect of treatment was established due to the antioxidant enzyme circulating ceruloplasmin, whose normalization occurred in 75.0% of patients. Its insufficiency was observed only in single cases. Normal catalase activity was observed in 2.9 times more frequently than before physical therapy. Primary enzyme activity was insufficient in a half of women. Finally, enzyme level was increased on 14.2%. **Conclusions.** Application of the developed program helps to increase activity of antioxidant enzymes and to reduce aggressiveness active forms of oxygen.

Key words: metabolic syndrome, oxidative stress, physical therapy.

Introduction

In recent years, pathological conditions which formation is based on a complex of metabolic disorders have become particularly important. The classic representative of such conditions is the metabolic syndrome (MS), which belongs to the group of "diseases of civilization". MS is a complex of pathogenetically related disorders of carbohydrate, lipid, purine metabolism, tissue sensitivity to the insulin, abdominal obesity and hypertension (Kvasha, 2008; Alberti et al., 2009; Ciolac, Guimarães, 2004; Hawley, Lessard, 2008; Ilanne-Parikka et al., 2010; de Souza Bastos et al., 2016; Diachenko-Bohun et al., 2020; Savchenko et al., 2020; Shestopal et al., 2021).

Negative metabolic effects such as obesity, impaired glucose tolerance, decreased insulin sensitivity are significantly reduce quality of patients' life, carried out on the scales of physical health, physical and role-playing functioning, indicators of life activity and mental health (Maikova et al., 2017; Grygus et al., 2019; Nogas et al., 2019; Karpukhina et al., 2020; Dido et al., 2021; Kashuba et al., 2021; Lazko et al., 2021; Nesterchuk et al., 2020).

Current approach in the treatment of patients with MS is based on the body weight correction, impact on the insulin resistance, normalization of blood pressure (BP), achievement of the best metabolic control.

On the one hand, therapeutic solutions are not always effective. On the other hand, pharmacotherapy focused on a weight loss does not deliver the desired results, especially in a long-time perspective. This cause necessitates for analysis causes of the lack effectiveness the traditional treatment and search ways of it prevention.

The common factor all components of MS is oxidative stress. Oxidative stress is a condition, which characterized by increasing content of free radical molecules due to imbalance between production and inactivation active forms of oxygen with cell damage. It underlies a great number of pathological processes: inflammation, hypoxia, reperfusion of tissues and organ. (Zenkov et al., 2001). The oxidative stress and further inflammation cause insulin resistance, which binds various components of MS, including vascular changes (Golbidi et al., 2012). MS manifestations are exacerbated in the absence of physical activity partly due to impaired insulin-stimulated glucose uptake in the skeletal muscle (Golbidi et al., 2012; Hawley, Lessard, 2008).

Metanalysis testifies that basic body fat is oxidized in muscle tissue, in particular in slow and fast oxidative fibers. The fast glycolytic fibers are deprived of this ability. The ability of muscles to oxidize fat is significantly reduced in hypokinesia. The regulation of fat metabolism in skeletal muscle is clearly multifactorial, and different mechanisms may dominate under the different conditions (Golbidi et al., 2012; Hargreaves, Spriet, 2018; Kiens, 2006).

As shown in studies of Golbidi S. et al. one of the main effects of training exercises is to increase oxidative capacity of skeletal muscle, which leads to increased rate of fat oxidation in the body (Golbidi et al., 2012). Practical experience shows that oxidative stress often occurs in medical workers who undertake emergency interventions in emergency and life situations of the patient. Suddenly they are involved in disaster relief operations. Recently, in the treatment of patients with MS a great importance is focused on the physical activity among therapeutic factors. It has a multilateral wellness effect by increasing functional activity of various organs and systems in a sick organism and relaxation training in the prevention of post-traumatic stress for medical workers.

The aim: to improve state of oxidative homeostasis in the patients with metabolic syndrome through application of physical therapy.

Materials and methods

On the basis of medical center for outpatient services for children and adults "Doctrine" (city Dnipro) 27 women with metabolic syndrome at the age of (50.1±1.9) years were examined. Metabolic syndrome is confirmed by increasing of a body mass index (BMI), waist circumference (WC) more than 80 cm, hyperglycemia, changes of the serum lipid profile, persistent arterial hypertension, reduced glucose tolerance, presence of insulin resistance according to HOMA-IR index.

Blood lipid spectrum was analyzed by the following biochemical parameters of general level of cholesterol (GL CHL) and its fractions: cholesterol of a high-density lipoprotein (CHL HDL), cholesterol of a low-density lipoprotein (CHL LDL), cholesterol of very low-density lipoprotein (CHL VLDL), triglycerin (TG), non-esterified fatty acids (NEFA).

Intensity of processes of free radical lipid oxidation (FRLO) was evaluated by concentration of malondialdehyde (MDA) in a blood serum. The content of primary, intermediate and final products of lipid peroxidation (LDPO) was analyzed in isopropanol and heptane fractions of the lipid spectrum. It allowed to differentiate determination of an ester-bound products of phospholipid peroxidation (PHL) contained in the isopropanol phase and non-esterified intermediates of fatty acid peroxidation extracted with heptane phase (Honcharenko, Latinova, 1985).

In order to characterize state of antioxidant system, which control FRLO processes, the activity of antiradical components was evaluated: activity of superoxide dismutase (SOD) and catalase, content of circulating ceruloplasmin (CP).

Descriptive statistics were used for statistical analysis of the obtained data. Comparison of average values for variables was performed using parametric methods (Student's t-criterion) with normal distribution of these meanings, which are expressed in an interval scale. The correspondence type of distribution signs according to a law of normal distribution was checked by Shapiro-Wilkie method. In other cases, a nonparametric method (U-criterion of Mana-Whitney) was used. The χ^2 -test was used to compare the particle distribution of two or more variables. Correlation analysis was performed by Pearson (for data expressed in interval scale) and by Spearman (for data, which were not expressed in interval scale). All calculations were performed in the program SPSS 9.0 for Windows.

Results

Among surveyed prevailed women with I degree of obesity – 70.4%, which is confirmed by BMI (32.6 ± 0.8). The II degree of obesity was detected in 29.6% with BMI (36.3±1.2). All patients had abdominal type of obesity. Ratio of WV/HV is (0.91±0.06).

In the study of carbohydrate metabolism was shown level of fasting glycemia (7.3±1.2) mmol/l, H_{vA1c} – (8.51±1.6) %, HOMA IR (5.3±1.7).

Lipid profile of the blood was characterized by increasing level of GL CHL (8.04±0.33) mmol/l, CHL LDL (4.47±1.1) mmol/l, CHL VLDL (1.25±0.09) mmol/l, TG (3.44±0.37) mmol/l, and decreasing of CHL HDL (1.03±0.17) mmol/l. The concentration of NEFA was increased to (1.36±0.01) mmol/l.

Characteristics of parameters that reflect the state of oxidative homeostasis are shown in Table 1.

The given data testify increased level a primary product of LDPO – DC in 1.4 times ($p<0.001$) carried out in a heptane phase of lipid extract and its increasing in 1.9 times – in the isopropanol phase ($p<0.001$) in the vast majority of patients. The LDPO increasing is corresponding to the level of its secondary product – MDA was determined in 88.9% of cases after growing of MDA content in 1.8 times ($p<0.001$). Revealing of the final product of LDPO – SHO in the majority of patients at considerable concentration in both phases of lipid extract indicates about deep destructive processes, which are caused by enhanced peroxidation of PHL and fatty acids.

Table 1. Indicators of pro-oxidative link of oxidative homeostasis in the examined patients (n=27)

Indicator, units of measurement	Reference values	Phases	Characteristic of state	M±m	%
DC, from units /ml	0.67±0.03	α	normal	0.64±0.08	7.4
			increased	0.92±0.03 ²	92.6
	1.53±0.08	β	normal	1.51±0.06	22.2
			increased	2.88±0.13 ²	77.8
IPZ, from units /ml	0.99±0.04	α	normal	0.96±0.06	33.3
			increased	1.17±0.08 ¹	55.6
			decreased	0.77±0.05 ¹	11.1
	3.12±0.12	β	normal	3.03±0.09	7.4
			increased	4.82±0.15 ²	88.9
			decreased	2.7±0.0	3.7
SHO, from units /ml	0	α	normal	0	18.5
			increased	0.24±0.03 ²	81.5
	0	β	normal	0	14.8
			increased	0.38±0.04 ²	85.2
MDA, μmol/l	1.78 ± 0.16		normal	1.64 ± 0.01	7.4
			increased	3.19±0.22 ²	88.9
			decreased	1.39±0.10	3.7

Notes: ¹ – $p<0.05$; ² – $p<0.001$ – significance of differences between patients' indicators and reference values; 2. α – heptane phase; 3. β – isopropanol phase.

The increasing substrate content for free radical reactions – IPZ was greater on 1.5 times ($p<0.001$) in the isopropanol phase. Its level correlated with CHL LDL ($r=0.66$; $p=0.01$) and CHL VLDL ($r=0.73$; $p=0.001$). In the heptane phase such cases were observed on 1.6 times less often due to the localization of polyunsaturated fatty acids in cell membranes in the composition of phospholipids.

Taking into account given changes in the processes of LDPO, it is very important to study state of antioxidant protection system, especially its enzymatic link (Table 2).

Table 2. Indicators of antioxidant link of oxidative homeostasis in the examined patients (n=27)

Indicator, units of measurement	Reference values	Characteristic of state	M±m	%
SOD, conventional units	30.3±1.22	normal	34.3±3.8	3.7
		increased	42.8±3.7 ¹	14.8
		decreased	11.8±2.3 ²	81.5
CP, mg/ml	308.1±8.8	normal	306.3±9.4	7.4
		increased	436.8±12.3 ²	29.6
		decreased	232.6±7.7 ²	63.0
KA, μM/min/ mgHg	1122.6±21.8	normal	1126.9±15.7	18.5
		decreased	916.3±12.9 ²	81.5

Notes: ¹ – $p<0.05$; ² – $p<0.001$ – significance of differences between patients' indicators and reference values.

The key mechanism of organism protection from oxidative stress is SOD enzyme. Its activity was decreased in 2.6 times ($p<0.001$) in the majority of patients. SOD activity is hinged correlate with SHO ($r=-0.81$; $p=0.001$) and MDA ($r=-0.86$; $p=0.001$), which testified to depletion of antioxidant protection system (APS) at the intensification processes of LDPO.

Activity of extracellular antioxidant enzyme CP was reduced in 1.3 times ($p < 0.001$). The content of cell protection factor is naturally increased in response to the high rates of LDPO indicators: SHO ($r = -0.88$; $p = 0.001$), MDA ($r = -0.82$; $p = 0.001$). Decreasing of CP leads to the release of copper ions into extra-vascular space and further contributes to the action of pro-oxidant factors.

In the vast majority of patients there was a lack of catalase. Decrease of its activity was observed in 18.7% ($p < 0.001$). It was shown about decompensation of the corresponding link in antioxidant protection system.

Negative correlation link between catalase activity and level of NEFA was revealed ($r = -0.86$; $p = 0.001$), glycemia ($r = -0.54$; $p = 0.01$) and HbA1c ($r = -0.72$; $p = 0.001$). It indicates a significant dependence towards disorders of carbohydrate metabolism and lipolysis processes and activity of detoxification active forms of oxygen by antimicrobial enzymes.

Therefore, in the most women with MS there was an imbalance between accumulation of LDPO primary products and significantly accelerated breakdown of their transformation products into dialdehyde products (MDAs).

Kinesitherapy program aimed at overcoming metabolic syndrome and based on the basic principles: individuality, overload, i.e. exercise was performed with a load that exceeds usual, with control of the intensity, duration and frequency of exercise. The third principle is specificity, characterized by the fact that exercise exhibits a special adaptation that promotes specific physiological reactions. The principle of reversibility is characterized by the fact that physiological adaptations facilitated by exercise return to their original state before training, when a person returns to non-active lifestyle.

The physical therapy program includes components that improve the condition of cardiovascular and respiratory systems, strength and muscular resistance: aerobic exercise, flexibility, exercises on stationary recumbent exercise machines and water exercises, exercises with light resistance using an elastic band.

In determining intensity and duration of the exercises, they focused on the Borg' Perceived Voltage Scale.

The physical therapy program lasted 16 weeks. During the first 4 weeks, aerobic exercise was performed 5 times a week, lasting from 20 to 60 minutes, without exercise with loading.

In the complex did not apply exercises with rapid changes of body position, and causing rapid and significant changes in a heart rate and blood pressure: running with high intensity or lifting heavy objects.

Over the next 2 weeks, patients were trained in a proper technique and range of motion in order to anatomically adapt to weight training and acclimatize to weight training equipment.

For the next 4 weeks, the patients performed exercises with weight training: training with dumbbells having an initial weight 3 kg with a gradual increase their weight weekly; exercises with a barbell; on exercise machines in a reclining position.

During the last 6 weeks, patients were performed a leg presses, lunges, leg extensions, leg bending, chest presses, triceps extension and biceps twisting. Resistance exercises were performed in a form of circular training.

The number of repetitions is gradually increased from 6 to 15 every week.

The exercise with a weight training patients performed independently such as aerobic exercise at the patient's choice.

A control study of oxidative homeostasis was performed in 24 women who completed the kinesitherapy program.

In the heptane phase, level of DC is recovered more than in half of the patients, the rest decreased on 16.3% from the primary level ($p < 0.01$) (Table 3).

Table 3. Dynamics of pro-oxidative link of oxidative homeostasis in examined patients

Indicator, units of measurement	Reference values	Phases	Characteristic of state	M±m	%	χ^2	P
1	2	3	4	5	6	7	8
DC, from units / ml	0.67±0.03	α	normal	<u>0.64±0.08</u> 0.68±0.02	<u>7.4</u> 75.0	21.6	3.36E-06
			increased	<u>0.92±0.03³</u> <u>0.77±0.04^{1/**}</u>	<u>92.6</u> <u>25.0</u>	21.6	3.36E-06
	1.53±0.08	β	normal	<u>1.51±0.06</u> 1.50±0.01	<u>22.2</u> 58.3	5.52	0.02
			increased	<u>2.88±0.13³</u> <u>1.87±0.1^{2/***}</u>	<u>77.8</u> <u>41.7</u>	5.52	0.02
IPZ, from units / ml	0.99±0.04	α	normal	<u>0.96±0.06</u> 0.94±0.01	<u>33.3</u> 87.5	13.2	0.0003
			increased	<u>1.17±0.08¹</u> 1.12±0.05 ¹	<u>55.6</u> 12.5	10.7	0.001

			decreased	$\frac{0.77 \pm 0.05^1}{-}$	$\frac{11.1}{0}$	1.18	0.28
	3.12±0.12	β	normal	$\frac{3.03 \pm 0.09}{3.1 \pm 0.11}$	$\frac{7.4}{66.7}$	17.0	3.7E-05
			increased	$\frac{4.82 \pm 0.15^3}{3.61 \pm 0.2^{1/****}}$	$\frac{88.9}{33.3}$	14.5	0.0001
			decreased	$\frac{2.7 \pm 0.0}{-}$	$\frac{3.7}{0}$	0.004	0.95
SHO, from units /ml	0	α	normal	$\frac{0}{0}$	$\frac{18.5}{83.3}$	18.8	1.42E-05
			increased	$\frac{0.24 \pm 0.033}{0.11 \pm 0.042/**}$	$\frac{81.5}{16.7}$	18.8	1.42E-05
		β	normal	$\frac{0}{0}$	$\frac{14.8}{62.5}$	10.4	<u>0.001</u>
			increased	$\frac{0.38 \pm 0.043}{0.15 \pm 0.061/**}$	$\frac{85.2}{37.5}$	10.4	<u>0.001</u>
MDA, μmol/l	1.78±0.16		normal	$\frac{1.64 \pm 0.01}{1.67 \pm 0.01}$	$\frac{7.4}{75.0}$	17.0	3.7E-05
			increased	$\frac{3.19 \pm 0.22^3}{2.23 \pm 0.14^{1/****}}$	$\frac{88.9}{25.0}$	17.0	3.7E-05
			decreased	$\frac{1.39 \pm 0.10}{-}$	$\frac{3.7}{0}$	0.04	0.95

Notes: 1. In the numerator – indicators of patients before kinesitherapy, in the denominator – indicators of patients after kinesitherapy. 2. ¹ – p<0,05; ² – p<0,01; ³ – p<0,001 –level of reliability differences between patients' indicators and reference values; 3. * – p<0,05; ** – p<0,01; **** – p<0,001– significance of differences between patients indicators before and after kinesitherapy; 4. α - heptane phase; 5. β – isopropanol phase

The normal content of IPZ in the heptane phase was observed in 2.6 times more often than before kinesitherapy ($\chi^2=13.2$; p=0.0003). Their initially increased

level decreased on 25.1% (p <0.001). The number of patients with absence of final product of LDPO – SHO increased in 4.5 times ($\chi^2=18.8$; p=1.42E-05). The level of their excess formation decreased on 2.2 times compared to the primary indicator (p <0.01). In the isopropanol fraction of lipid extract, normal content of DC was observed in 2.6 times more frequently ($\chi^2=5.52$; p=0.02), although in almost half of the patients their concentration remained increased, but level of this increase decreased in 1.5 times, compared with initial observation phase (p<0.001). A similar pattern was found with respect LPO – IPZ substrate, whose normal content was observed in 9 times more frequently than before kinesitherapy ($\chi^2=17.0$; p=3.7E-05). Their initially increased level was decreased in 1.3 times (p<0.001). Absence of the final product LPO –SHO was observed in 2.3 times more often than before physical therapy ($\chi^2=10.4$; p=0.001). Level of their excess formation decreased in 2.5 times compared to the primary indicator (p<0.01). Increased concentration of the secondary product LPO –MDA was observed less than in 3.6 times ($\chi^2=17.0$; p=3.7E-05). At their presence level of increasing MDA decreased in 1.4 times (p <0.001). Therefore, implementation of the proposed kinesitherapy program had a significant positive effect, contributing to the weakening of LDPO. Such results became possible due to the enhancement of protective properties of APS (Table 4). This is confirmed by increasing in 7.9 times number of patients with normal SOD ($\chi^2=5.76$; p=0.02) and decreasing in 3.9 times with its suppression ($\chi^2=16.4$; p=5.12E-05). Severity of SOD decreased in 2.1 times (p <0.001).

Table 4. Dynamics antioxidant link indicators of oxidative homeostasis in examined patients

Indicator, units of measurement	Reference values	Characteristic of state	M±m	%	χ^2	P
SOD, conventional units	30.3±1.22	normal	$\frac{34.3 \pm 3.8}{31.1 \pm 0.44}$	$\frac{3.7}{29.2}$	4.45	0.03
		increased	$\frac{42.8 \pm 3.7^1}{35.3 \pm 0.17^{3/*}}$	$\frac{14.8}{50.0}$	5.76	0.02
		decreased	$\frac{11.8 \pm 2.3^2}{25.2 \pm 1.4^{1/****}}$	$\frac{81.5}{20.8}$	16.4	5.12E-05
CP, mg/ml	308.1±8.8	normal	$\frac{306.3 \pm 9.4}{326.6 \pm 8.4}$	$\frac{7.4}{75.0}$	15.0	0.0001
		increased	$\frac{436.8 \pm 12.3^2}{370.2 \pm 9.3^{2/**}}$	$\frac{29.6}{20.8}$	0.16	0.69
		decreased	$\frac{232.6 \pm 7.7^2}{266.1 \pm 6.9^{1/*}}$	$\frac{63.0}{4.2}$	9.41	0.002
KA, μC/min/mgHg	1122.6±21.8	normal	$\frac{1126.9 \pm 15.7}{1137.2 \pm 3.9}$	$\frac{18.5}{54.2}$	5.60	0.02
		decreased	$\frac{916.3 \pm 12.9^2}{1068.1 \pm 10.2^{1/****}}$	$\frac{81.5}{45.8}$	5.60	0.02

Notes: 1. In the numerator – indicators of patients before kinesitherapy, in the denominator – indicators of patients after kinesitherapy. 2. ¹ – p<0,05; ² – p<0,001 – level of reliability differences between patients' indicators and reference values; 2. * – p<0,05; ** – p<0,01; *** – p<0,001– significance of differences between patients indicators before and after kinesitherapy.

It was established significant positive effect of treatment on the level of antioxidant enzyme CP. The normalization of its activity occurred in 75.0% of patients. Its insufficiency was observed only in single cases.

Normal catalase activity was observed in 2.9 times more often than before physical therapy ($\chi^2=5.60$; p=0.02). It is shown that in a half of women was observed its insufficient levels, but enzyme level increased on 14.2% (p <0.001).

Discussion

MS manifestations are exacerbated in the absence of physical activity partly due to impaired insulin-stimulated glucose uptake in the skeletal muscle (Golbidi et al., 2012; Hawley, Lessard, 2008). It is known that basic body fat is oxidized in muscle tissue, in particular in slow and fast oxidative fibers. The fast glycolytic fibers are deprived of this ability. The ability of muscles to oxidize fat is significantly reduced in hypokinesia. The regulation of fat metabolism in skeletal muscle is clearly multifactorial, and different mechanisms may dominate under the different conditions (Golbidi et al., 2012; Hargreaves, Spriet, 2018; Kiens, 2006).

In the last decade, significant progress has been made in understanding the molecular basis focused on the positive effect of regular exercise in a stimulating glucose penetration into insulin sensitive tissues, an improving action of insulin in skeletal muscle of the insulin resistant individuals. As shown in studies of Golbidi S. et al. one of the main effects of training exercises is to increase oxidative capacity of skeletal muscle, which leads to increased rate of fat oxidation in the body (Golbidi et al., 2012).

Many researchers have demonstrated the therapeutic effectiveness of aerobic exercise, endurance and exercise in patients with MS on the lipid profile, glycemic control, levels of glycosylated hemoglobin, peripheral blood vessels, body composition, quality of life (Abdolali et al., 2012; Ciolac, Guimarães, 2004; Grygus et al., 2019; Ilanne-Parikka et al., 2010; Keating et al., 2017; Ramos et al., 2017; Strasser et al., 2010).

Although combination of both aerobic and strength training is suggested by most professionals, the advantages of these interventions is remaining unclear research (Keating et al., 2017; Weatherwax et al., 2018; Zapata-Lamana et al., 2018). Meanwhile, progressive development of MS causes the need for looking ways how to prevent it.

In our opinion, answer to these questions should be sought in the field of improvement kinesitherapy technologies aimed at reducing oxidative stress, since such studies are clearly insufficient.

An important result of this study is substantiation of a kinesitherapy program based on the basic principles such as individuality, overload, specificity and reversibility.

The phased application of developed program helps to increase activity of antioxidant protection enzymes and reduce aggressiveness active forms of oxygen. Moreover, the most effective kinesitherapy showed relatively on the oxidative processes of neutral lipids, whose role in the development of MS is difficult to overestimate.

Conclusions

1. Metabolic syndrome in all women was accompanied by increased lipid peroxidation processes and insufficient activity of antioxidant system, which led to the deepening disorders of carbohydrate metabolism and lipolysis processes.

2. In order to improve oxidative homeostasis, program of physical therapy is proposed. It was based on the principles of individuality, overload, specificity, and reversibility, with step-by-step application of aerobic exercise, training exercise and resistance with a gradual increasing of intensity, duration and frequency of exercise during 16 weeks.

3. Implementation program of the proposed physical therapy has a significant positive effect, contributing to the weakening of LDPO due to enhancement of the protective properties enzyme link of the antioxidant protection system. Moreover, the most effective kinesitherapy showed on the oxidative processes of neutral lipids.

Conflict of Interest. The authors declare that there is no conflict of interest that could be perceived as interfering with publication of the article.

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