DIGITAL REALITY
SCIENTIFIC AND PRACTICAL FORUM
2021

ІНФОРМАЦІЙНА БЕЗПЕКА ТА ІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ

ПРАЦІ
III МІЖНАРОДНОЇ НАУКОВО-ПРАКТИЧНОЇ КОНФЕРЕНЦІЇ

13 – 19 вересня 2021 року
Харків - Одеса, Україна

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

SIMON KUZNETS KHARKIV NATIONAL UNIVERSITY OF ECONOMICS
ODESSA STATE ENVIRONMENTAL UNIVERSITY
ODESSA NATIONAL UNIVERSITY N.A. MECHNIKOV

INTERNATIONAL SCIENTIFIC AND PRACTICAL CONFERENCE "INFORMATION SECURITY AND INFORMATION TECHNOLOGIES"

13-19 September 2021
Kharkiv – Odesa, Ukraine

Conference Proceedings

Kharkiv – Odesa
Simon Kuznets Kharkiv National University of Economics

2021

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ

ХАРКІВСЬКИЙ НАЦІОНАЛЬНИЙ ЕКОНОМІЧНИЙ УНІВЕРСИТЕТ
ІМЕНІ СЕМЕНА КУЗНЕЦЯ
ОДЕСЬКИЙ ДЕРЖАВНИЙ ЕКОЛОГІЧНИЙ УНІВЕРСИТЕТ
ОДЕСЬКИЙ НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ ІМЕНІ І.І. МЕЧНИКОВА

МІЖНАРОДНА НАУКОВО-ПРАКТИЧНА КОНФЕРЕНЦІЯ “ІНФОРМАЦІЙНА БЕЗПЕКА ТА ІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ”

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Матеріали конференції

Харків – Одеса
Харківський національний економічний університет імені Семена Кузнеця

2021

UDC 681.518.54

I 45

International Scientific And Practical Conference “Information Security And Information Technologies”: Conference Proceedings. Kharkiv – Odesa : Simon Kuznets Kharkiv National University of Economics, 2021. 298 p.

ISBN 978-966-676-818-9

Міжнародна науково-практична конференція “Інформаційна безпека та інформаційні технології”: матеріали конференції. Харків – Одеса : Харківський національний економічний університет імені Семена Кузнеця, 2021, 298 с.

Збірка містить праці III Міжнародної науково-практичної конференції з інформаційних систем, технологій захисту інформації, використання сучасних інформаційних технологій в управлінні системами за різними галузями народного господарства.

Матеріали публікуються в авторській редакції.

ISBN 978-966-676-818-9

Information Technology For Identification Of Electric Stimulating Effects Parameters

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Abstract

A wide range of modern therapeutic devices based on various physical principles, widely used in medicine, cosmetology, sports. Among them, electric massage devices occupy a worthy place, alternative to classic manual massage. Therapeutic electromassage procedures are popular, convenient and beneficial for the recovery of the body. They are widely used in the treatment of chronic diseases of the circulatory system, musculoskeletal system, internal organs, etc. The restoration of damaged muscles is especially effective, при условии, что параметры стимулирующих воздействий выбраны правильно. Therefore, in this work, it is proposed to use an information method for studying the neuromuscular system based on electromyography.

The parameters of the stimulating effect do not always optimally correspond to a specific patient or a selected area of the body, which leads to insufficient effectiveness of therapeutic procedures, prolongation of rehabilitation. Elimination of shortcomings is possible due to the adjustment of the parameters of electrical stimuli depending on the data of myographic studies of a particular patient.

Based on the data obtained by EMG, specific parameters of stimulating effects (electrical impulses) are selected, such as amplitude, frequency, duty cycle, etc., which makes it possible to implement a technical device for carrying out rehabilitation procedures. Therefore, an electromassage apparatus is proposed, built on the basis of a modern microcontroller, which allows, on the basis of EMG data, to change stimulating impulses of exposure in a fairly wide range, thereby realizing an individual approach to each patient and increasing the efficiency of therapeutic procedures.

Keywords

Biomedical parameters, electromyostimulator, total electromyography, electromyogram, neuromuscular system, musculoskeletal system, time-frequency analysis

1. Introduction

In the modern world, the number of factors negatively affecting human health is becoming more and more. The human body ceases to have time to heal itself. All this requires a search for new combinations of recovery methods., when medical devices are used in conjunction with drug methods, implementing various types of electrotherapy.

The effectiveness of the use of electrotherapy devices is largely based on the use of methods and means of diagnostic support, which would give objective information about the patient's condition, contributing to the successful solution of the problem localization of zones of influence for electrostimulation, correct setting and achievement of treatment goals.

In order to improve the quality and speed of treatment, system development required, in which automation will be provided, allowingprovide the most effective treatment result.

The ultimate goal of creating an automated electrotherapy system is to develop modeling methodsand research of control systems and devices percutaneous electroneurostimulation, characterized by adaptation to changes in biological objects.

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The novelty is the development of a methodology for analyzing the functions of electrostimulating devices, which makes it possible to minimize negative effects during the stimulation procedure.

2. Electrostimulation

Electrical stimulation in this approach causes minimal changes in the treated area of the skinand nearby tissues, which allows to increase the efficiency of the treatment process.

Skeletal muscle electrical stimulation, which are the basis of the musculoskeletal system, gives a positive healing, preventive and training effects.

During electrical stimulation of the neuromuscular system, a rational choice of modes is importantand a combination of tonic and kinetic contractions, which significantly affect the increase in mass, development of strength, increased excitability and muscle performance [1, 2].

Electrical stimulation is successfully combined with traditional drug therapy. To enhance metabolic and trophic processes, muscle tissue stimulation is performed using targeted stimulation and contraction of a specific muscle group.

An important property of neuromuscular structures when irritated by electric currents, the dependence of excitability on the rate of change in the amplitude of the stimulating signal [1].

Depending on the signal amplitude and the excitation threshold of the neuromuscular structure, the following electrostimulation modes are distinguished: subthreshold, threshold and suprathreshold (fig. 1) [3-5].

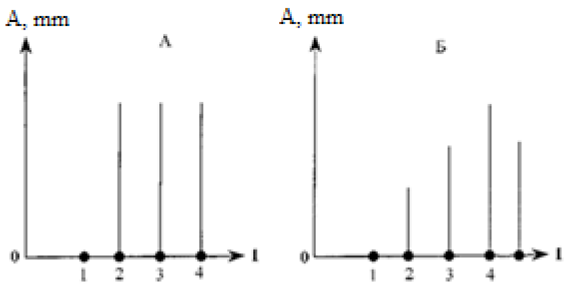

Figure 1: Dependence of the signal amplitude and the excitation threshold of the neuromuscular structure (a) - muscle fiber, б) – muscle, 1) subthreshold stimulus, 2) threshold stimulus, 3) submaximal suprathreshold stimulus, 4) maximum suprathreshold stimulus)

The dependence of the amplitude of muscle contraction on the strength of the stimulus occurs according to the law of power relations:

- Each excitatory tissue has its own functional reserve.
- Each excitatory tissue has its own functional boundary.

3. Electromyographic signal processing method

For a qualitative and quantitative assessment of the state of the human neuromuscular system using electromyogram (EMG) the information method of time-frequency analysis based on spectrograms can be used (fig. 2, fig. 3) [6-12].

To conduct a quantitative analysis of EMG signals, it is necessary to calculate the following parameters of the time-frequency representation of the total EMG: lower and upper cutoff frequency, median frequency, effective spectrum width and a number of others [13-41]. These processing parameters make it possible to fully assess the frequency content of the EMG signal.

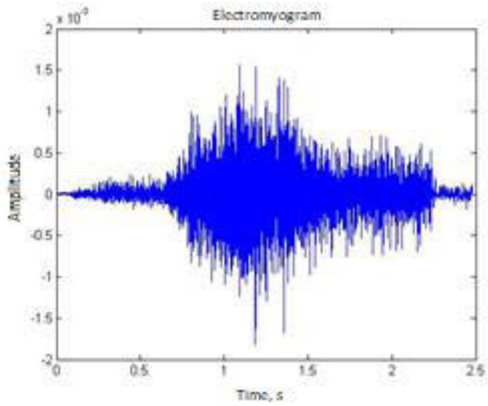

Figure 2: Electromyogram of the muscle *m. bicepsbrachii*

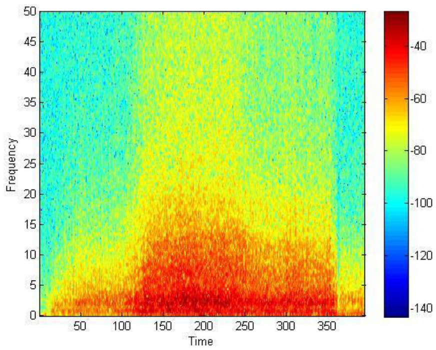

Figure 3: Corresponding spectrogram of the muscle *m. bicepsbrachii*

Let us represent the parameters of the EMG signal in the form of a certain finite set

$$A_m = \{a_i\}(i = \overline{1, m}), \quad (1)$$

where A - the designation of this set; m – cardinality multitudes; a_i – elements of the set.

The elements of the set can be amplitudes, frequencies of the spectrum components, phase shifts, etc.

Let us represent the parameters of stimulating influences also in the form of a finite set

$$B_n = \{b_i\}(i = \overline{1, n}), \quad (2)$$

where B - the designation of this set; n – cardinality multitudes; b_i – elements of the set.

The elements of the set can be the amplitude and frequency of stimuli, the type of modulation, modulation parameters, time intervals, etc.

Thus, the task is to determine such a transformation ω, which provides an unambiguous display of the elements of the number A to the corresponding elements B

$$A_m \xrightarrow{\omega} B_n, \quad (3)$$

EMG signal processing allows for ongoing monitoring the effectiveness of therapeutic effects due to the optimal selection parameters of stimulating effects.

4. Conclusions

Thus, carrying out qualitative and quantitative analyzes the structure of an EMG signal that is unsteady in natureand the dynamics of its parameters in the process of muscle contraction is performed based on the spectrogram, realizing graphical visualization of the amplitude, frequency and time components of the biomedical signal in real time. Consequently, specific parameters of stimulating effects can be selected based on the data of the EMG signal, which makes it possible to implement an effective technical device for carrying out individual therapeutic procedures.

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