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THE MUSCULAR ANSWER OF THE HUMAN BODY IN A VIBRATIONAL ENVIRONMENT

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Abstract: *Adjustment of the mechanical vibration parameters (frequency, amplitude, direction, expose time) lead to the elimination the negative effects that the vibrations have on the human body, which can be used with positive effects on the labor force, by improving muscle, bone density, as well as for the quality of life by reducing backache and the decrease in risk of falling. This article contains the results of an experiment in which is the aim of lower limbs muscles reaction when the body is in an environment with vibration parameters checked, while aiming at first tonic vibration reflex, in view of the use this reflex in training on the vibrating plate.*
Key words: *Electromyography, vibrating plate, reflex tonic to vibrations.*

1. INTRODUCTION

To study effects of the mechanical vibrations on the human body is not a new field. Investigations have been carried out since the beginning of the twentieth century, but it is a chapter that supports new challenges.

At the moment, the benefits on mechanical vibrations are used on a large scale, in terms of the fitness rooms, as well as by the recovery centers.

In carrying out the studies must take into account the following:

•Human body should be regarded as mechanical system and biological system;

•Effects that the vibrations have on these two types of systems;

•Criteria of the human organism tolerance on exposure to vibration.

2. INFORMATION

2.1 Striated muscle structure

Somatic muscle system, consists of about 434 muscles, and represents approximately 40% of body weight; of this percentage, 10% it is represented by the smooth muscles of the walls internal organs and blood vessels together with cardiac muscle. A striated muscle is made up of several components: the body muscle, sinew down, the tendon-muscle junction, muscle insert, the sheaths synovial, vessels and muscle nerves (Fig. 1).

The muscle is composed of specialized contractile cells (fiber muscles), grouped in a well-organized (Fig. 2). Each muscle fiber contains two types of structure called miofilaments: Some thick (the filaments of miozin) and some thin filaments (the filaments of actin).

Muscle fibers contain numerous arrangements of miofilaments, parallel to each other and separated by a dark band, called Z tape. The portion of miofibers between two Z is a sarcomer. Striated muscle fiber has a length of between 1 mm to 12 cm in diameter, and 10 100 μ and consists of:

• **muscle fiber membrane (sarcolema)** that plays a role in producing the action potential and the leadership of excitation. It presents a series of holes that form the cross-sectional and longitudinal tubes that send action potentials from the sarcolema to miofibers;

• **sarcoplasmic reticulum** having an important role in controlling the muscle contraction, very extensible in white muscle fibers (specialized for rapid contractions);

• **sarcoplasma** represents the cytoplasm within the muscle fiber where the miofibers are located in. there are a lot of mitochondria in the sarcoplasma, at this level through the process of oxide-reduce the energy that is stored under the ATP form is released.

• **miofibers** are in number a few hundred to a few thousand in the muscle fibers. Each miofiber contains approx. 1500 filaments arranged in hexagon shape and cca. 1000 filaments of actin, 6 arranged around a filament of Miozine, and so that an Actin filament to be willing at the same distance from three neighboring filament of Miozine. Actin and Miozine represent contractile proteins.

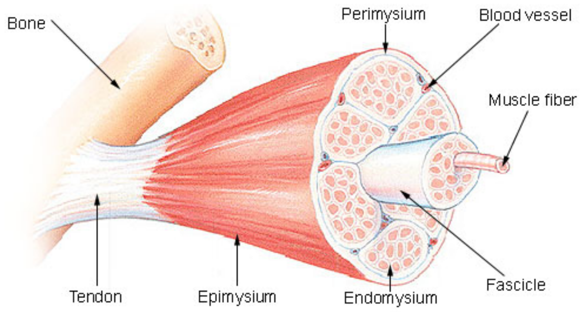


Fig. 1. Striated Muscle Structure [1]

Sarcoma is the functional unit of the muscle being its contractile. During contraction, the two types of miofilamentes glides, one to the other, and sarcoma can shorten and thus muscle contraction occurs. During relaxation, sarcoma returns to its original length.

2.2. Muscle Fiber Properties

The muscle fiber has these following properties:

- **Contractility** represents the ability of muscles to shorten its length. Any other type of cell in the human body does not have this property.
- **Extensibility** – is the ability of muscle fibers to stretching (expand), to increase the length.
- **Elasticity** - ability of the muscle to return to its original length in a state of relaxation.
- **Excitability** - muscle property to respond to a stimulus.

Muscle contraction is a manifestation of muscle elasticity changes. Muscle contractions are such classified in this way [2]:

Isometric Contraction – is a contraction of a muscle without it to be short, remaining at the same length. It is a static contraction of muscle strengthening, producing growth of muscle fibers and muscle weight, which is determined by the increase of the quantity of sarcoma plasma of muscle fibers. The length of the muscle fibers are not changed.

Isotonic contraction - contraction of a muscle with maximum shortening, tension remains the same. It is a dynamic contraction that produces muscle length change, causes joint movement. During the movement, the shrinking tension remains relatively the same.

Izokinetics contractions – it is carried out at constant speed. These contractions can be effected with special devices.

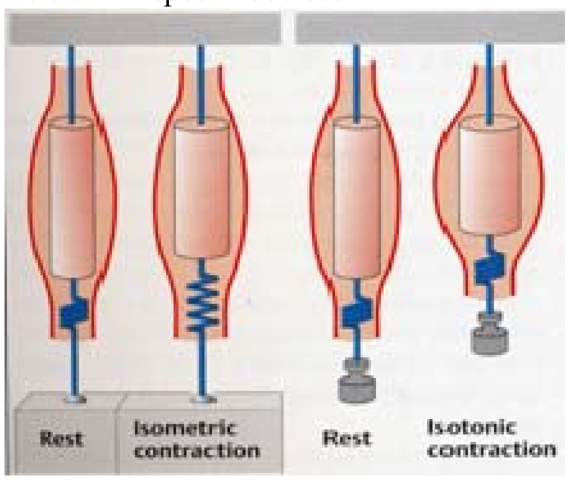


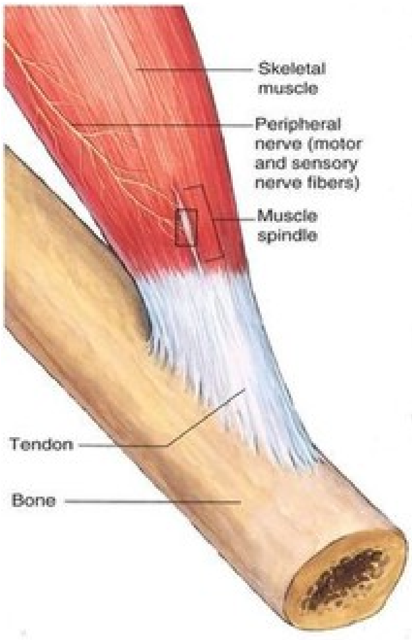
Fig. 2. Muscle Contraction Types [1]

2.3 Acceleration sensors of striated muscle

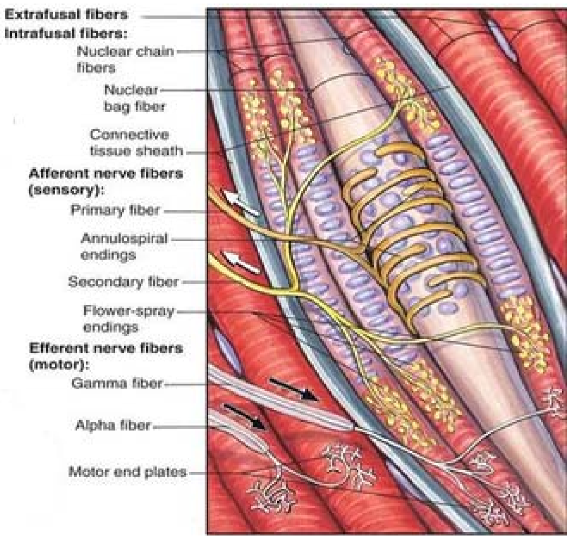
Proprioceptors- Kinestezics receptors are found in skeletal muscles, tendons, joints, being involved in regulating motor functions.

The muscular receptors take part: neuromuscular spindles and Golgi tendon organs. Tendons Golgi organ is a muscular-formation tendons uncommon compared to spindles, well represented in the muscles with slow contraction.

Neuromuscle spindles are arranged among the fibers in whole striated muscles body and have parallel direction to the muscle fibers.



a) Golgi tendon organs



b) Neuromuscular spindles

Fig. 3. Proprioceptors [1]

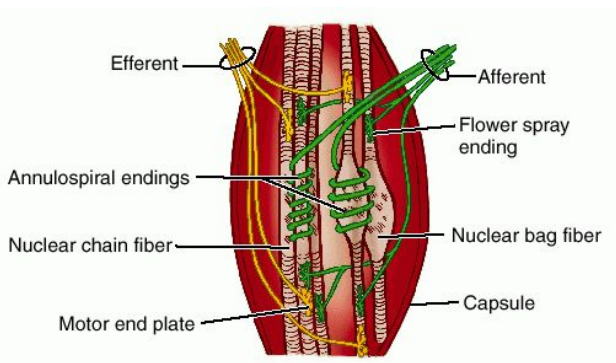


Fig. 4. Neuromuscle Spindles Structure [1]

The excitation of intrafusal fibers is ensured by sensory fibers (primary and secondary). They convey information about the extent of muscle kinetics stretch of the muscle allowing adaptation of the tonic of posture and movement, to the variation of the length and speed of muscle stretch. Mechanical action of vibration produces rapid and short movements in length, of muscle-tendon complex.

2.4 Tonic Vibration Reflex

Workouts on vibrating platforms generate a tonic vibration reflex (TVR) in the muscles that are involved in the effort. Due to the fact that the contraction and relaxation of muscles is achieved with very high speeds, the number of muscle fibers activate achieves 95% of all muscle fibers stimulated [3].

Tonic vibration reflex acts exclusively on alpha motor neurons (nerve cells whose spindles form the pyramid shape of the transmission of the nervous impulse) and does not use the same paths for which originate in the cortex [4].

Training-based mechanical vibration induces involuntary muscle contractions.

Vibration can trigger contractions even in muscles unable to react to electrical stimuli. This effect was originally attributed to a possible increase in the activity of the nerve cell. This phenomenon, involuntary contraction, was named by Eklund and Hagbarth as the effect of the tonic of vibration (TVR) [5].

3. ELECTROMYOGRAPHY

Electromyography is a method of assessment and recording of the electrical activity produced by skeletal muscles.

Electromyography (EMG) is a method of recording of biopotentials muscle using arc electrodes placed in the surrounding musculature (EMG Elementary) or with the help of skined electrodes (EMG overall) and studying their characteristics [4].

On each bone, there are two or more groups of antagonistic skeletal muscle, that means that when some of the musculare are contractions others are relaxing. Muscles are able to the command of a motor nerve. This command leads to the increase of calcium ions inside the muscle cell and the molecular mechanism launches associated with muscle contraction.

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The basic component of the skeletal muscles is the drive motors. A number of muscle fibers of the motor units form muscle fibre. When one unit is turned on, the electric potential is observed with sinusoidal amplitude between 20 and 2000 μV, with a frequency of between 6 and 30 Hz, within a range of 3-10 ms.

But one part of a muscle can be controlled by hundreds of motor units. The number of excited motors units is higher, the more muscle fibers are activated. Thus the number of excited motors units decide the measure activity of the muscle.

This activity can be recorded on the surface body by the electrode.

Conscious muscle activity produces typically variations of EMG signal, which consists of unregulared sinusoids.

The records shall be carried out with the help of electromiografului, which contains a collection of potential muscle power, a unit of amplification and a system of registration and display graphics.

3.1. The system for collecting

- **The system of collecting** electrical muscle potentials, is represented by the electrodes as:

Surface electrodes – are represented by pleasant small surface of metal approximately 1 cm, which is placed on the skin of muscled studied area, usually at the proximal end and distal end, and they record the electrical activity of muscles.

The *needle electrodes* are introduced into the muscles and allow the collection of electrical activity of a single motor units, obtaining such elementary electromyography.

- **Amplification System**-consists of an amplifier and a filter that allows the registration of biocurrent that take spontaneous birth and whose amplitude is very small.
- **Display System and enrollment**: monitor, paper.
- **The incentive System** is made by pulse with a specific duration and intensity depending on the particularities of the subject.

4. EXPERIMENTS DESCRIPTION

For the purposes of carrying out experiment used biomedical measurement system platform KL-7200 and vibrant Body Sculpture BM1500 Power Trainer.

The system KL-7200 consists of nine modules, for the present paper was used the electromyography module. The whole system is presented in the figure 4.

Fig. 5. Biomedical Measurement System KL-7200

Vibrant Platform (PV) BM1500 consists of a platform driven by a motor with an eccentric controlled by a control panel from which stimulus frequency control vibrator. This plate has three lines of action, and therefore subjects test will be subject to a stimulus vibrator what will act three-dimensional layout. It can set 9 frequencies between 18 and 30Hz. Measurements were made at a frequency mean S_4 = 22Hz with the amplitude of peak x=0.8mm, y=0.8 mm, z= 0.1mm and to the maximum frequency reached the Board, hereinafter referred to as "high-frequency" S_9 = 30Hz with pick amplitude x=0.5 mm, y=0.5mm, z=0.2 mm.

They have been tested 4 subjects with ages between 30 and 40 years, both men and women. It should be noted that subjects are persons carrying out a daily intensive physical activity and therefore they are relatively top muscles.

On each subject have been performed 4 measurement series, under the following conditions:

1. Subject is in the vertical position on the ground, before being subjected to attribute vibrator;
2. Subject is in a vertical position on PV (Plate in Vibration) which vibrates at a frequency average;
3. Subject is in a vertical position on PV which vibrates at a frequency high;
4. Subject is in the vertical position on the ground, after having been subjected to attribute vibrator.

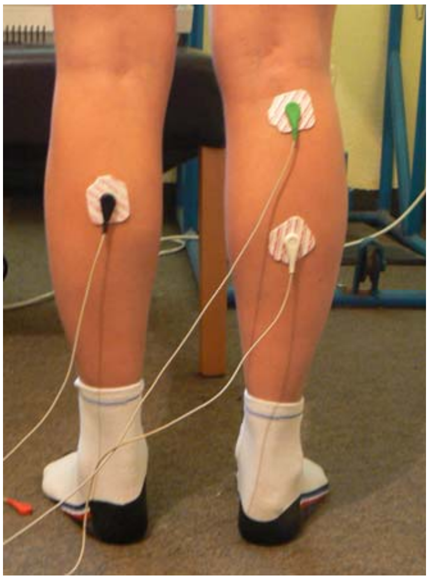

Fig. 6. Applying electrodes on the subject calf

4.1. The Calf Measurements

For calf muscles is observed moderate muscle activity during the measurement without vibrations. This activity gets worse during the vibration frequency. High frequency boosts more than muscle activity in calf. After removing stimulus vibrator muscular activity falls to a lower level than before in exposure to vibration. Average of 4 measurements is played back in the table below, where the notations are: IFV - before the application of vibrating stimulus, VM – in the mean vibration time; VI – in the time of high vibration; DFV - immediately after the termination attribute vibrator.

Table 1

Measurements Values.

IFV	VM	VI	DFV
1.1	5.6	7.6	0.6

There is a moderate muscle activity during the measurement without vibration, calf muscles being asked only to maintain the body in a vertical position.

During the application of vibrating stimulus frequency is observed average gain muscle activity due to tonic vibration reflex.

The increase is even stronger among high frequency from the application of the vibration.

Immediately after removing stimulus vibrator muscle activity drops to a level lower than that in advance by the submission to vibrations that shows a relaxation of muscle fiber after a request from the time of vibrations. Approximate time in which a subject has undergone to the vibration was 4 minutes.

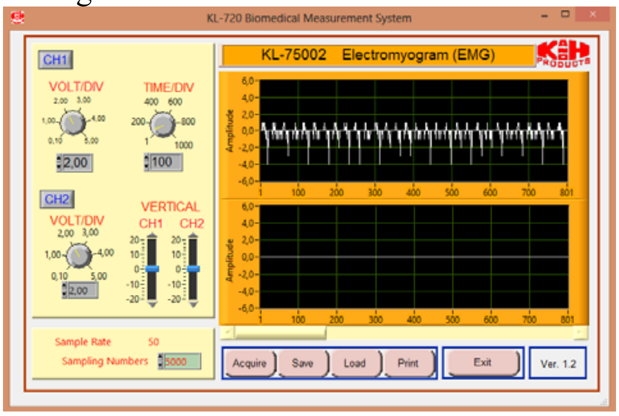

Fig. 7. Screen image with measurements during mean vibration

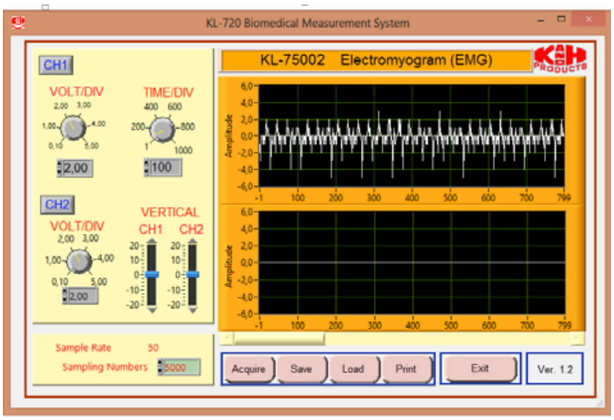

Fig. 8. Screen image with measurements during high vibration

4.2. The Thigh Measurements

Same set of measurements have been carried out and for the thigh muscles. The mean values are given in the Table 2.

Table 2

Measurements Values.

IFV	VM	VI	DFV
0,8	4.1	1.3	0.8

Although these muscles are higher than those of calf, having more fiber involved in contraction, waiting larger muscle activity, it is noted otherwise. The mean S_4 vibration muscle activity is increased, but increasing frequency at S_9 is notice a decrease in the muscle activity. This may be due to transmissibility because high frequency vibration spreads more difficult in the human body in a vertical position.

5. CONCLUSIONS

From those presented above may be seen as very important that you have the choice in frequency with training vibrations. If it is intended to train upper part of the body, it is appropriate to choose smaller and, where appropriate, if the plate vibrant allows it, to increase the amplitude, taking the care to avoid their frequencies of the various components or organs.

Body position, it is also important, as it influencing infectivity, being closely linked to the existing tension into the muscle, leading to an increase in stiffness human body as a whole.

The experiment showed that the mere exposure of the body to a stimulus vibrator leads to activation of muscular contractions which can be used to strengthen the muscles.

Use mechanical vibrations during training, in which the subjects are in positions with isometric contractions, leads to an increase in muscle activity, which is proportional to the force developed by muscles.

Knowledge of effects of the mechanical vibrations on skeletal muscle tissue may have implications on the programs of significant strengthen of the muscles.

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Răspunsul fiziologic al musculaturii corpului uman aflat într-un mediu vibraţional

Rezumat: Ajustarea parametrilor vibrației mecanice (frecventă, amplitudine, direcție, timp de expunere) conduce la eliminarea efectelor negative pe care acestea le au asupra organismului uman, putând fi utilizate cu efecte benefice asupra acestuia, prin îmbunătăţirea forței musculare, densităţii osoase, precum şi asupra calităţii vieţii prin reducerea durerilor de spate si scăderea riscului de cădere. Acest articol conţine rezultatele unui experiment în care s-a urmărit reacţia muşchilor membrelor inferioare atunci când organismul se află într-un mediu vibrațional cu parametrii controlați, urmărindu-se în primul rând reflexul tonic de vibrație, în vederea utilizării acestui reflex în antrenamentele pe placă vibranta.

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