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ВПЛИВ ВІБРАЦІЙ НА ДІЯЛЬНІСТЬ СПОРТСМЕНІВ

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Анотація. Відомо, що низькочастотні вібрації мають терапевтичний вплив на організм людини. Декілька останніх десятиліть були позначені зростанням інтересу до використання вібраційних впливів під час спортивної підготовки. Хоча більшість цих досліджень спрямовано на можливості розвитку сили, було б цікаво дослідити вплив постійних вібраційних коливань на діяльність спортсменів у видах спорту, зорієнтованих на тренування витривалості. У дослідженні взяли участь висококваліфіковані спортсмени (бігуни середньої дистанції), особи, що займаються оздоровчим бігом, та футболісти аматорського рівня. Для генерації місцевих вібраційних коливань застосовано технологічну систему «Techvibe» від компанії «Chen Beitar Hashkaot LTD» (Ізраїль), яка використовує унікальні поєднання частот і амплітуд, розроблену для лінійки продуктів «електронного підсилення м'язів» під торговою маркою «Spedox». Установлено, що застосування цього пристрою підвищує рівень швидкісної витривалості спортсменів: 6,4 % у чоловіків ($p<0,05$) і 6,5 % у жінок ($p=0,068$). Виявлено поліпшення індивідуальних проявів витривалості (збільшення подоланої дистанції до відмови від роботи до 3,97 %, $p<0,05$). Отримані дані вказують також на значну ефективність системи «Spedox» для поліпшення проявів витривалості непідготовлених осіб під час їхніх бігових навантажень. Було виявлено значний вплив систем «Spedox» на процес виділення молочної кислоти у бік його зменшення до десятої хвилини періоду відновлення після інтенсивного бігу (виявлено на 15,4–18,6 % нижчий її рівень ($p<0,05$) у пробах крові). Зростання максимального зусилля м’язів під впливом застосування системи «Spedox» підтверджено збільшенням максимального навантаження (на 10 %, $p<0,05$) і кількості повторень (на 15 %, $p<0,01$) під час розгинання ніг, яке виконували здорові нетреновані особи. Збільшення максимальної сили м’язів при застосуванні системи «Spedox» пов'язано з прискоренням процесу відновлення м'язів, що підтверджено зниженням з часом показників болю м’язів.

Ключові слова: бігуни, локальні вібрації, «Spedox», витривалість, втома м’язів.

THE INFLUENCE OF VIBRATION UPON SPORTSMEN ACTIVITY

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Summary. Several recent decades have been marked by growing interest in using vibration influences during sports training. While majority of these investigations is aimed at force training it would be interesting to investigate the effect of influence of continuous vibrations upon performance in sports originally aimed at endurance training. The study was attended by highly trained middle-distance runners, recreational runners and amateur level football players. «Techvibe» technology system developed by the «Chen Beitar Hashkaot LTD» (Israel) and being used in the line of products by the «Spedox» brand was used to supply local vibration. It was found that the use of this device improves the level of speed endurance of athletes as well as of individual manifestations of endurance. The obtained data also indicate the considerable effectiveness of the «Spedox» for improving the manifestations of endurance of the untrained persons during their running loads. Significant effect of the «Spedox» on the time course of lactic acid decrease in recovery period after the intensive run was found. The improvement of maximal strength under the «Spedox» effect was approved. Increase in muscle maximal strength in the case of «Spedox» application was associated with the acceleration of the muscle recovery processes.

Keywords: runners, local vibration, «Spedox», endurance, muscle fatigue.

Introduction. Attempts to use vibrational effects on the body to increase the effectiveness of its activities have been numbering for several hundred years. So in 1867, Swedish physician and inventor Gustav Zander developed an apparatus that used weights and pulleys to create a sense of vibration. Its purpose was therapeutic. In 1895, Dr. John Harvey Kellogg implemented vibration therapy in his health practice. Using a vibrating chair he developed himself, he claimed it could help improve circulation and alleviate constipation.

Based on current scientific data the therapeutic effect of low-frequency vibrations (usually in the range from 10 to 250 Hz) is based on the reflex act, caused by irritation of the mechanical and baroreceptors of the skin and deep tissues. The flow of nerve impulses through alternate compression and stretching of tissues through neuroendocrine mechanisms causes a number of body reactions that are used with a therapeutic purpose – to improve the functional state of the central nervous system, local blood circulation, metabolic processes, increase the tone of the sympathetic-adrenal system, produce analgesic effect, etc. (Samosyuk I. Z. et al., 2007; Layko A. A. et al., 2012).

As a result of influence of vibrations of moderate intensity the mobilization of protective and adaptive mechanisms of the body occurs, the lability of the neuromuscular apparatus increases, the redox processes are intensified, as well as the activity of the endocrine glands, the function of the internal organs is normalized, etc. One can also observe an increase in local blood flow and lymphatic drainage, activation of trophic in tissue, reduction of muscle tone, increase in sorption properties of cells and tissues, increase of the permeability of cell membranes, intensification of enzymatic reactions (Bogolyubov V. M., 2015).

Several recent decades have been marked by growing interest in using vibrational influences during sports training. For example Issurin V. B. and colleagues concluded that superimposed vibrations applied for short periods allow for increased gains in maximal strength and flexibility (V. B. Issurin, D. G. Liebermann & G. Tenenbaum, 1994). In more recent publications it has been found out that local vibration increases the metabolic and anabolic response to the resistance training, without changing the training volume (Couto B. P. et al., 2013). It has been shown that acute intermittent vibration exercise can enhance repetitive horizontal jump distance and velocity. Acute intermittent vibration exercise may be used as an additional method for warm-up intervention to increase explosive power performance (Cochrane D. J. and Booker H., 2014). Goebel R.T, with colleagues proves, that segment-body vibrations applied in resistance training can offer an effective tool to increase maximum isometric force, compared to traditional training (Goebel R. T. et al., 2015). The same group of scientists report that combined intervention of strength training and local vibration improves isometric maximum force of arm flexor muscles (Goebel R. et al., 2016). Whole body vibrations decreased pulsatility index in the popliteal artery after maximal exercise and was effective to increase performance in a later exercise test-to-exhaustion (Sanudo B. et. al., 2016). The addition of indirect sinusoidal vibrations during exercise induced increases in the rate of force development (explosive strength), without affecting the peak force (maximal strength) and the ability to sustain strength production (de Paula L. et al., 2017).

While majority of these investigations is aimed at force training it would be interesting to investigate the effect of influence of continuous vibrations upon performance of cycle origin aimed at endurance training. To implement this idea we used the specially designed device «Spedox» produced by "Chen Beitar Hashkaot LTD" company from Israel.

Research Design and Methods. We have studied the influence of Spedox on the level of athletes and healthy people performance. Three test protocols have been used – A, B and C. The aim of A test was to study the Spedox effect on the running the short distance with maximal speed. The protocol started with 2 km running warm-up followed by 600 m maximal speed run. After the 2, 5 and 10 minutes of rest the capillary blood was sampled. Lactate concentration was determined by Accutrend plus lactate meter. The A1 test was performed without any devices, in A2 test participants wore Spedox™ TechVibe™ ("Spedox") system during and after the test, in A3 test they wore a regular vibrating system without the original techvibe system technology but with the exact same look of the Spedox device ("faкe Spedox"). Running with moderate speed till exhaustion was tested according to B protocol. During the B test participants performed run at stadium track until exhaustion without any devices (test B 1, control) or with Spedox (test B 2). Spedox's effect on muscle maximal strength and flexibility was studied by sled leg press (test C). Participants pressed the weight of 80 % from the individual maximum until exhaustion. The C 1 test was performed without Spedox, while the Spedox system was used by participants during the test and 5 min of rest period in C 2 test.

Participants in groups M1, F1 and M2 were trained athletes (middle-distance runners). The group M3 participants were physically fit, recreational runners with 2–3 training sessions per week. Participants of M4 group were healthy subjects, amateur level football players (Table 1).

All the participants were informed about the aim and methodology of the study and they volunteered to participate in it. Informed consent was obtained. This study was approved by ethics committee of the Lviv State University of Physical Culture. All procedures accorded with the principles of the Code of Ethics of the World Medical Association (Declaration of Helsinki).

Table 1

The description of the test participant's groups

Group	n	Sex	Age, years	Qualification	Test
M1	8	male	18–20	CM–MS	A1–A3
F1	4	female	18–20	CM–MS	A1–A3
M2	8	male	18–20	CM–MS	B 1, B 2
M3	7	male	18–20	RR	B 1, B 2
M4	10	male	18–20	AFP	C 1, C 2

Footnotes: MS – master of sport; CM – candidate master; RR – recreational runners, AFP – amateur football players.

A statistical analysis of the results was carried out by means of SPSS 11.0. All values are given as mean M±m (standard error of the mean). Difference between groups was analyzed by paired Wilcoxon test. Changes with P≤0.05 were considered to be significant.

Results and Discussion. While carrying out the research, it was found that in A1 test the representatives of the M1 group overcame the 600 meter distance at 124.50±4.41 s. The average run speed was 4.85±0.14 m/s (Fig. 1). In group F1, the time of overcoming the same distance was 139.00±4.06 s, and the average speed was 4.33±0.13 m/s. Differences between groups did not reach a statistically significant level.

In the A2 test, under the influence of the Spedox system, we identified some differences in the

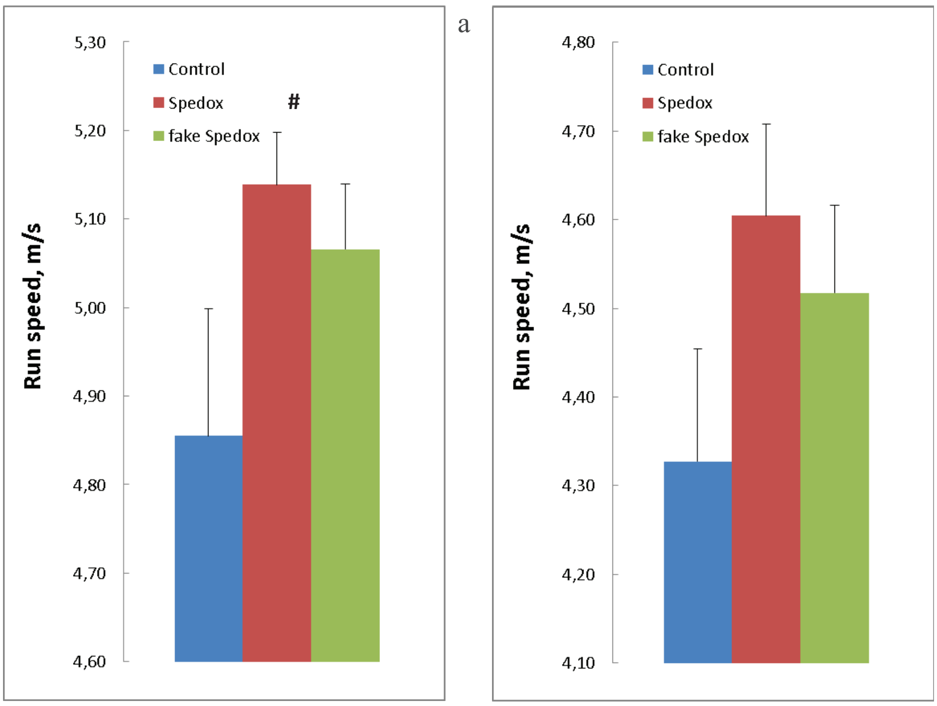

***Fig. 1.** Influence of the Spedox on the results of running for a distance of 600 m by athletes of groups M1 and F1. The data of group M1 are displayed on inset a, group F1 – on inset b. The blue columns show the result of A1 test (control level), the reds are the results of A2 test (effect of Spedox), and the results of A3 test are green (fake Spedox). Indication of the difference in reliability with the control level: # – p <0.05.*

results of the 600 m run (Fig. 1a). Thus, in the M1 group, time to overcome the distance decreased to 116.88±1.38 s ($p<0.05$), and the speed of overcoming the distance increased to 5.14±0.06 m/s ($p<0.05$). The obtained data point to an increase of 6.4 % of the athletes' endurance indices under the influence of Spedox. Although the average run speed using the Spedox reached 4.60±0.10 m/s in the F1 group (106.48±1.19 % compared with the control), and each of the athletes displayed the result improvement by 3–8 %, however, the statistical significance of the changes is insufficient ($p=0.068$). Consequently, it can be argued only about the tendency to speed endurance improvement in a group of athletes in terms of Spedox application.

Under the conditions of the fake Spedox application in A3 test (Fig. 1b) the average speed recorded was 5.07±0.07 m/s in the M1 group during the overcoming the 600 m distance, and 4.52±0.10 m/s in the group F1. Both of these values are not significantly different from the control level, though in the M1 group, there is a tendency to improve the result ($p=0.063$). The obtained results point to the absence or much less effectiveness of the regular vibrating system (fake Spedox) effect on the athletes' speed endurance indices.

The analysis of the Spedox effect on the athletes' endurance indices was based on the determination of the maximum time and run-to-failure distance (test B). It was established that the time of run without the Spedox application ranged from 46 minutes to 58 minutes in the group of male athletes (group M2). At the same time, they overcame the distance from 10.8 to 14.4 km with an average speed of 3.78±0.16 m/s (Fig. 2).

With the Spedox application, the athletes' time of run was from 44 minutes up to 1 hour and 3 minutes. Although the average value of this index was 102.48 % of the initial level, these changes do not reach the level of statistical reliability. Using the Spedox while running, the distance was increased to 11.84±0.87 km ($p<0.05$), i. e. by 3.97 % (Fig. 2). The average speed of run with the Spedox application did not significantly change and was 3.85±0.18 m/s. Thus, the results obtained indicate the improvement of individual manifestations of endurance (distance overcome) for athletes in terms of the Spedox application.

The evaluation of the Spedox effect on the endurance indices was also done for the group of recreational runners (Fig. 3). In the absence of the Spedox influence, the representatives of this group overcame the distance from 1600 to 2225 meters, running in average 2.75–2.81 meters per second (group M3, test B 1).

During re-run, untrained people of the M3 group used Spedox. A comparative analysis of data shows

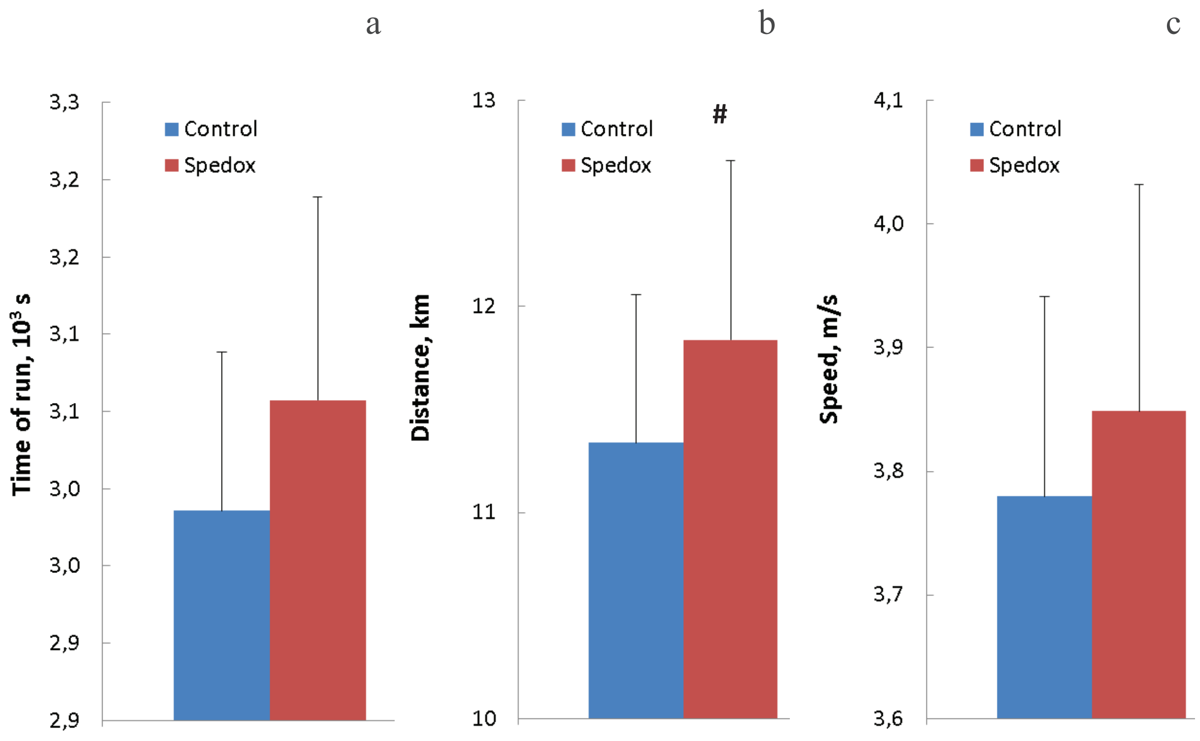

Fig. 2. *The effect of the Spedox on the results of run-to-failure of athletes in the group M2. The insets show the average values of such indices – time of run a, distance b, average run speed c. The blue columns mark a control level (B1 test), while reds are the effect of the Spedox (B2 test). Indication of the difference in reliability with the control level: # – p<0.05.*

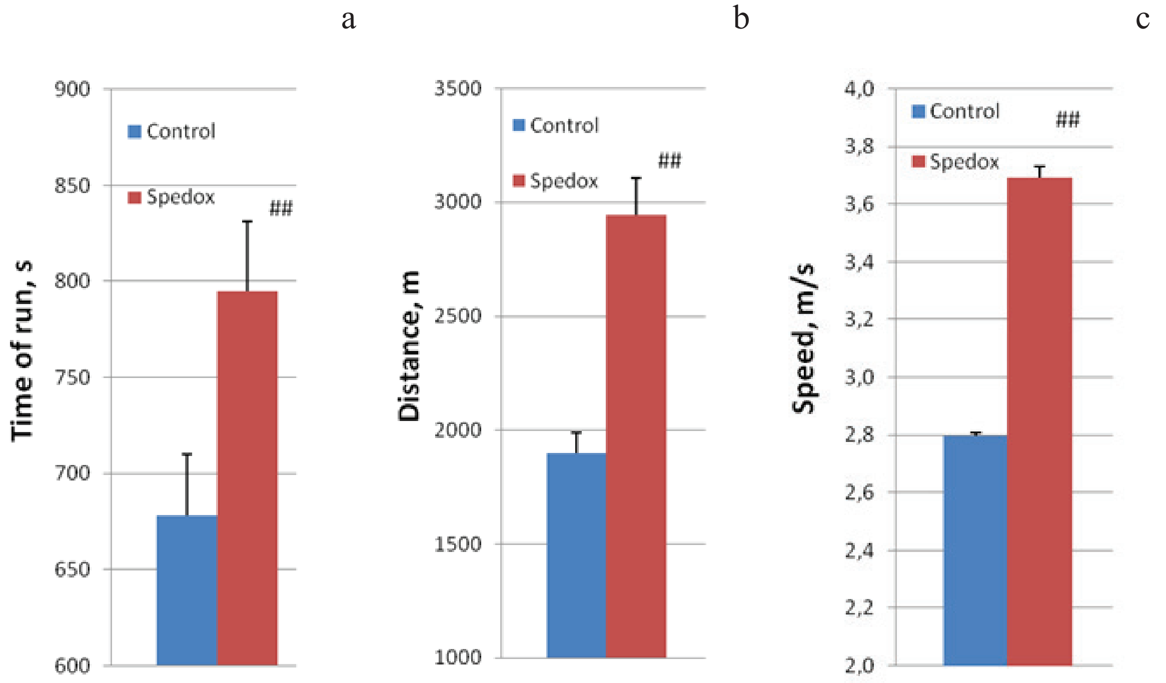

Fig. 3. *Influence of the Spedox on the run-to-failure results of the representatives of the recreational runners of M3 group. The insets show the average values of such indices – time of run a, distance b, average run speed c. The blue columns mark a control level (B1 test), reds are the effect of the Spedox (B2 test). Indication of the difference with the control level: ## – p <0.01.*

that the time of run increased by 17.4% (p<0.01), and the speed increased by 31.9% (p<0.01). The largest changes were found for the indices during the race which increased by 55.0% (p<0.01). Consequently, the Spedox application for recreational runners during the run-to-failure leads to a significant improvement of performance level. A similar, but much less pronounced tendency was observed in the group of athletes (see Figure 2). The obtained data testify to the considerable efficiency of the Spedox for improving the endurance indices of people performing running loads.

The effect of Spedox on the lactic acid build up in the professional athletes was studied with the use of A1–A3 protocols with the next blood samples analysis (Fig. 4). The gradual decrease of lactic acid concentration during the rest period from the 12.76–13.25 mM at the 2 min of rest to the 10.07–8.12 mM at the 10 min of rest was found. Significant effect of Spedox was shown at the 10 min of recovery. At that point the lactic concentration in the blood of athletes was by 15.4–18.6% lower (p<0.05) during Spedox application (A2 test) in comparison to control (A2 test) and fake Spedox application (A3 test).

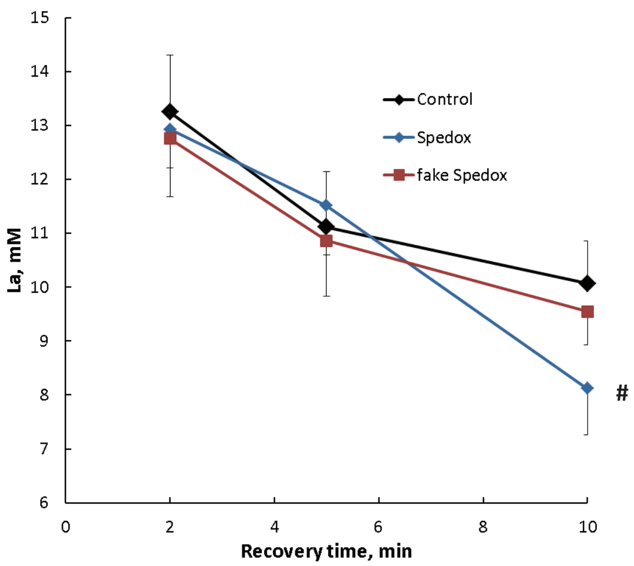

Fig. 4. *The effects of Spedox on the lactic acid build up after the intensive running in the group of professional athletes. Black line – control (test A1), blue line – Spedox effect (test A2), red line – fake Spedox effect (test A3). Indication of the difference with the control level: # – p<0.05.*

According to the data of Table 2, the Spedox usage significantly reduced the level of shin muscles pain after the intensive run in A2 test (in comparison to the control level, obtained in A1 test). The possible reason for this may be the faster lactic acid breakdown during the recovery period.

The results of sled leg press (test C) revealed the significant effect of Spedox on the muscle maximal strength and flexibility. In control (C 1 test) the average load in test was 123,00±8,70 kg, number of repetitions – 32,50±3,96 (Fig. 5). During the C 2 test, when participants used Spedox, the average load increased to 136,50±8,30 kg ($p<0.05$) and number of repetition increased to 37,50±4.19 ($p<0.01$).

Table 2

The level of shin muscles pain (points in numeric rating scale) during the recovery period after the A1 and A2 tests

Test	Recovery period, min					
	2	5	10	30	60	120
A1 (control)	5.92 ± 0.34	4.17 ± 0.32	2.67 ± 0.22	3.00 ± 0.37	4.67 ± 0.53	4.00 ± 0.44
A2 (Spedox)	3.33 ± 0.22 ##	2.00 ± 0.17 ##	0.83 ± 0.24 ##	0.75 ± 0.22 ##	1.08 ± 0.29 ##	0.67 ± 0.19 ##

Footnotes: 0 points – no pain; 10 points – worst pain; indication of the difference with the control level: ## – p <0.01.

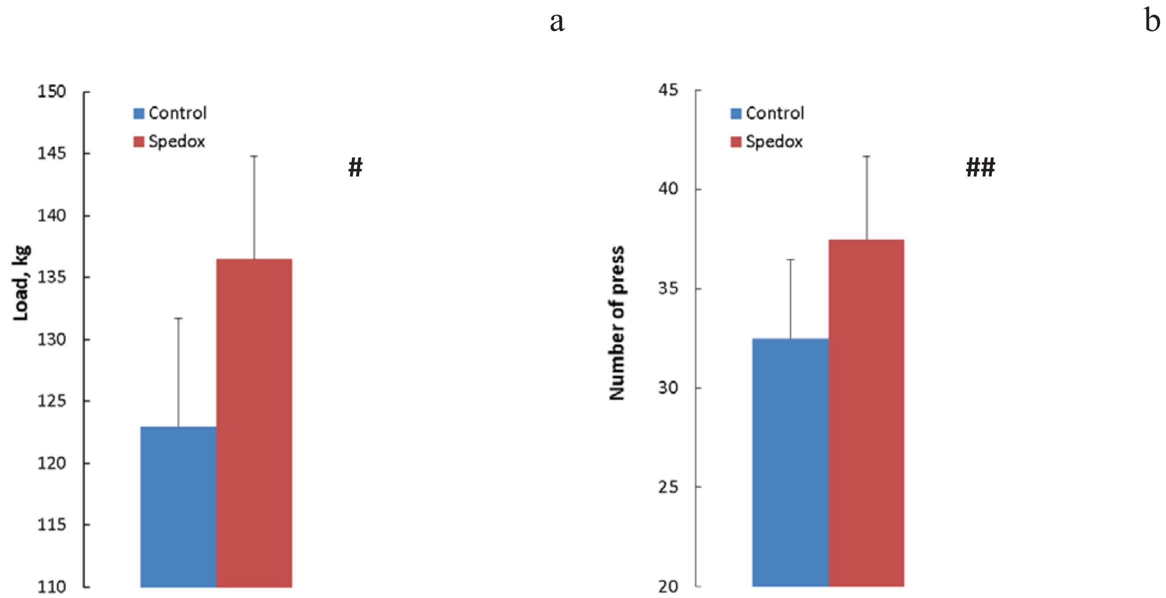

Fig. *5. Results of sled leg press in M4 group (amateur football players). The insets show the average values of such indices – average load a, number of repetitions b. Blue bars – control (test C1), red bars – Spedox effect (test C2). Indication of the difference with the control level: # – p <0.05, ## – p <0.01.*

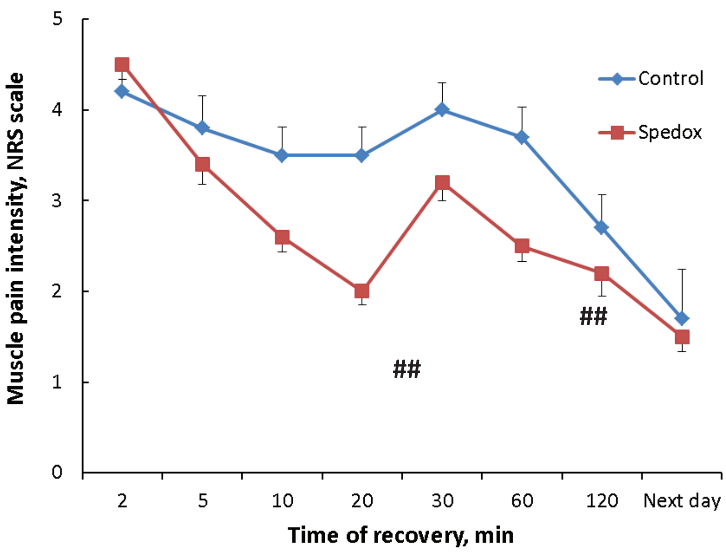

Fig. 6. *The effect of Spedox on the muscle pain intensity after the sled leg press (C test protocol). Blue line – control (test C1), red line – Spedox effect (C2). Indication of the difference with the control level: ## – p <0.01.*

The increase in muscle maximal strength in the case of Spedox application was associated with the acceleration of the muscle recovery processes. We can suppose that on the basis of data from Figure 6, on which the data of muscle pain estimation by the numerical rating scale (NRS) after the sled leg press was shown. In the case of Spedox application (C 2 test) the pain was substantially lower at the 20 and 60 minutes of recovery ($p < 0.01$), and tendency was revealed at 10 and 30 minutes ($p = 0.09$) in comparison to control level.

The participants of the experiment point to a high level of comfort while using the Spedox (Figure 7). In particular, the general level of comfort during the main mode of work sportsmen rated at 7.63±1.18 points, and sportswomen – at 7.50±1.50 points.

When performing running exercises, the level of comfort rating was slightly lower than that of male athletes (5.25 points, p = 0.21–0.07), and at female athletes (5.25–5.75, p = 0.20–0.46), although there was no significant difference in comparison with the rest level. General feelings during restoration period were evaluated by male athletes at 6.88±1.42 points, and female athletes – at 5.25±2.06 points. The comfort of using the device on the leg was highly appreciated by male athletes (7.13±1.60 points), and at a slightly lower level by female athletes (5.75±1.44 points). Average values of subjective evaluation of the comfort level of the Spedox application in the simulation mode by male athletes were not significantly different from the previous estimates ($p > 0.05$). Similar results were obtained for female athletes.

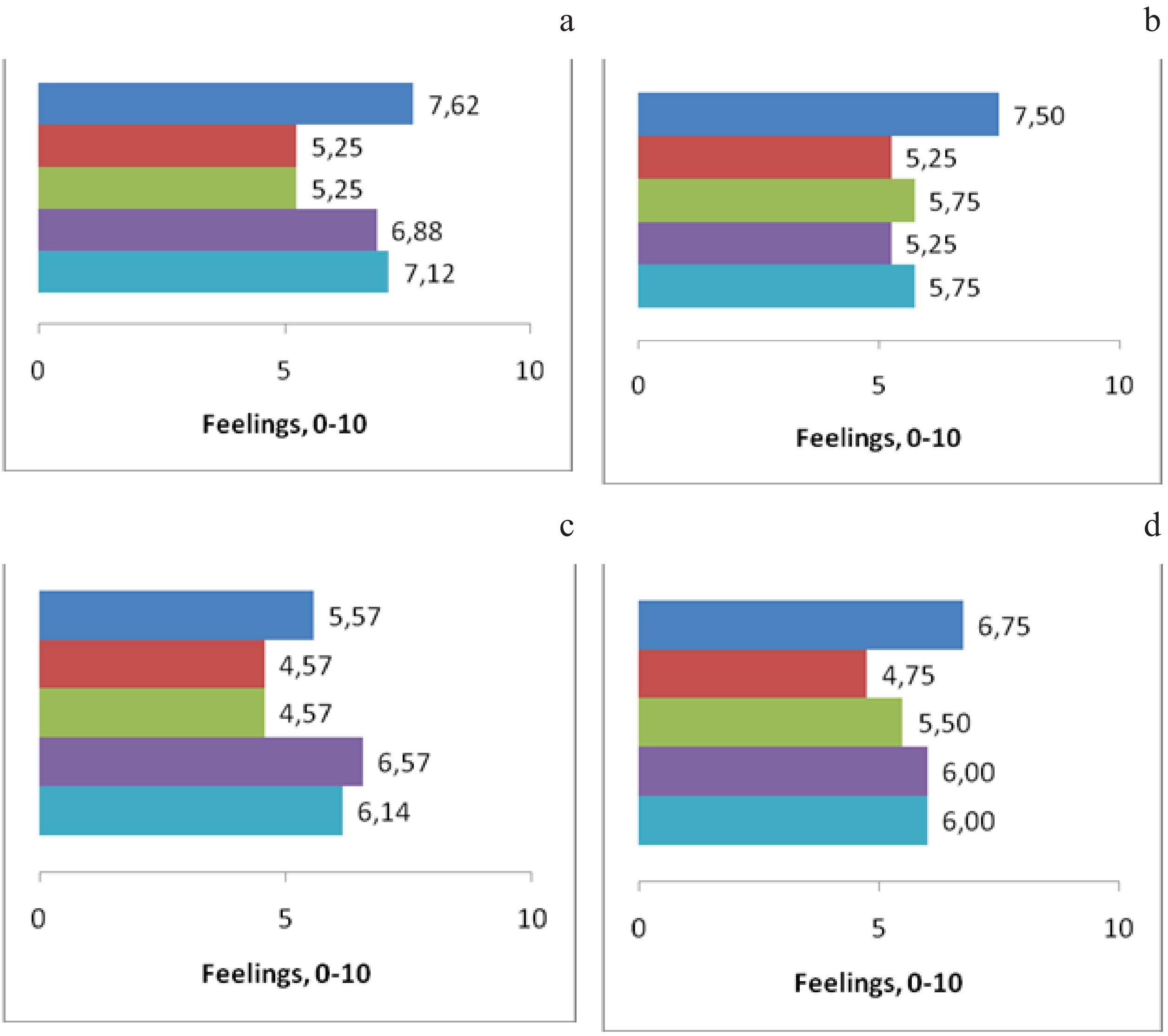

Fig. 7. *Estimation of the comfort while using the Spedox by athletes of groups M1 a, b and F1 c, d. Data obtained by questionnaire when using the Spedox (insets a, b) and fake Spedox (insets c, d). The level of comfort was assessed in points in the following states: blue – the general level of comfort; red – during 2 km run; green – during 600 m run; violet – during the period of restoration; blue – the comfort of using the device on the leg.*

Conclusions. The obtained data point to the highly trained sportsmen's endurance indices improvement by 6.4 % ($p<0.05$) under the Spedox influence, Improvement of certain manifestations of endurance (increase of the overcome distance run-to-failure by 3.97 %, $p<0.05$) with the Spedox application also revealed. And a similar tendency can be observed in the highly trained sportswomen group (6.5 %, $p=0.068$), all in comparison to control level. The reliable influence of the Spedox simulated mode of operation on the sportsmen's speed endurance indices was not revealed.

The healthy untrained persons displayed the improvement of all the main indices of run-to-failure: duration (by 17.4 %, $p<0.01$), speed (by 31.9 %, $p<0.01$) and distance overcome (by 55.0 %, $p<0.01$), in comparison to control level. This indicates the considerable effectiveness of the Spedox for improving the manifestation of the untrained people's endurance during their running loads.

Significant effect of Spedox on the time course of lactic acid decrease at the 10 min of recovery period after the intensive run was found. At that point the lactic concentration in the blood of athletes was by 15.4–18.6 % lower ($p<0.05$) during Spedox application in comparison to control and fake Spedox application. This indicates the Spedox effect on the facilitating the flushing of the lactic acid.

The improvement of maximal load (by 10 %, $p<0.05$) and number of repetitions (by 15 %, $p<0.01$) in sled leg press after the test was revealed in the case of Spedox usage. This indicates the Spedox effect on the muscle maximal strength, reduce of muscle fatigue (estimating by numerical rating scale (NRS)), and reduce time for muscle recovery in comparison to control.

The analysis of the point estimation of feelings that arose when using the Spedox in different modes indicates a high level of comfort while using the device.

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