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Wykorzystanie głębokiej oscylacji i elekrostymulacji mięśni gładkich w niwelowaniu wybranych parametrów zmęczenia mięśniowego

Application of Deep Oscillation and Electric Stimulation in Smooth Muscles to Minimize the Selected Parameters of Muscular Fatigue

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Streszczenie

W literaturze naukowej obserwujemy wzrost zainteresowania metodami, których celem jest aktywacja pracy układu limfatycznego oraz mikrokrążenia, a co za tym idzie – wpływ różnych bodźców na układ immunologiczny. Niestety, nadal są to doniesienia nieliczne. Nie jest poznana kwestia wpływu metod stymulujących limfangiomotorykę jakimi są głęboka oscylacja oraz elektrostymulacja typu bodyflow na napięcie mięśniowe i ból mięśniowy. Medycyna fizykalna, w zakresie wpływu stymulacyjnego na procesy regeneracji tkanek, jest na uprzywilejowanej pozycji w stosunku do manualnych metod, wykorzystuje bowiem własności elektryczne i magnetyczne związków organicznych.
Bagatelizowanie fizjologicznych wskaźników przeciążenia, takich jak zmęczenie, zaburzone napięcie mięśniowe czy ból mięśniowy, zdecydowały o tym, że urazy wynikające z przeciążenia przybrały rozmiar epidemii. Metody i środki fizjoterapeutyczne, by sprostać nowym wyzwaniom stale ewoluują stając się nieodzownym elementem periodyzacji treningu i fizjoterapii pourazowej.
Celem pracy była analiza wpływu innowacyjnych metod medycyny fizykalnej w postaci elektrostymulacji mięśni gładkich (Bodyflow) oraz drenażu głęboką oscylacją (Deep Oscylation) na zjawisko bólu mięśniowego i zaburzenia napięcia mięśniowego. Badaniem zostało objętych 60 mężczyzn trenujących mieszane sztuki (ang. mixed martial arts – MMA) walki w wieku 18-35 lat.
Zastosowanie fizykalnych metod drenażu limfatycznego w postaci bodyflow oraz głębokiej oscylacji w procesie wyrównywania zmian w tkance mięśniowej związanych z bólem i napięciem mięśniowym poprzez stymulowanie mikrokrążenia, wydaje się być w świetle przedstawionych wyników badań skuteczną metodą.

Słowa kluczowe:

głęboka oscylacja, elektrostymualcja mięśni gładkich, mikrokrążenie, zmęczenie mięśniowe

Abstract

In the scientific literature on the subject, we observe an increased interest in the treatment techniques, which target the activation of lymphatic system and microcirculation, and hence the impact of different stimuli on the immune system. Unfortunately, the reports are still rather scarce. Not very well researched is the impact of the techniques stimulating lymphatic motoricity, such as deep oscillation and electric stimulation of the body flow type, on the muscle tension and the muscle pain. Physical medicine, in the area of stimuli impact on the processes of tissue regeneration, has an advantage over the manual techniques, as it utilizes the electrical and magnetic properties of the organic compounds.
Underestimation of physiological indicators of muscles overload, such as fatigue, impaired muscle tone or muscle pain, has caused the number of injuries resulting from muscles overload raise to quite epidemic proportions. The methods and means of physiotherapy, in order to face the new challenges, are constantly evolving and have become an indispensable part of the periodization training and post traumatic physiotherapy treatment.
The aim of this study has been to analyze the impact of the innovative methods of physical medicine, such as smooth muscles electrical stimulation (Body Flow) and deep oscillation drainage (Deep Oscillation), on the phenomena of muscle pain and abnormal muscle tone. In the study participated 60 male subjects, engaged in training of the Mixed Martial Arts (MMA), 18-35 years old.
The use of physical methods of lymphatic drainage, such as the body flow and the deep oscillation, in the process of rebalancing – through the stimulation of microcirculation – of the changes in the muscle tissue associated with pain and muscle tension, appears to be effective in light of the test results presented in the study.

Key words:

deep oscillation, smooth muscles electric stimulation, microcirculation, muscular fatigue

Introduction

In the scientific literature on the subject, we observe an increased interest in the treatment techniques, which target the activation of lymphatic system and microcirculation, and hence the impact of different stimuli on the immune system [1, 2]. Unfortunately, the reports are still rather scarce [3]. Physical medicine, in the area of stimuli impact on the processes of tissue regeneration, has an advantage over the manual techniques, as it utilizes the electrical and magnetic properties of the organic compounds. The human body is not only a chemical system, controlled by the enzymes and the related electrochemical phenomena, such as the ion transport, but also is a system of the electrodynamic, photodynamic and the acoustics-dynamic nature [4].

Characteristics of the life and regeneration processes in the human organism are much more complex and richer, than it had been thought when it was being described in the biochemical models. Biological mass may be electrically active also by means other than the chemical reactions. The proteins are semiconductors, and thanks to it they can activate the electric charges with no chemical changes, mainly the delocalized electrons. In addition, the muscle tissue, proteins, amino acids, DNA and RNA, involved in a movement, are prone to the electromechanical effect, the "Piezoelectric effect," that is they polarize electrically, and in the variable electric fields they vibrate or oscillate with the frequency of the applied field [4]. This effect may be observed during the deep oscillation stimulation. The piezoelectric effect in crystal, discovered in 1880 by Pierre and Jacques Curie, has also been found, by other researches, in collagen – which in its structure is similar to crystal. The deformations of its fibers generate potential differences. Probably such deformation produces a piezoelectric micro-current, which affects the transportation of particles, including the markers of the muscular fatigue [5].

Even though electricity applied in medicine is probably the oldest, documented method of physical treatment, dating far back to the ancient times, it still undergoes modifications within the applied electrical current parameters, depending on the type of tissue on which the current is to operate. The real breakthrough in this area appears to have been the discovery, and the attention of the world of science, drawn to the alternating current – all done by N. Tesla [6].

The electrical current generated by the electric stimulation of the body flow type is the current of low frequency, 1.52 Hz, and recreates the information generated in the autonomous nervous system, transferred to the smooth muscles located between the electrodes, thus stimulating the natural peristalsis of the venous and lymphatic system. This is a monophasic, triangular wave current, with the duration of 2 or 5ms and the interval of 500ms (Fig. 1). Peristalsis is a cyclical contraction and expansion of smooth muscles, controlled by the sympathetic and parasympathetic nervous system. The methodology for application of the electrical BF (Body Flow) stimulation is nothing more than a selection of the electrical current parameters and the proper placement of the electrodes. The electrodes are always positioned on the skin that is dry and clean, and in the area of the main veins and lymph vessels, along the

direction of the flow (Fig. 2). The electrical current amperage is set to the first visible minimal contraction of the muscles, and then lowered by 1mA to the individual value. If so prescribed, the electric stimulation may be applied together with the contraction of striated muscles, thus achieving the kind of electro exercises for both, the smooth and the striated muscle tissue. The advantage of the body flow electric stimulation, is the ability of the patient to apply the treatment on his/her own, as instructed, which contributes to the therapy efficiency – through the more frequent applications (3-5 times a day). In addition, the therapy is well tolerated by patients and does not cause any skin burning sensation.

The basic contraindications for the body flow therapy include: implanted cardioverter defibrillator (ICD) and other electronic implants, vascular thrombosis, vascular malformation, pregnancy, cancer dispersion. In addition, the vacuum electrodes should not be placed in the areas with significant varicose veins, superficial veins, damaged continuity of the skin surface. The indications for the therapy application are: lymphatic and venous edemas, post-traumatic exudates, post exertional muscle regeneration processes, sports injuries, acute muscle pain syndromes, and DOMS (Delayed Onset Muscle Soreness), degenerative changes in the joints, chronic wounds (particularly in the course of venous insufficiency and diabetic foot).

Fig. 1. Device for the body flow electric stimulation

Fig. 2. Example of placement of the electrodes on the lower limbs

Deep oscillation (DO) is a relatively "young" method of therapy. Works on the device for the DO therapy go back to the 1980s. In the deep oscillation system, developed under the leadership of Seidel and Walder [7], through the therapist hands movements, while applying the appropriate pressure, the rhythmic and deeply penetrating tissue deformations take place, which are perceived as pumping or vibrating. The whole structure of tissues is being raised and lowered up to 250 times per second. The voltage is 500V, but the amperage remains within a few microamperes. At the present time, the treatment is usually applied with the new type of the devices, equipped with a special head, which obviously excludes the manual application. In this procedure, the insulation constitutes a very poorly conductive capacitor surface. At the same time, thanks to the active electrical discharge on the device, there is no dangers of electrifying of the patient or the therapist (Fig. 3, 4).
The therapy, in terms of methodology, is performed in accordance with the principles of the lymphatic drainage, according to doctor Asdonk. The DO method is an effective physiotherapy tool, because if such intense vibrations take place within the body, then interference of these stimuli with the subcutaneous tissue is possible, and through this – mechanical stimulation of the muscle tissue of the lymphatic vessels, which causes the improvement of the lymph flow. There also occurs the ion transport, due to external application of the electric field.

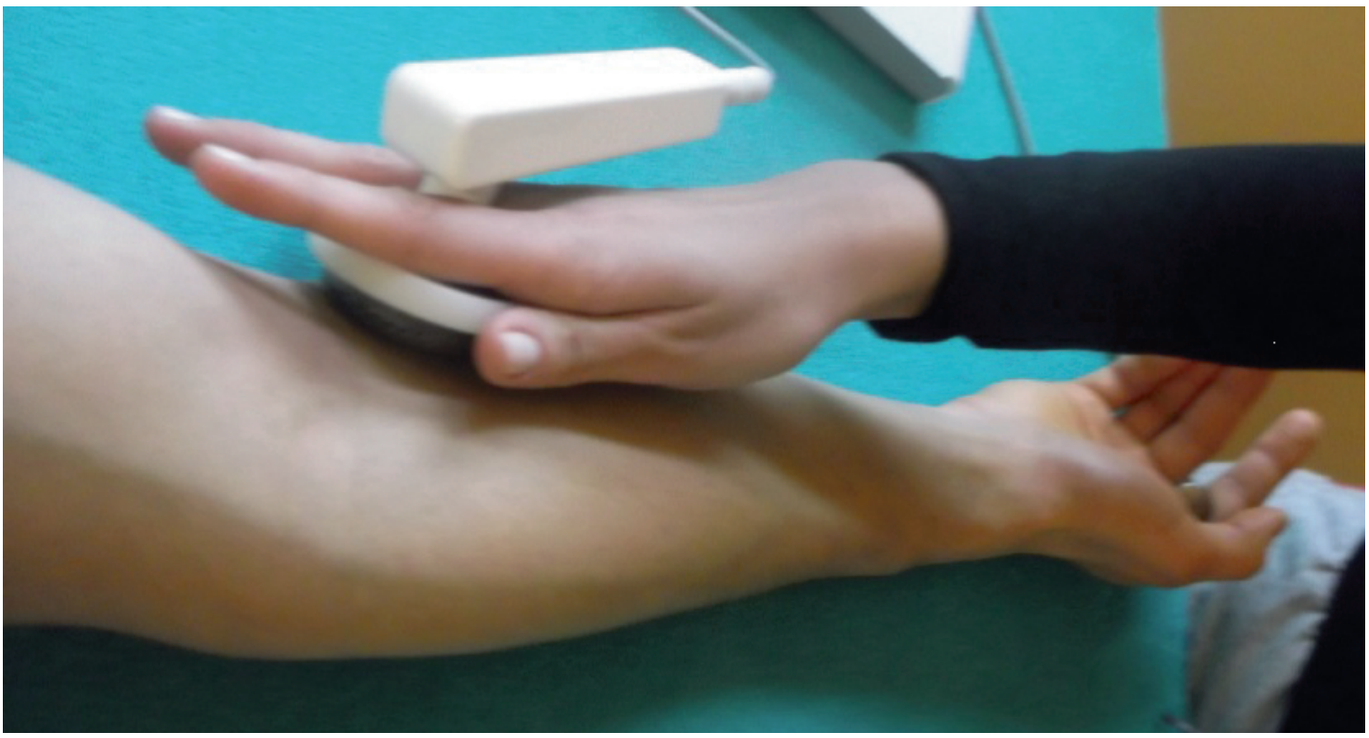

Fig. 3. Application of deep oscillation therapy

Fig. 4. Current version of device for deep oscillation therapy

The electricity related phenomena, used in the deep oscillation system, are the electrostatic influence and the Johnson-Rahbek effect. Crucial for the deep oscillation therapy is the Johnson-Rahbek effect, which describes the creation of an electrostatic force, when electrical current goes through a plate made of a semiconductor (e.g. slate plate), which is being placed between the electrodes and causes creation of a strong drawing force between these electrodes. If this force connects with a semiconductor layer and a weak electrostatic field, there is the possibility to apply this force, in compensated form, to human tissue [8, 9].

This model describes the drawing forces between the connected materials, as the result of electrical voltage applied between them. This takes into account the existence of surface irregularities, and is being accomplished through the assessment of the effect of field emission on the electrostatic forces between the adjoining surfaces. The surface of a solid, in a submicroscopic scale, is very uneven. Since the actual contact surface is very small, as opposed to the visible contact surface, the electrical resistance of the contact zone is high. This, on the most of the semiconductor's surface, creates the electrical charge in the form of a drawing force, which is being applied to human tissue (Fig. 5).

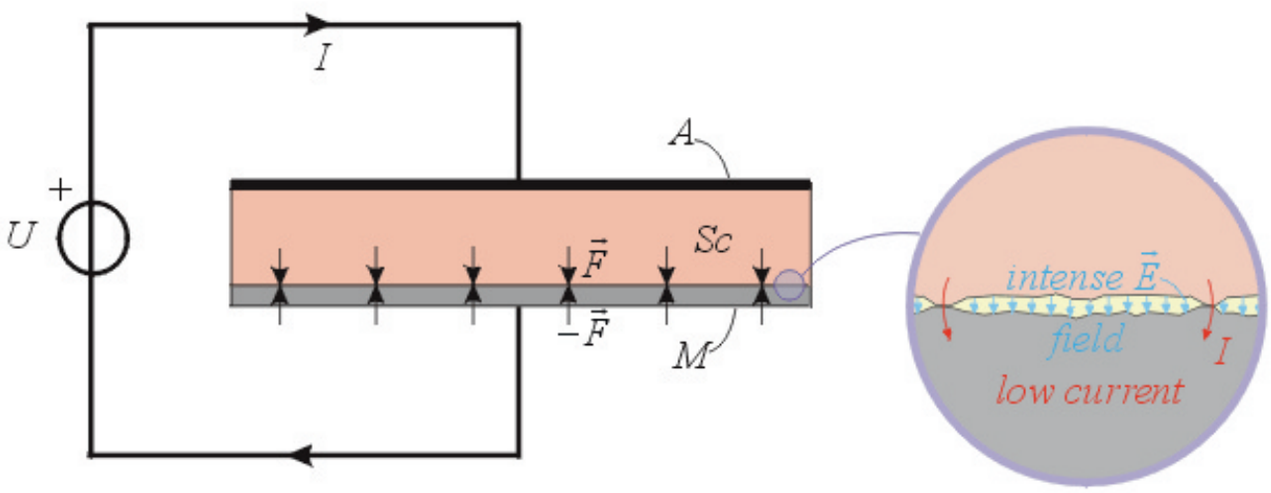

Fig. 5. Diagram of the Johnson-Rahbek effect. The surfaces (A and M) stick to each other with immense force, because the plates are joint in a few points, so through those "connecting points" only a very weak electrical current goes. Between the electrodes, there occurs a microscopic air gap, and the strong electrical field creates an enormous drawing force

DEEP OSCILATION® causes [10, 11]: eradication of the pain resulting from an injury, improvement of immunological regulations in the inflammation area (ratio of monocytes, lymphocytes T), improvement of the lymphatic drainage vessels, activation of fibroblasts through the – created by the DO treatment – variable pressure, stretching and the electrostatic field force, quicker movement through the lymphatic system of the exudate, which tends to inhibit the wound granulation because of its cytokines – destroying the extracellular matrix, regulation of the cells' proteases activity – destruction of the extracellular matrix by the uncontrolled release of proteases is the main factor that prevents complicated wounds from healing, acceleration of the transition of the wound healing process from the inflammation to the recreation phase, subsequent proper dressing of the wound, with the immunological consequence (improving the phagocytosis), relaxation of the inter-section and intramuscular connective fascia anastomosis – anti adhesion function, transfer of the intracellular space fluids, including their components (protein,

cell decomposition products, neurotransmitters, etc.), painless tissues mobilization, through the variable raising of their layers. Application of the DO system: treatment of edema, pain therapy, healing of wounds (including open ones), treatment of respiratory diseases, biological renewal treatment. Contraindications for the DO therapy application [10]: acute venous thromboembolism, electronic implants, like pacemaker for example.

Aim of the Study

The aim of this study has been to analyze the impact of the electric stimulation of smooth muscles (Body Flow) and of the lymphatic drainage with the deep oscillation (Deep Oscillation), on the muscles pain and muscle tension.

Materials and Methods

In the study participated 60 male subjects, engaged in training of the
Mixed Martial Arts (MMA), 18-35 years old. The participating athletes were qualified at random, from the sports clubs of the Silesian Voivodeship. Study participants were divided into the following groups:

- electric stimulation with the body flow technique (BF),
- deep oscillation technique (DO),
- control group (placebo effect – P).

Prior to the tests, the sportsmen had been subjected to an assessment of their body composition, by means of the Bioelectrical Impedance Analysis – BIA. Examinations and tests have been carried out by the qualified medical personnel, including: physician, nurse, physiotherapists, laboratory specialists. The study had been conducted in the period from January to June 2014, in the Provita Rehabilitation Clinic, in Żory. For the implementation of the study, proper consent has been obtained from the Bioethics Commission of the Academy of Physical Education, in Katowice. The studied groups, due to the specific variables, have been described on the basis of age and their somatic features. We have also performed a significance of differences test, in the form of one-way analysis of variance, based on the somatic build parameters. No significant differences have been found for the mean value, between the control group (placebo-P) and the test groups DO (Deep Oscillation) and BF (Body Flow), Exclusion criteria included: persons not physically active, with damages of the skin continuity at the place of the PMD (Physical Method of Drainage) application, with active inflammatory disease of various etiology, with the current injury of the musculoskeletal system or another condition, which precluded training during research (ruptures, strains, bruises with hemorrhage within the muscle-tendon structures, fractures and cracks within the skeletal system, insufficiency in the circulatory, respiratory and internal organs), taking of medications or illegal substances improving the physical performance, which could affect the variables, analyzed in the tests. Prior to our research, we have assessed the effect of the physical methods of lymphatic drainage on the microcirculation and venous circulation, in the superficial system of the forearms. Using the laser Doppler velocimetry, we have recorded the wave reflected from red corpuscles, in the forearm skin tissue volume of 1mm3 and depth of 2.5mm. The

laser velocimetry method, due to its repeatability, significant sensitivity and non-invasive character, allows the precise assessment of the reaction of microcirculation in response to the specified physical stimulus. It should however be stressed, that we employ in this case the relative unit, that is the Perfusion Unit (PU). We have established the beneficial effects of the physical methods of the lymphatic drainage, in the area of the superficial venous outflow as well as the transcutaneous perfusion. We have also observed the increase of the flow velocity in the cephalic vein and the increased perfusion unit (PU), in relation to the rest flow values. Particularly important seems the increased, by almost 900 percent, perfusion – during the deep oscillation stimulation (Table 1.) the assessment is comparative only, and does not have reference values [12].

Table 1. Comparison of reactions of circulation and microcirculation

Rodzaj metody Type of method	Prędkość przepływu w żyle odpromieniowej (cm/s)	Cephalic vein flow velocity (cm/s Wskaźnik perfuzji (PU)
Rest flow	15.57	11.8
Deep oscillation	26.89	108
Body flow electric stimulation	23.60	25.6

All the study participants had been examined over the three subsequent days, while the fatigue test had been performed only on the first day of the research. The examinations have been carried out after a period of a night rest, 2 hours after the last meal and not earlier than 48 hours after a physical workout. Before proceeding with the examinations, the tested men had not taken any substances, medications or drugs, which could have had an impact on the results of the examinations. After the fatigue test and taking the particular measurements, the athletes had undergone actual treatment, with application for 20 minutes of the physical methods for lymphatic drainage, in accordance with the sportsmen division into the groups. For the placebo group we had been switching on the light of a laser scanner, without applying any doses of the acoustic stimulant, so the subjects had been convinced, that they were undergoing a therapy, while in fact no stimuli had been applied to their tissue. To run the actual fatigue test, we have used the modified test described by Vigouroux & Quaine [13], based on maintaining the 5-seconds hand grip valued at the maximum strength at 60% kG (±10%), with the 2-seconds breaks in between, until the refusal to perform the task. The subjects have done the fatigue test in a sitting position, with the upper limb flexed in the shoulder joint at an angle of 90° (± 10°) and extended in the elbow joint, supported on the medical couch to eliminate the synergistic

fatigue of the shoulder girdle muscles. For the measurements, a manual hydraulic dynamometer made by Baseline® Evoluation Instruments (USA, 1993) had been used. In front of every examined man, a mirror had been placed, to achieve the biofeedback effect. Each of the participants was accompanied by an assistant, who controlled the time of the test and the value of the grip strength. The examined men had repeated the fatigue test 4 times only on the first day of our research. For all the participants we have analyzed the particular variables, in the following periods, while adopting the times of the measurement:

- rest value,
- post exercise (Post-ex.) value ,
- value after procedure, after 20min rec20min,
- after 24 hours – rec24h
- after 48 hours – rec48h

Analysis of the tension was based on the 8 thruts of the probe, weighing from 0.25 to 2kG, on the designated spot and for the specified in millimeters depth, and then programmatically calculating the so-called area under the curve (AUC), which is a conventional unit, being in fact the integrated value of tissues deformation curve, force applied by myotonometer times size of the displaced tissue (Fig. 6).

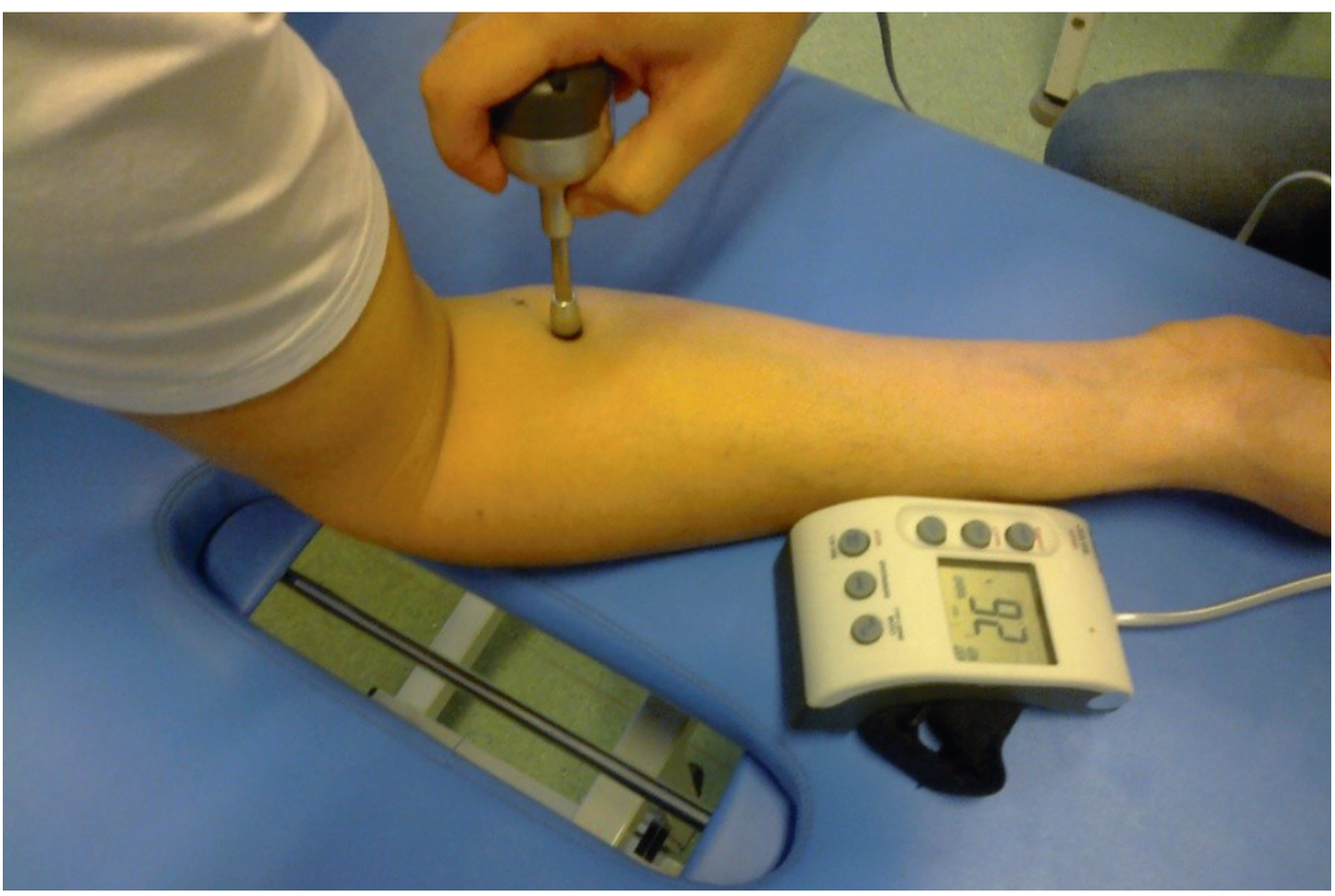

Fig. 6. Measurement of pain threshold (PT) with algometer

Research results have proven no statistically significant differences between the use of the myotonometric measurement method and the use of the surface electromyography method. For our study the myotonometer made by Neurogenic Technologies (USA 2010) had been used. Being significantly in correlation with the EMG results, and the non-invasive technique, the myotonometric method has been successfully adopted for the assessment of the muscle and subcutaneous tissue tension. The device used to assess the pain sensation has been the algometer, manufactured by the Medical Industries (USA 2011). Determination of the pressure pain threshold (PT) seems to be an objective attempt to assess the so-called rest pain threshold and its changes after the application of the therapeutic techniques, in this case the physical methods of the lymphatic drainage. An examined man had been subjected three times to the pressure test with the probe (the parameter was: r = 4mm) on the particular area of the tissue (in the plane of the palmaris longus muscle), which generated the compressive strength. The value of the strength (In kG or N) was digitally shown on the display with two decimal place accuracy, and calculated as the average of the 3 measurements (Fig. 7). In the case of too great deviations in the measured value, the device signaled the need to repeat the test. The pressure had been applied until the the examined man described the sensation caused by the stimulus as unpleasant. The higher the PT values the less pain experienced the tested person. All the measurements (PT, AUC) had been performed in accordance with the diagram.

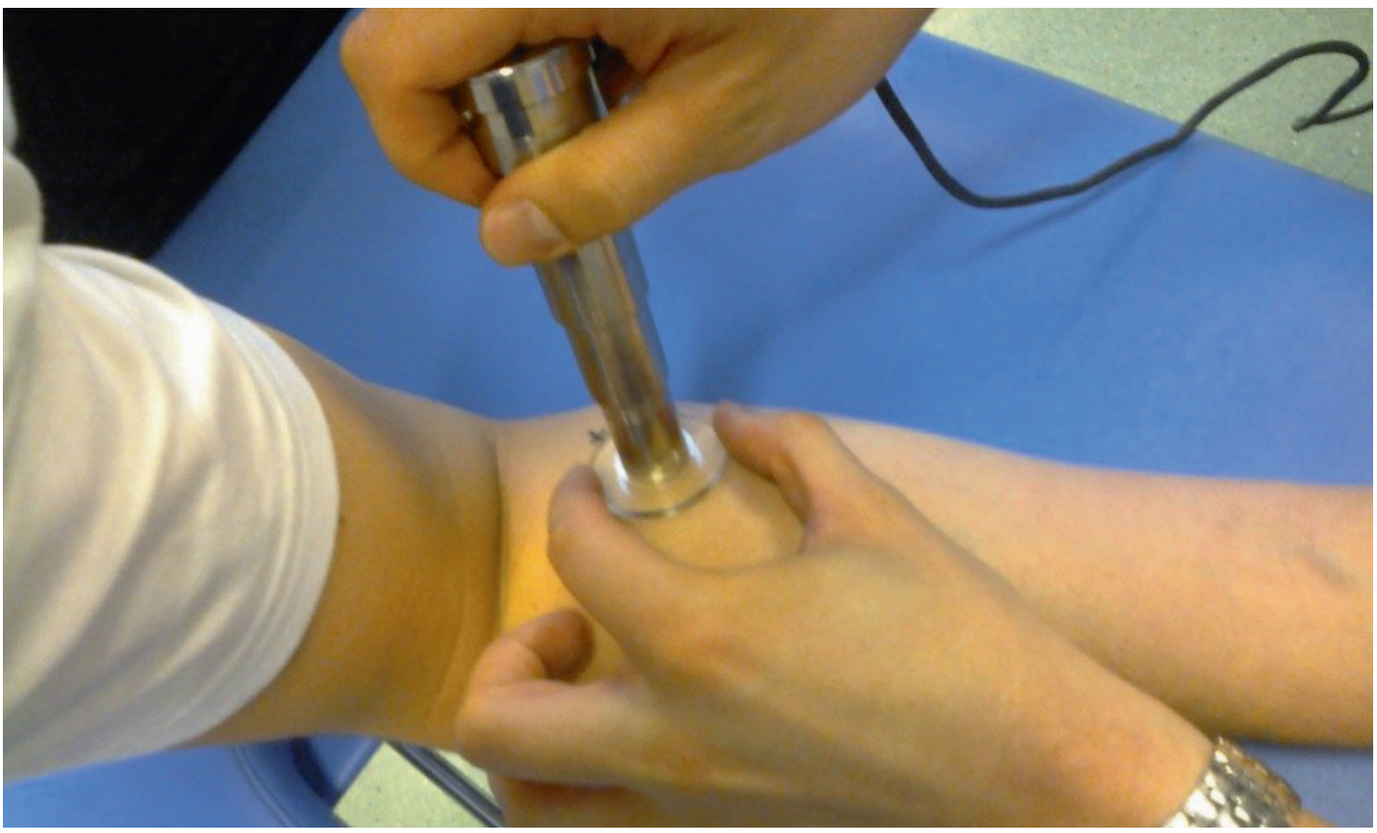

Fig. 7. Measurement of muscle tension with myotonometer

Statistical Analysis

In order to analyze the variables tested, the basic descriptive statistics have been calculated in the form of position and variability measurements, also verified has been the normality in frequentist statistics, with the Shapiro-Wilk test. To determine the significance of the differences for the mean values, the one-way analysis of variance and the variance analysis have been applied for the repeated measurements. Since the variance analysis yielded no indication, between which groups or tests there have been significant differences, in order to determine between which of them there were the actual significant differences, we have used the post-hoc, multiple comparisons Tukey's range test. The level of statistical significance has been set at: α=0.05. The research data have been processed using the statistical software package of Statistica ver. 10 by StatSoft company. To present the study results in the form graphic diagrams, we have used the Excel application of the Microsoft Office ver. 2010.

Results

Impact of the DO and BF methods on the pain threshold (PT). Muscle pain is an important factor affecting both, the nature of the physiotherapy treatment and the future physical performance of the patient.

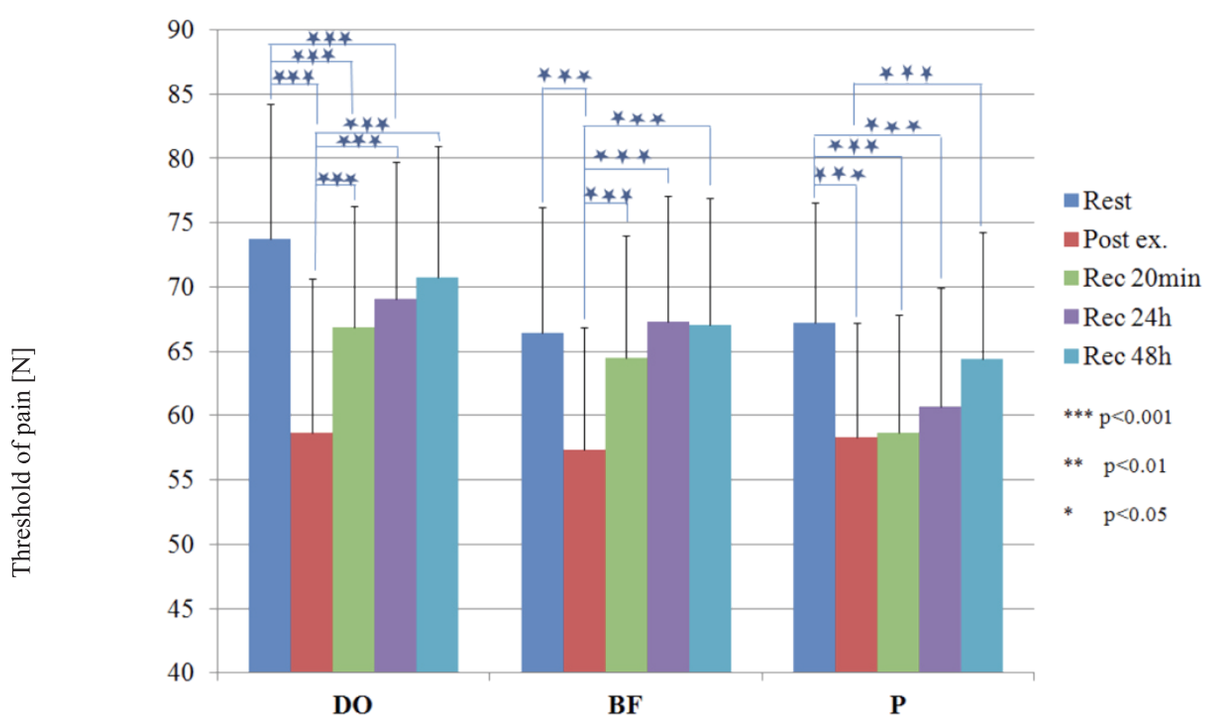

Fig. 8. PT changes, depending on the time of measurement. Differences are significant when: *p<0,05; **p<0,01; ***p<0,001

The presented results of the threshold of pain (PT) (Fig. 8, 9, 10) allow to conclude, that the physical exercise effort, performed for the purpose of this study, has had an effect in the occurrence of the muscle fatigue pain. In all the studied groups (DO, BF, P) there has been a decrease in the threshold of pain (PT), after the strength exercise (p <0.001). Significant differences in the increase of the threshold of pain (PT), have occurred in the case of the physical methods of the lymphatic drainage (PMD: DO, BF) in the time of Rec20min (p <0.001), and between the result after the application of the PMD in the time of Rec24h and Rec48h (p <0.001). In the placebo group (P), the significant differences in the pain threshold have been noted only between the result at rest and the results after the exercise (Post-ex.) (p <0.001), on the 2nd day (Rec24h) and on the 3rd day (Rec48h), after the application of the method - p <0.001.

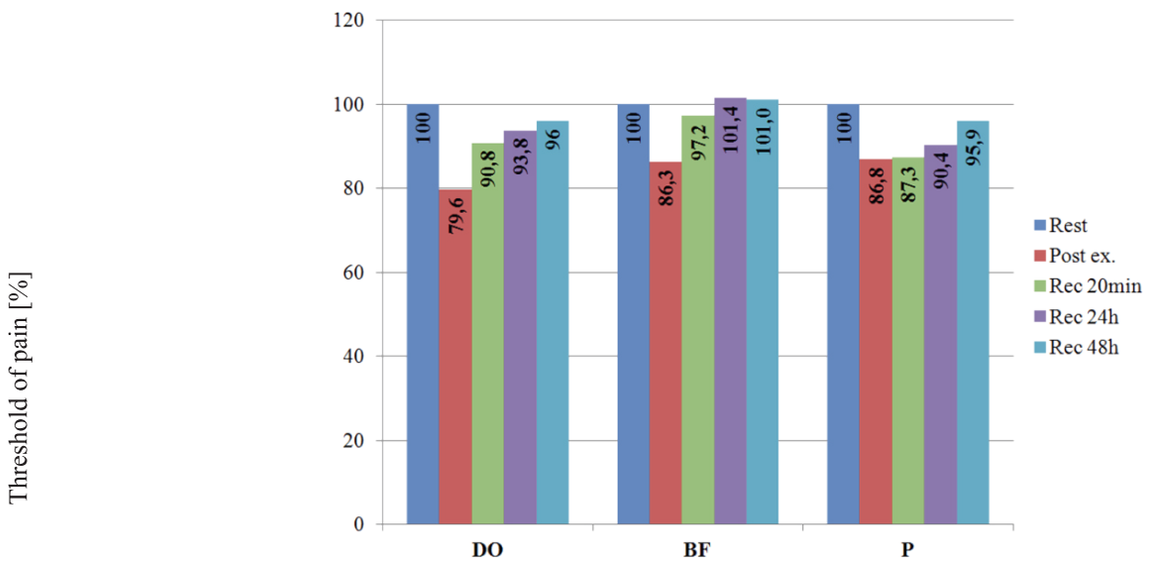

Fig. 9. PT changes in percentages, depending on the time of measurement

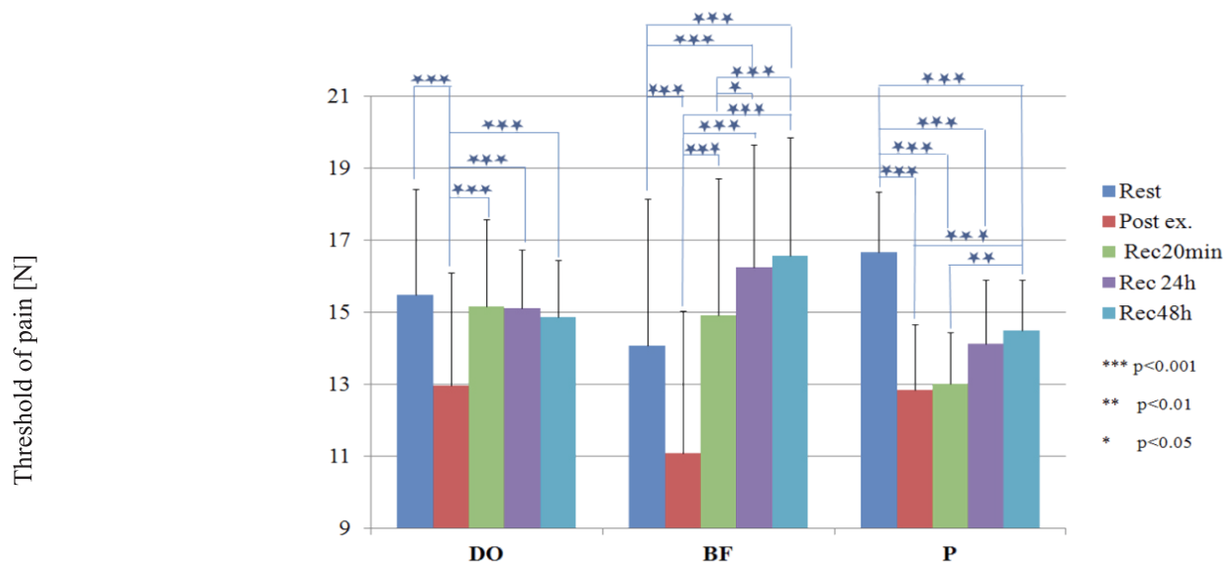

Fig. 10. PT changes, between the methods, in the individual times of measurements. Differences are significant when: *p<0,05; **p<0,01; ***p<0,001

In conclusion of the analysis of the pain threshold (PT) it can be said, that after the application of the deep oscillation and the body flow electric stimulation, there have been observed the pain relief effect and the increase in the pain threshold - such a significant difference has not been noted in the P group. In the DO group, the pain threshold after the therapy has been increased on the 1st day by 11.2 %, in the BF group - by 10.9%, in the P group - by 0.5%. When analyzing the data from the second and the third day, one should note the pain threshold increase above the initial values for the BF group (by 1.4% on the 2nd day, and by 1% on the 3rd day of the study) (Fig. 9). In the groups DO and P, in the following days of the study, there has been demonstrated the increase in the pain threshold, but the values have not exceeded the initial values of the 1st day, and have been as follows: for the DO group 4% below the initial value, and 4.1% below the initial value for the group P (Fig. 9). Considering the above, it can be stated, that the tested methods of the lymphatic drainage demonstrate the pain relief effect directly after the exercise (statistically significant differences), and are more effective in combating the muscle fatigue pain, than the passive forms of recreation.

Another analysis focused on the impact of the BF and DO methods on the muscle tension, expressed in the conventional unit - the area under the curve AUC. A muscle with the increased tension at rest, causes the inefficient (excessive contractile response) work in the exercise effort. This may lead to the reduction of the muscle performance, and consequently to the increase of the risk of injury during sports activities. In effect of the carried out tests, it can be concluded, that the applied test loads have led to the change in muscle tension, in the participating groups (methods: DO, BF, P), in particular those which have occurred in the period between the Post-Ex. and the Rec20min ($p < 0.001$), with the exception of the control group (P), wherein in this period there have not been noted any statistically significant changes ($p > 0.05$). In the analysis of the rest muscle tension, expressed in the AUC, the particular groups (DO, BF, P) have not shown statistically significant differences ($p > 0.05$). The presented results of the muscle tension measurements (Fig. 11, 12, 13) allow the conclusion, that the analyzed methods (DO, BF) caused a significant increase in the AUC ($p < 0.001$), after they have been applied (the difference between Post-ex and Rec20min). In the case of BF and DO, the significant differences in the AUC have been shown between the result at rest and the result after the exercise stress test (Post-ex.) ($p < 0.001$), and the result after the application of the PMD in further days, Rec24h and Rec48h ($p < 0.001$). In the control group (P-placebo effect) there have been no statistically significant differences noted between the Post-ex. and the Rec20min times ($p > 0.05$). In the other times (Rec24h and Rec48h), there have been observed the significant differences in relation to the Post-ex. time ($P < 0.001$) (Fig. 11).

In conclusion of the analysis of the muscle tension, it should be noted, that the greatest decrease of the AUC, and thereby the increase in the muscle tension after the exercise stress test (Post-ex.), has occurred in the BF group, and amounted to 21.2%, while the smallest one has been in the DO group - 16.3% (this group has also shown the greatest muscle tension at rest) (Fig. 12). While observing the differences in reduction of the post exercise muscle tension, it should be stressed, that the largest percentage increase of the AUC on the 1st day

(Rec20min) has been noted in the BF group - it amounted to 27.2%, and interestingly, it has exceeded on the 1st day (Rec20min) the rest value in the group DO - by 14.3% and in the group P - by 1.1%. A very important observation is the constant and statistically significant increase of the AUC during the following days of the study in the BF group (15.5% on day 2nd (Rec24h) and 17.8% on day 3rd (Rec48h) - above the initial value). Taking into account the average percentage values for those groups, between the muscle tension after the exercise (Post-ex.) and on the last day of the study (Rec48h) in the group BF, there has occurred the difference of 39% in AUC, which has confirmed a very strong anti-tension effect of the method used. This difference for the other groups was, accordingly: DO 12.3%, P – 10% (Fig. 12). The above data demonstrate, that the analyzed physical methods of the lymphatic drainage have had the immediate anti-tension effect, but due to the small size of the groups, there have not been shown statistically significant differences between them (the P group excluded). Particularly noteworthy is the fact, that the BF method has further reduced muscle tension, which has confirmed the research hypothesis in the following days (Rec24h and Rec48h) (Fig. 13).

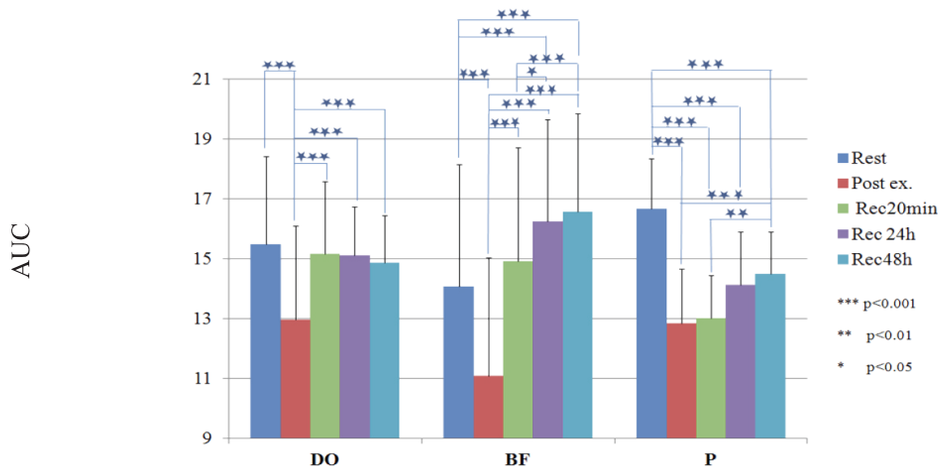

Fig. 11. AUC changes, depending on the time of measurement. Differences are significant when: *p<0,05; **p<0,01; ***p<0,001

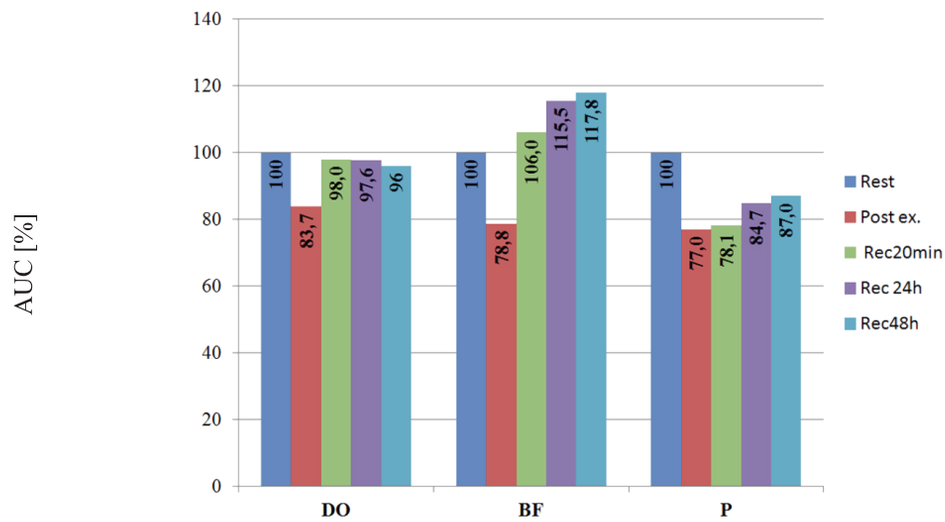

Fig. 12. AUC changes in percentages, depending on the time of measurement

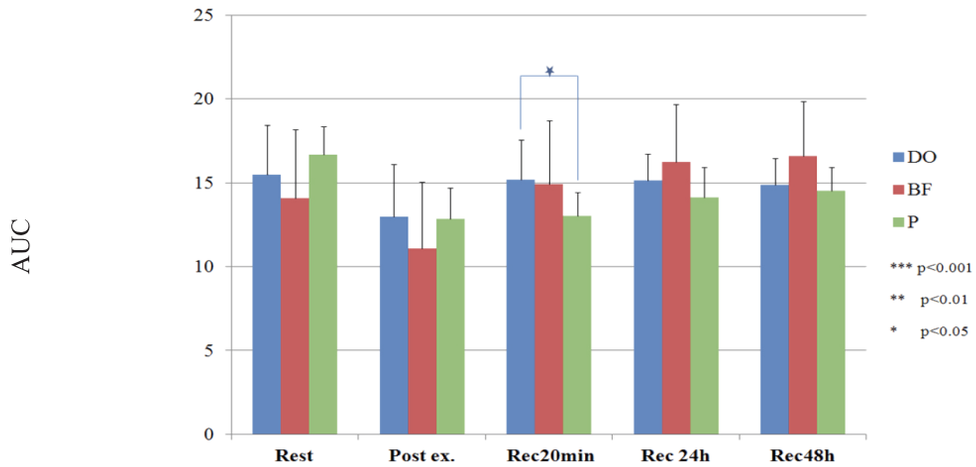

Fig. 13. AUC changes, between the methods, in the individual times of measurements. Differences are significant when: *p<0,05; **p<0,01; ***p<0,001

Discussion

In the scientific literature on the subject, still not very well researched is the impact of the techniques stimulating lymphatic motoricity, such as deep oscillation and electric stimulation of the body flow type, on the muscle tension and the muscle pain. In addition, there have not been comparative analysis made of all the methods of drainage available, and currently in use, in physiotherapy. [14, 3, 2]. The thesis seems to be confirmed also by other authors. Schillinger [14], in his master degree thesis on the various forms of the therapeutic massage for reduction of fatigue and DOMS, stresses the lack of a sufficient number of the research results to evaluate the impact of the various methods of lymphatic drainage, on the post-workout muscle regeneration processes. Vario et al., in their systematic review of the literature (100 studies) about the impact of the manual lymphatic drainage on rehabilitation and sports medicine, from the years 1998-2008, have documented only 9 articles, meeting the criteria set out by the authors [3].

The choice of methods to be analyzed in this study, has also been dictated by our aim of the multifaceted stimulation of the lymphatic system. Different types of energy used in the study also made it possible to assess the effectiveness of the particular type of stimulus. In addition, the athletes who have been subjected to the analysis of the impact of the above methods, practice the Mixed Martial Arts (MMA) - a sport discipline relatively "young" by Polish standards. The author of this study, while researching the literature, has not found many descriptions of the smooth muscles electric stimulation, perhaps due to the fact, that the verified here method of the body flow electric simulation is a novelty. Although generally, the electric stimulation itself is well developed and very well researched [15, 16, 17, 18], still the electrical current with such parameters has not been widely examined so far. Interesting results in the reduction of the fatigue markers have been achieved by Sostaric et al. [19]. There are some reports about the popular electrotherapy methods, especially the electric stimulation of the TENS type, and the most popular these days in the area of the microcirculation stimulation - the high voltage electrotherapy [15, 20]. In this area some satisfactory analgesic results have been observed, however la-

sting no longer than a few hours [21]. There have also occurred discrepancies regarding the methodology of the treatments [22]. Piller et al. [17] obtained in their studies interesting results in application of the body flow electric stimulation in patients with the lymphedema after the mastectomy.

Scientific reports on the impact of the deep oscillation (DO) on the reduction of the muscle fatigue and overtraining symptoms. In literature, most widely described are the volumetric analyses of women after mastectomy. In many different centers, there have been observed satisfactory results of the lymphedema reductions, and the improvement of the joints mobility together with the improvement of the subjective pain sensation [23, 24, 10]. An interesting study on the activity of proteolytic enzymes and their anti-inflammatory and anti-exudate effect in experimental animals has contributed the team led by Mikhalchik et al. [25] from the Central Clinical Hospital in Moscow, where they have evaluated healing processes in wounds prepared on the skin of rats. Although the physical methods for lymphatic drainage already have their history, and a number of studies in the field of lymphology, it is not reflected in the application of these methods in the biological regeneration of the professional sportsmen. At the same time, we should remember, that any regeneration methods will be optimal in the situation, when we will learn exactly what changes occur renewal will be optimally when we learn exactly changes due to physical training of the MMA. Only the combination of both directions of the research will bring the expected results and, in consequence, further decrease in the number of injuries and overtraining in this exhaustive contact sport.

Summary

In the process of repairing the changes in the muscle tissue, associated with pain and muscle tension, the key issue is to stimulate the microcirculation. The engagement of the skeletal muscles, in particular in the static effort, increases the peripheral resistance to blood flow, stimulates the cardiac adrenergic fibers and, in consequence, causes disturbances in the microcirculation and reduced venous return. The application of the bodyflow and the deep oscillation drainage methods to improve the processes of reducing the pain and the post exercise skeletal muscles tension, seems to be effective, in light of the presented research results.

Conclusions

1. Physical methods for lymphatic drainage (BF, DO), applied in this study, have had an impact on the reduction of the muscle tension in the initial phase of the post exercise recovery (Rec20min), which confirms the positive impact on the ability to perform repeated efforts, while reducing the risk of injury.
2. Application of the treatment employing the DO and BF drainage methods, significantly reduces the subjective pain sensation immediately after the treatment (Rec20min) and 24h after the recovery (Rec24h),
3. The observed changes in the muscle tension and pain threshold, after application of the physical methods of lymphatic drainage, when compared to the persons in which the methods have not been applied, have been the most significant in the

initial stages of recovery, i.e. on the first day after the analyzed methods have been applied. The important conclusion is, that these methods should be quickly implemented to improve the ability of athletes to perform the repeatable strength efforts.
4. Since the BF method does not require a significant engagement of a therapist and can be applied on the fatigued tissue when an athlete does other things, such as: participating in a press conference after the event – significantly reduces the time required for the biological recovery.

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