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Touch static analysis and dynamic exercises of insulated patients

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ABSTRACT

For the first time, studies were conducted on the study of the amplitude indices (C-EMG) and the frequency of the oscillations following (CSC-EMG) when performing dynamic and static exercises among patients with stroke and healthy people. It was revealed that in healthy individuals (control group) the amplitude of the EMG depends on the nature of the exercises. The largest EMG amplitude is registered when performing static exercises. It was found that patients who were hospitalized in the acute period of stroke when flexion and extension of the fingers were performed were mainly recorded low-amplitude movement stretched for the entire cycle without a clear peak of the extremum of EMG activity. When performing static exercises in these patients, a greater amplitude and an increase in the frequency of the EMG oscillations were revealed.

KEYWORDS: Electromyography, sick and healthy patients, average amplitude (SA-EMG), frequency of fluctuations following (CSK-EMG), dynamic and static exercises.

Análisis estático táctil y ejercicios dinámicos en pacientes aislados

RESUMEN

Por primera vez, se realizaron estudios sobre el estudio de los índices de amplitud (C-EMG) y la frecuencia de las oscilaciones posteriores (CSC-EMG) al realizar ejercicios dinámicos y estáticos entre pacientes con accidente cerebrovascular y personas sanas. Se reveló que en individuos sanos (grupo de control) la amplitud del EMG depende de la naturaleza de los ejercicios. La mayor amplitud EMG se registra al realizar ejercicios estáticos. Se encontró que los pacientes que fueron hospitalizados en el período agudo de accidente cerebrovascular, cuando se realizaron la flexión y la extensión de los dedos, se registraron principalmente movimientos de baja amplitud estirados durante todo el ciclo, sin un pico claro del extremo de la actividad EMG. Al realizar ejercicios estáticos en estos pacientes, se reveló una mayor amplitud y un aumento en la frecuencia de las oscilaciones EMG.

PALABRAS CLAVE: Electromiografía, pacientes enfermos y sanos, amplitud media (SA-EMG), frecuencia de fluctuaciones posteriores (CSK-EMG), ejercicios dinámicos y estáticos.

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Introduction

In cerebral strokes, the earliest possible and most comprehensive rehabilitation plays a significant role and can significantly improve the functional and social outcome of the disease. Rehabilitation measures are effective in about 80% of post-stroke patients, another 10% recover spontaneously, and 10% have no success in rehabilitation measures (Khitrov et al., 2012; Vakhitrov, 2017). At the same time, post-stroke motor disorders remain the leading cause of maladaptation in this category of patients (Kirilchenko, 2006; Iusevich, 1958). Cerebral stroke is the most common cause of disability. According to various sources, the level of disability in patients who survived after a stroke reaches 70–85% (Vakhitov, 2014).

Despite significant achievements in disclosing the etiology and pathogenesis of acute cerebrovascular accidents (ACVA), the outcome of this disease remains unfavorable so far, which indicates the need for further improvement of medical care for stroke patients, especially at an early stage of the disease (Vakhitov, 2014; Lukianov, 2013). The most common symptom of ischemic stroke is hemiparesis, however, this group of patients has a complex motor defect, different in nature and severity. Data on the effect of the affected side is contradictory. Some authors note that patients with right-sided damage have a worse prognosis in terms of recovery (Vakhitov, 2017; Kirtly, 2006; Petrilli et. al., 2002). Other researchers suggest that worse recovery is observed in damages of the left hemisphere (Lukianov, 2013; Vakhitov, 2017). One of the methods of objectifying post-stroke motor disorders is surface electromyography with a change in the amplitudes of the maximum bilateral arbitrary activation of the muscles of the forearm, hand, and shoulder and the calculation of the coefficients of adequacy (CA) and reciprocity (CR) (Skvorytsova, 2006; Khitrov et al., 2012; Vakhitov, 2017; Petrilli et al., 2002). The ratio of the amplitude of the muscle during its involuntary activation (with the active maximum tension of the antagonist) to the amplitude of the same muscle in the mode of maximum arbitrary tension is called CA. CR characterizes the interaction of muscle antagonists and is calculated for a muscle in antagonistic tension. It shows the degree of its activation as a percentage in relation to the activity of the agonist muscle. Under normal conditions, the extensor muscles have a higher coefficient of adequacy and reciprocity than in the flexor and are up to 20%.

Currently, various medical simulators of domestic and foreign manufacture are widely used for the rehabilitation of patients along with other activities. However, a common drawback of these simulators in our opinion is the lack of feedback. The simulators are not equipped with sensors to provide information from the patient in dynamics, and subsequently, to promptly make correction into the rehabilitation process. Adequate correction of motor impairment is impossible without considering and analyzing changes in the body without using a feedback system. Moreover, the existing medical simulators are largely aimed at performing only dynamic exercises, excluding practically static exercises. Although many researchers have recently substantially supported the role of the latter in the rehabilitation process.

The objective of this study was to quantify EMG recordings in healthy individuals and stroke patients. This article presents the first results of a comparative analysis of muscle activity profiles of healthy individuals and stroke patients when performing dynamic and static exercises.

Materials and methods. The study involved 20 healthy subjects - 9 men and 11 women aged 45–63 years (control group), and 26 patients - 14 men and 12 women aged 42–65 years, with cerebral stroke (main group). The control groups at the time of the examination did not have neurological, orthopedic, and severe somatic diseases. The main group consisted of patients with spastic hemiparesis in the acute period of ischemic stroke.

To study the biomechanics of movements, all subjects were asked to perform a series of motor exercises. Given the healthy and post-stroke motor capabilities of patients, the following movements were selected: 1) at rest; 2) flexion and extension of the hands; 3) maximum abduction of the hand and further retention in a static position, and) maximum adduction of the hand and its further retention in this position.

Surface electromyogram (EMG) was performed using an electromyograph developed on the basis of the Myoware Muscle Sensor (AT-04-001). Disposable cutaneous electrodes were applied in accordance with the standards for biomechanical studies. Поверхностная ЭМГ регистрировалась со следующих мышц: m. flexor carpi ulnaris, m. flexor carpi radialis, m. flexor digitorum superficialis, m. extensor carpi ulnaris, m. extensor digitorum,

m. extensor carpi radialis longus. The average amplitude (AA-EMG) and the oscillation repetition rate (ORR-EMG) were analyzed.

To assess the significance of differences, standard values of Student t-test were used.

1. Results and Discussion

EMG in healthy individuals. Most healthy subjects showed spontaneous activity in EMG. EMG of healthy subjects resembled a static pattern of the so-called segmental irritation according to the classification of Iu.S. Iusevich (Skvortsova et al., 2006) — rhythmic constant fibrillations or fasciculations, sometimes recorded in relaxed muscles (at rest) with segmental lesions. A similar EMG picture (spontaneous activity) was recorded at rest in the majority of examined healthy individuals (Table 1). Exercises in the form of flexion and extension of the fingers caused in examined healthy subjects the rhythmic potentials of EMG with increased amplitude. Static exercises caused slight changes in the EMG record. Holding the hand in a static adducted position caused a significant increase in the EMG potentials that reached up to 2,14 mV, which turned out to be significantly higher compared to the EMG values obtained with the dynamic exercise (flexion and extension of the fingers). Holding the hand in a static abducted position caused a significant increase in the EMG amplitude compared to all EMG values obtained during the previous exercises. Thus, in healthy individuals, the amplitude of EMG depends on the nature of the exercises performed. The largest amplitude of EMG was recorded during static exercises.

EMG of stroke patients. EMG of patients with hemiparesis in the studied motor activities differed from healthy ones in clear "uniformity". In the majority of stroke patients, the studied movements included more than necessary muscles, i.e. there was significant irradiation. A clear uniformity in patients with stroke also differed in the profiles of EMG curves (Table 2). All patients in the acute period of a stroke during flexion and extension of their fingers showed predominantly a low amplitude stretched over the entire cycle of movement, without a clear peak of the extremum of EMG activity. There was an almost complete absence of activity of this muscle in the studied movement. In our opinion, it could involve other, additional muscle groups to perform the motion. EMG of these patients was characterized by low amplitude and a lower frequency, tremor, excess conjugate activity of antagonist muscles and the presence of so-called "gaps" - sections of bioelectric silence lasting 10-30 ms in the analyzed fragments of records. During static exercises in patients with an acute stroke, the EMG profiles were slightly different from previous records.

2. Key indicators of total EMG

During dynamic and static exercises in healthy people

Table 1

Muscles	Type of exercise		AA-EMG (mV)	ORR-EMG (per sec)
m.extesnor carpi ulnaris	dynamic	M ±m	1.01 0.08	243 24
	static	M ±m	2.14 0.07	296 26
m.flexor carpi radialis	dynamic	M ±m	1.08 0.09	267 14
	static	M ±m	2.18 0.20	294 25
m. flexor carpi ulnaris	dynamic	M ±m	1.07 0.06	249 29
	static	M ±m	2.04 0.08	298 23
m.flexor digitorum superficialis	dynamic	M ±m	1.06 0.07	251 20
	static	M ±m	2.09 0.09	297 26
m. extensor digitorum	dynamic	M ±m	1.01 0.06	245 26
	static	M ±m	2.17 0.09	294 18
m.extensor carpi radialis longus	dynamic	M ±m	1.03 0.08	261 28
	static	M ±m	2.15 0.07	295 13

3. Key indicators of total EMG

During dynamic and static exercises in patients

Table 2

Muscles	Type of exercise		AA-EMG (mV)	ORR-EMG (per sec)
m.extesnor carpi ulnaris	dynamic	M ±m	0.11 0.03	190 14
	static	M ±m	0.24 0.07	222 6
m.flexor carpi radialis	dynamic	M ±m	0.18 0.06	178 14
	static	M ±m	0.28 0.20	254 15
m. flexor carpi ulnaris	dynamic	M ±m	0.07 0.02	209 29
	static	M ±m	0.14 0.01	304 13
m.flexor digitorum superficialis	dynamic	M ±m	0.16 0.07	241 20
	static	M ±m	0.29 0.07	256 16
m. extensor digitorum	dynamic	M ±m	0.11 0.02	215 26
	static	M ±m	0.27 0.09	271 8
m.extensor carpi radialis longus	dynamic	M ±m	0.13 0.02	201 28
	static	M ±m	0.25 0.07	295 13

Conclusion

Adequate correction of motor impairment is impossible without considering and analyzing changes in the body without using a feedback system. The currently used medical simulators are largely aimed at performing only dynamic exercises, excluding practically static exercises. In our work, we for the first time analyzed the average amplitude (AA-EMG) and the oscillation repetition rate (ORR-EMG) in healthy and sick people during dynamic and static exercises. According to our data, in healthy individuals, the amplitude of EMG depends on the nature of the exercises performed. The largest amplitude of EMG was recorded during static exercises.

All patients in the acute period of a stroke during flexion and extension of their fingers showed predominantly a low amplitude stretched over the entire cycle of movement, without a clear peak of the extremum of EMG activity. During static exercises, the EMG amplitude and the frequency of EMG fluctuations in these patients were slightly higher than during dynamic exercises.

Thus, both healthy and sick patients, when performing static exercises, show a significant increase in the amplitude and frequency of EMG. In our opinion, the use of dynamic exercises in combination with static exercises as part of rehabilitation measures would significantly reduce the time needed to restore the lost functions of the upper limbs.

The preliminary results obtained by us in the clinical settings are sufficiently strong evidence of the need for EMG for the dynamic analysis of the recovery process. The data obtained should be considered as an additional justification for the use of static exercises in the rehabilitation process.

Summary

- The analysis and operational correction of the rehabilitation process require using sensors, in particular, EMG recording. This will provide feedback and promptly adjust the recovery process.

- Static exercises in patients ensure significant positive changes in the average amplitude (AA-EMG) and oscillation repetition rates (ORR-EMG).

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