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CURRENT USE OF MODULATED ELECTRIC IN REHABILITATION

Abstract. We have investigated paravertebrally applied modulated low frequency electric current influence on the functional state of trained and untrained healthy young (17-24 years old) males and females during physical activity and recovery from physical workload, and attempted to evaluate underlying physiological mechanisms.

Application of modulated low frequency electric current was shown to restore vegetative nervous system balance and optimise blood circulation during physical load. In untrained persons, it decreased sympathetic system activity. In contrast, significant cardiotropic function gain was noted in trained individuals. In the examined subjects, modulated low frequency electric current effect on physical workload efficiency has been primarily manifested as an increase in aerobic efficiency (in comparison with anaerobic), as demonstrated by the PWC170 index increase.

Optimisation of cardiovascular and vegetative nervous systems indices accompanied by the recovery time reduction was observed during the post-exercise recovery period. Repeated modulated electric current application has also led to an increase in correlation force between the measured both cardiovascular and vegetative nervous systems indices during the recovery stage.

Introduction. Non-invasive physiotherapy methods and appliances can be of a great therapeutic utility allowing localised treatment application while being devoid of side effects commonly exhibited by drugs [2, 12, 15].

While numerous publications report clinical benefits of modulated electric current (MEC) use [1, 3-10, 14], physiological mechanisms

underlying the observed effects are often sidelined or unclear. In particular, this applies to systemic mechanisms and effects which go beyond the stimulated local area and tissue, and may affect remote organs, whole bodily systems, and the overall patient state. Furthermore, the treated individual's circumstances, for instance, being fatigued or under physical stress, are commonly disregarded. Therefore, we have attempted to investigate MEC effects on physical workload and workload recovery in healthy young volunteers while trying to discern physiological mechanisms behind MECinduced human functional state changes.

Apart from purely theoretical interest, the outcome of our research can have significant practical implications in sports medicine and optimization of clinical physiotherapy programs, especially in cardiovascular and neurologic disorders.

The aim of the study was to determine physiological mechanisms of modulated electric current influence on trained and untrained volunteers' functional state during physical workload and recovery, therefore providing rationale for its putative use in sports and clinical rehabilitation.

Research materials and methods. 102 healthy young (17-24 years old) volunteers have participated in the study. The groups of trained young males and females included qualified sportsmen (51 persons – 33 young males and 18 young females). The volunteers have been divided into 4 groups: the first group (the main trained) – 25 persons (11 trained males and 14 trained females); the second group (the main untrained) – 25 persons (16) untrained males and 9 untrained females); the third group (the trained control) – 26 persons (12 trained males and 14 trained females); the fourth group (the untrained control) – 26 persons (17 untrained males and 9 untrained females).

The study has been done in two stages: the baseline functional condition was estimated in all groups (stage 1); then the responses to the repeated pulses of lowfrequency electric current during physical activity were recorded at the end of the study (stage 2).

Central blood circulation indices have been determined by rheography, and included systolic blood pressure (SBP, mm Hg), diastolic blood pressure (DBP, mm Hg), heart rate (HR, bpm), heart contractile function (HCF, Om·s-1), systolic blood volume (SBV, ml), minute blood volume (MBV, ml/min), cardiac index (CI, l/min·m2), systemic vascular resistance (SVR, din·s·cm-1). Reactions to physical workload were studied by the PWC170 method using a veloergometer. Heart rate variability assessment included the stress index (SI, r.u.), vegetative (system) balance index (VBI, r.u.), Kerdo's autonomic regulation index (KARI, r.u.), and adaptive potential (AP, r.u.) evaluation.

The results obtained were processed using "STATISTICA 10" software (StatSoft, USA). Exposure to MEC was carried out by paravertebral scanning application of the LEIT device along all spinal sections for 20-30 minutes depending on skin impedance-based real time biofeedback. MEC characteristics were as follows: alternating current (shifting between 24-40 V and 2-4.3 mA) with high 4-5 kHz carrier frequency modulated by 60 Hz low frequency, and wave form shape emulating peripheral neuron action potential. The listed sliding current parameters were used to prevent tissue tolerance development. The stimulation application time was controlled via biofeedback based upon real time tissue impedance measurement, with sound signal indicating end of the local exposure.

Results and their discussion. The differences in MEC influence in trained and untrained young males and females are summarised in Table 1. SBP levels decrease accompanied by HCF and SBV increase, and SVR decrease were predominant in untrained individuals. In contrast, MEC influence in the trained groups was manifested by HCF and SBV increase accompanied by significant MBV and CI increase. At the same time, the influence of MEC on autonomic regulation and adaptive capability in untrained individuals manifested as reduction in SI and VBI, and in the trained groups by increase in SI and KARI, possibly due to noted initial differences in the autonomic nervous system state between trained and untrained individuals (underlined by such differences in the control groups).

We did not observe any significant differences between males and females in both test and control groups. The results obtained during our study allowed us to discern and summarise some physiological aspects of MEC influence on untrained young males and females functional states, and to determine systems which are the most reactive to the stimulation applied.

According to previous publications [2, 11-13], any physical factor influence has different physiological effect levels: molecular and cellular, tissue (organ level), systemic (organism level). Therefore, we have proposed a scheme of MEC effects splitting them into these levels.

We assume that low (molecular, cellular) level MEC effects are due to excitable membranes depolarization by the current applied. MEC effect was manifested in macroergic compounds (ATP, creatine phosphate and others) content increasing at the tissue level, enzymatic activity and oxygen utilisation rates going up, and energy expenditure upon stimulated contraction being reduced as compared to spontaneous contraction. Blood supply and lymph outflow activation led to trophoenergetic processes increase. Generalised MEC effect resulted in peripheral blood vessels dilation promoting their blood flow increase accompanied by simultaneous passive muscles contraction.

Due to the segmental-reflex nature of somatic innervation, an increase in symmetrical muscles metabolism alongside stimulated nerves and muscles functional properties improvement was observed, and neurohumoral regulation of the affected organs and tissues was activated. High efficiency of MEC influence was achieved by using pulse waveform shape emulating neuronal action potential. Wide frequency range used provided selective electrical stimulation of almost all nerve fibers types present, facilitating a more efficient response to bipolar impulses of cutaneous nerves and local blood flow control systems. Moreover, paravertebral exposure has triggered segmentalmetameric reactions that regulate the innervated internal organs and tissues. Due to the different shape and frequency of the electrical pulses applied, adaptation to the current was significantly reduced [2, 11].

The obtained MEC effects have reinforced previously published data [15] describing general analgesic effect, vascular corrective action, pronounced sedative effect, reparative processes and cellular immunity mechanisms stimulation caused by MEC. Thus, despite the initial autonomic nervous system state being dependent on the individual training degree, MEC influence has an optimising effect on the sympathetic nervous system function employing a variety of action mechanisms, and leading to a significant increase in overall physical performance.

Conclusions The employed paravertebral MEC application immediately after physical workload in young healthy male and female volunteers had pronounced effects on vegetative nervous system state and cardiovascular function. These effects depended on the individual physical training level but were not affected by sex. MEC influence on the untrained groups manifested in sympathetic system activity reduction (to the normative values) accompanied by systemic blood circulation optimisation. The latter was evident from the heart chronotropic function optimisation shown by both reduced heart rate increase in response to physical exercise, and increase in blood circulation volume.