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The Impact of Compression Garments on the Change of Creatine Kinase and Lactate Dehydrogenase Levels in the Athlete's Body During Aerobic Training.

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ABSTRACT

The work is devoted to the study of the impact of compression tights intended for use in the process of sports training on the change of creatine kinase (CK) and lactate dehydrogenase (LDH) levels in the blood of athletes during an aerobic workout on a treadmill for 10-30 minutes (three regimens of intensity). To ensure tight defect-free fit, the experimental tights model, necessary for carrying out the experiment, was developed on the basis of obtained anthropometric information of the athlete's body surface curvature. To ensure the compression effect we used the recommended pressure quantity. According to the results of the study, we found an unstable decrease in levels of CK and LDH in almost all regimens of aerobic training. Along with that, after the statistical analysis with the usage of the t-test, the veracity of CK and LDH levels reduction hypothesis was not ascertained. After analysis by means of the Wilcoxon signed-rank test, we ascertained the statistical veracity of the obtained data and the proposed hypothesis.
Keywords: compression tights, compression garments, sportswear, creatine kinase, lactate dehydrogenase, blood lactate level, aerobic exercises.

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INTRODUCTION

The last decades are characterized by a significant breakthrough in the development of sportswear [1]. Now, clothing not only performs its basic functions - provides the thermal balance of the space under clothes, it has an anthropometric concordance in a static and dynamic position, indicators of tactile, hygienic and operational characteristics of the textile materials from which it is made are satisfactory [2]. But it also possesses communication ability, being thus a platform that receives, processes and sends signals from the environment and the human body [3, 4].

One of the identified possible types of interaction is the ability of a strong physical impact on the athlete's body through the compression ability of a closed knitted sheath [5, 6, 7].

Compression sportswear as an innovative product has gained considerable popularity in recent years, thus it contributes to the development of the economies of the producing countries [8, 9]. Among the factors that affect compression sportswear are:

- increase in the intensity of muscle oxygenation [10];
- increase in blood perfusion and oxygen consumption [11];
- improving proprioception and muscle coordination [11];
- improvement of postural stability and dynamic balance [12];
- increase endurance[12];
- attenuation of the vibration of muscle fibers [13];
- injury prevention[13];
- reduction of muscle edema[14];
- deceleration of a symptom of muscle soreness manifestation [15];
- reduction of the intensity of delayed onset muscle soreness (DOMS) [15];
- acceleration of the recovery of muscle strength and muscle power [16];
- improvement of metabolic products removal [17];
- acceleration of blood lactate reduction [12, 18];
- decrease in creatine kinase concentration [12, 18].

A lot of scientific works are devoted to the study of the effectiveness of compression garment for sports purposes usage. The bulk of current research is focused on assessing the changes in heart rate (HR), maximum oxygen consumption, muscle blood flow, blood pH, the concentration of creatine kinase and lactate dehydrogenase, decrease in muscle pain. At the same time, research methods are divided according to the principle of time of compression products usage: in the process of training or in the process of the recovery period.

We have analyzed studies aimed at studying the effect of wearing of compression garments (in the process of training) on various indicators of the physiological state of athletes. Berry (1987) [19] ascertained in his work that when an athlete wears compression tights, the level of lactate in the blood decrease. Bringard (2006) [10] and Kemmler (2009) [20] in their work found out that when an athlete uses compression tights and socks during aerobic training on a treadmill with an intensity of 12 km/h the efficiency increases because of the reduction in expended energy amount.

Ali (2007) [21] investigated the reduction of delayed onset muscle soreness when wearing a compression garment during a workout. In the works of Scanlan (2008) [22] and Sperlich (2013) [23]was observed an increase in the oxygenation of the quadriceps femoris tissues of the thigh when performing aerobic exercise on the ergocycle and simulating a mountain climbing. Sperlich (2013) [23] also found out suppression of the oscillatory motions of the quadriceps femoris when wearing compression tights during training, which affects the amount of energy spent by an athlete.

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Berry (1987) investigated the fact of reduction of the lactate concentration in the blood. [19]. According to Jakeman (2010) [24] and Trenell (2006) [25], the impact of compression garment wearing in the process of training on changes in the level of creatine kinase in the athlete's blood was not found.

Thus, according to the analysis of scientific works in the given field, we established the relevance of our research aimed at studying the impact of compression garment wearing on various indicators of the physiological state of athletes during training.

We decided to undertake a study of the creatine kinase and lactate dehydrogenase (LDH) levels in the blood of athletes in order to evaluate the effectiveness of the method of designing tight-fitting sportswear proposed in the works [4, 26].

Lactate dehydrogenase is an enzyme that catalyzes the oxidation of lactic acid to pyruvate. LDH is most active in skeletal muscle and heart muscle. Among the reasons for the excess of its reference values are:

- myocardial infarction;
- pulmonary embolism and pulmonary infarction;
- malignant tumors of various localizations;
- leukemia;
- liver pathology;
- kidney disease;
- muscle pathology;
- bone fractures;
- acute pancreatitis;
- intense training;
- stroke, etc. [27, 28].

Creatine kinase is an enzyme that catalyzes the process of the phosphoryl residue and adenosine triphosphate (ATP) transference to creatine,with the formation of creatine phosphate and ATP. In the biochemical composition of human blood, this enzyme is represented in the form of 3 isozymes, among which the MM-isozymeis located in skeletal muscle and myocardium, it characterizes the damage to the muscles. The other two isozymes, the MB-isozymeis contained in the myocardium and the BB- isozyme in brain tissues, characterize myocardial damage and oncological diseases respectively. To study the concentration of the MM-isozyme we should carry out a study of total creatine kinase, and to study the concentration of MB-isozyme we should analyze creatine kinase-MB.

The reasons for the increase in CK are somewhat similar to the reasons for the increase in LDH:

- myocardial infarction;
- myocarditis;
- myocardial dystrophy;
- polymyositis;
- dermatomyositis;
- muscular dystrophy;
- tumor process in the body;
- intense physical activity;
- spasm, status epilepticus;
- surgical interventions, etc.

Thus, both CK and LDH enzymes serve as markers of inflammatory processes in the skeletal muscles of an athlete and can be used to evaluate the impact of the compression products usage for sports purposes on a sportsman's body in the process of sports training.

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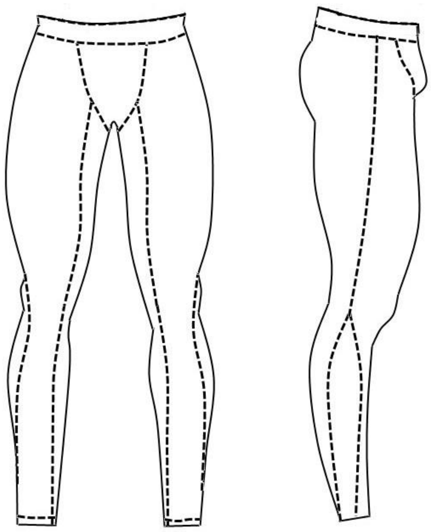
EXPERIMENTAL

To conduct the study, we developed an experimental model of compression tights on the basis of the data obtained in the previous work [26], which is devoted to the study of the complex curvature of the athlete's body surface based on the example of Cross Fit athletes.

As a result of cluster analysis applied to the “cloud” of points obtained in the study and subsequent approximation, we obtained characteristic vertical lines on the athlete's body surface: on the lateral parts of the gastrocnemius muscle, on the lateral inner part of the hip quadriceps. We used these lines in the development of the experimental model construction of compression tights. The technical sketch of tights is shown in thepic.1.



Pic 1: Technical sketch of the experimental model of compression tights

We used the values recommended in works [29, 30, 31, 32] to find out the pressure level of clothing shell on the athlete's body. We used the Laplace law about thin shells of revolution to ascertain the values of the narrowing of rubbery knitted fabric (RKF):

$$p = \frac{\sigma}{R_2}, \qquad (1)$$

where p – the pressure of the shell on the human body, kPa; σ- knitted fabric tension, N/m; R_2– the radius of curvature in the cross-sectional plane, m.

Then we carried out an anthropometric study of a group of individuals. The study group consisted of 7 males aged 19–25 years. Their parameters are presented in table 1.

Table 1: Dimensional parameters of the studied athletes

Height, см	Weight, kg	BMI	Chest	Waist	Hip
169,3 – 182,2	55,7 – 74,2	18,8 – 22,35	82,4 – 91,2	72,6 – 78,2	94,6 – 98,5

In the program of anthropometric measurements (except for dimensional parameters presented in table.1) we measured the radius of the athlete's curvature at the levels of the hips girth, upper and lower levels of the thigh girth, the knees girth, the calf girth and the tibia girth. After that, we calculated the fabric tension required for the ascertainment of the recommended pressure values.

After we carried out a study of the physico-mechanical characteristics of a rubbery knitted fabric, we obtained the stretching values of the knitted fabric from the curvature of the tensile force - stretching of the fabric. The data presented in table 2.

Table 2: Baseline data for the design of an experimental model of compression tights

№	Area denomination	Pressure value, kPa	Radius of curvature, m	Values of the narrowing RKF, %
1	Hip	1,21	0,152 ± 0,005	7,2
2	Upper hip	1,21	0,095 ± 0,012	9,8
3	Lower hip	1,49	0,081 ± 0,01	8,9
4	Knees	1,27	0,062 ± 0,006	12,2
5	Calves	2,35	0,058 ± 0,005	7,4
6	Ankles	2,4	0,042 ± 0,004	10,3

Then we made experimental models of compression tights. For the development of the experimental model, we used a gradient scheme for the distribution of compression pressure along the closed contours of the clothing shell. The pressure-gradient force is formed due to the nonuniformity of the curvature of the athlete's body surface: the presence of fat deposits and the development degree of muscles, ligaments and joints in the area under study. In order to make the pressure values homogeneous, it is necessary to introduce a differentiated pattern of pressure distribution along the closed contours of the clothing shell through the development of new lines of constructive divisions in places where the curvature of the body surface changes.

The chosen scheme of the experiment: athletes did aerobic training on a treadmill for 6 days in a row in the evening. After training within an interval of 60–90 minutes, we took athlete's venous blood for subsequent biochemical analysis of creatine kinase and lactate dehydrogenase. The duration of aerobic training was 10, 20 and 30 minutes with 3 different modes of intensity (6, 8 and 10 km/h). The study of the CK and LDH levels was carried out by the authors in a commercial laboratory in Moscow. In the study we used a biochemical analyzer Beckman Coulter AU 5800 (USA).

RESULTS AND DISCUSSION

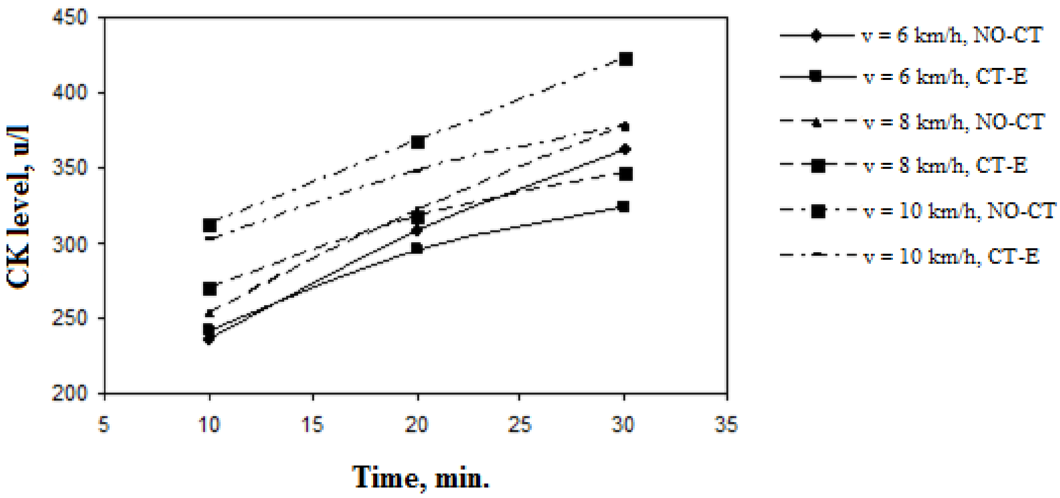
The obtained data of CK and LDH levels are presented in Table. 3. The values measured after the aerobic training (during which the athlete used compression tights) are listed in the column "Value of the indicator with CT-E (Compression tights in exercise – The usage of compression tights during training)". CK and LDH levels control was performed on the first day of the study before sports training. In pic. 2 and pic. 3 we can see the dependence of the CK/ LDH levels on the time spent for various intensities (speeds) of aerobic training.

Table 3: The results of the study of the CK and LDH levels after aerobic exercise for CT-E and NO-CT

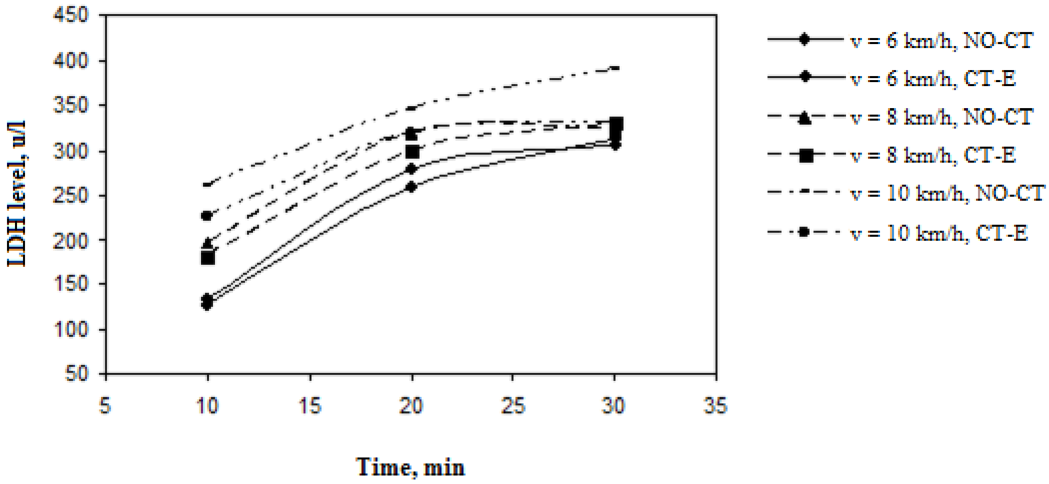
Marker	Aerobic training duration, min.	Aerobic training speed, km/h	Value of the indicator with CT-E, U/l	Value of the indicator with NO-CT, U/l	Control, U/l
CreatineKinase	**10**	**6**	242 ±39 *p<0.05	237 ± 42	205 ± 42
		8	271 ±38 *p<0.05	254 ± 41	
		10	302 ±32 *p<0.05	312 ± 46	
	20	**6**	295 ±38 *p<0.05	309 ± 41	
		8	318 ±41 *p<0.05	322 ± 44	
		10	348 ±37 *p<0.05	368 ± 34	

	30	**6**	325 ±43 *p<0.05	362 ± 39	
		8	346 ±42 *p<0.05	378 ± 51	
		10	378 ±38 p<.40 *p<0.05	422 ± 32	
LactateDehydrogenase	**10**	**6**	128 ±29 **p<0.05	134 ±25	112 ± 18
		8	182 ±32 **p<0.05	196 ±28	
		10	225 ±31 p<.50 **p<0.05	262 ±32	
	20	**6**	259 ±34 **p<0.05	279 ±49	
		8	298 ±48 **p<0.05	320 ±41	
		10	320 ±31 **p<0.05	345 ±37	
	30	**6**	312 ±54 **p<0.05	305 ±38	
		8	329 ±47 **p<0.05	324 ±53	
		10	331 ±31 p<.30 **p<0.05	390 ±42	

p - the level of significance in the evaluation of the statistical reliability of CK/ LDH level reduction in the blood for CT-E by means of the t-test.
*** p / ** p is the level of significance in the evaluation of the statistical reliability of CK/ LDH level reduction in the blood for CT-E by means of the Wilcoxon signed-rank test**



Pic 2: Dependence of creatine kinase level on the duration of the various intensity of aerobic exercise



Pic 3: Dependence of lactate dehydrogenase level on the duration for the various intensity of aerobic exercise

According to the presented data the values of the CK and LDH level continuously increase throughout the increase in the level of aerobic training, both in time and in intensity (speed of run). The CK level increases from 237 ± 42 u/l to 390 ± 42 u/l, The LDH level from 128 ± 29 u/l to 390 ± 42 u/l. We noted that in all stages of the study, the concentration of CK and LDH abruptly increase due to an increase in the intensity of aerobic training from 8 to 10 km/h.

At the same time, after statistical data analysis with the usage of the t-test (we used it due to the normal distribution of the CK and LDH values of the samples), it was found that only 3 pairs of compared samples have relative statistical confidence: the CK values for CT-E and NO-CT, with the training duration of 30 min. and intensity of 10 km/h. The data are statistically significant for the significance level $p < .40$. LDH values for CT-E and NO-CT are statistically significant for the following variants: duration 10 min, speed 10 km/h (for significance level $p < .50$) and duration 30 min, speed 10 km/h (for significance level $p < .30$).

Since the data of the CK and LDH levels were obtained from the same group of athletes but under different conditions (for CT-E and NO-CT), we used the Wilcoxon signed-rank test. To test the null hypothesis, statistical analysis was performed for 2 samples, respectively. We ascertained that a decrease in the creatine kinase and lactate dehydrogenase levels during the training process with the use of compression tights is statistically significant ($p < 0.05$).

CONCLUSIONS

Due to the data obtained during the experiment and statistical analysis, we made the following conclusions and recommendations:

- it is necessary to carry out a research with a larger group of the athletes under study;
- it is necessary to carry out a research of the professional athletes;
- due to the large straggling of the obtained values of CK and LDH in the group of athletes, we ascertained the need for statistical analysis by means of the Wilcoxon signed-rank test separately for each athlete from the experimental group under equal physical conditions (equal intensity/ speed and duration);
- we ascertained the need for research with larger values (close to critical) of compression pressure for compression garments for sports purpose;

- due to the data obtained from the works within the scope of our investigation, it was found that the study of CK and LDH levels should be carried out not only immediately after training, but also during the recovery process after training within a time period of 8-48 hours;
- it is recommended to develop an experimental model of compression tights with a differentiated pattern of pressure distribution along the closed contours of the clothing shell.

The study was aimed at ascertainment of the influence of sportswear compression garments on the athlete's body in the process of high-intensity functional training (functional all-around, Cross Fit). The subsequent critical analysis will help us to determine the effectiveness of the design method of tight-fitting sportswear to vary the set of parameters in order to increase the efficiency of the products: improve the productivity of athletes and accelerate the recovery of their muscular operability after intense physical training.

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