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IMPACT OF LOCAL VIBROSTIMULATION ON PARAMETERS OF LEG MUSCLES STRENGTH ENDURANCE

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Abstract. *Vibration as a tool for massage and rehabilitation has been known for a long time. However, the vibration as a tool in sport workout is used very recently and is being used to increase strength, power, flexibility and coordination. It should also be noted that proper dosing of whole-body vibration plays a very important role in lymph drainage and in the treatment of overloaded joints. Improving and retaining physical fitness as well as repeating sets of exercises on one muscle group to spend as much energy resources in this muscle is important in fitness, in order to increase muscle mass and conditioning. Tonic effect of local vibrostimulation can warm up single muscle or muscle group, but also it can lead to excessive fatigue. So the aim of research is assessment of the effects of local vibrostimulation on the strength endurance for women in seated knee extension motion. Literature was analysed and an experiment was used to find out how strength endurance parameters change for 18-23 year old women after local vibration stimulation. A study was conducted with 20 women aged 18 to 23 years. For these women, control of single leg strength endurance was performed by seated leg extension movement, followed by local vibrostimulation of the quadriceps femoris muscle. This procedure was followed by a repeated strength endurance control. In this study, we found that the strength endurance parameters of the stimulated leg increased by an average of 5 repetitions during 30 seconds of control motion. We conclude that dosed local vibrostimulation sessions can increase strength endurance parameters locally for one muscle group.*
Keywords: *leg muscles, local vibrostimulation, seated knee extension.*

Introduction

Vibration can pass its positive effect on the body mainly through the neuromuscular system. As a result of vibration, the human muscles work the same way as during physical exercise, but this process does not produce lactate, which in turn does not accumulate in the blood and the level of work capacity does not decrease. Thanks to vibration, muscle relaxation can be achieved, the person gets rid of stress, reduces the feeling of pain, and reduces body weight as the excess body fat (Krauksts, 2012). One of the first scientists to disseminate the idea of using vibration in sports was Vladimir Nazarov. He practiced both the whole body

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vibration and the vibration of some parts of the body, namely local vibrostimulation. The scientist himself called this method biomechanical stimulation (Назаров, 1987). This idea was further developed in Belarus, the University of Physical Culture and led by professor Mikheev, who used Nazarova's vibrostimulation equipment to stimulate biological activity. Exercises and methods for various sports with the usage of the Nazarov's system were created (Михеев, 2007). Using this equipment, a vibratory workout was developed that included a vibration training plan for various muscle groups and was used by many athletes and sports representatives. Improvement of acute muscular work capacity through whole-body vibration has been demonstrated by many authors (Cardinale & Wakeling, 2005; Issurin, 1999; Rittweger, 2010).

With the application of prolonged vibration, there is possibility to get a vibration disease. It is stated, that prolonged vibration with a frequency less than 1000Hz can negatively affect bone structure, ligaments and joints. A vibration with frequency from 2000Hz to 10000Hz can lead to disorders in blood weasels in extremities, but higher frequencies can affect nervous system (Jankovskis, Beldava, Čūrišķis, & Strēlis, 2005). It is possible to avoid these negative effects, if vibrostimulation is applicated locally (Abercromby, Amonette, Layne, McFarlin, Hinman, & Paloski (2007).

Application of local vibrostimulation

During the experiment, the author used local vibrostimulation, so it is necessary to look over a methods of vibration application. The first method is the previous mentioned local vibrostimulation or method of direct application of local vibrostimulation, when the vibrotode can be applied straight to a muscle or its tendon. During this method it is possible to vibrate only a separate muscle, not a whole body. Usually in this method can be applied relatively high frequency of 100-150 Hz with a low amplitude no 1-2mm. When this method is applied, there can be observed an increasement of muscle tone, so it is called the tonic effect of local vibrostimulation. Other method includes indirect application of vibration, when the vibrations can be passed to a target location through other parts of the body. This method is called a whole body vibration, most of applications includes a subject standing on a vibration platform, or a subject can perform exercises on vibration platform. For example, when training a thigh quadriceps muscle while standing on a vibration platform, where vibration is made in a vertical direction, subject can perform various exercises, such as a squat, lunges and others. Vibration from the platform is guided through the lower leg to the four-headed muscles and other parts of the body (Krauksts, 2012). In this method usually low frequency oscillations are used, 25-45 Hz, but an amplitude can be 2-10 mm (Cardinale & Bosco, 2003). A side effect of this method is that other parts of a

body also receive vibrations, excessive or prolonged vibrations can lead to vibration sickness.

It is noted that the impact of vibration on work capacity is best seen by elite athletes, but it also depends on the individual's gender, age, psychological and, of course, physical fitness level (Cardinale & Bosco, 2003). Each individual has its own optimal vibration frequency depending on the set of goals and vibrating position. Therefore, during our experiment, subjects were able to individually adjust the frequency of local vibrostimulation according to their muscle senses to obtain a relaxing effect. This was necessary to temporarily improve the outcome of the next control set.

Methodology

At the beginning of the practical part of the work, an empirical method was used - an experiment using a method of control tests for women aged 18-23. The results of the study were compiled with a set of mathematical statistic methods: arithmetic mean, standard error, standard deviation and t-test.

During the experiment, local vibrostimulation was applied between the sets of control tests, during recovery period. Vibration was done on the femoral muscle of the lower extremity.

Initially, the participants of the experiment were interviewed for a short anamnesis vitae to find out about their health, and the history of injuries. If a subject previously had knee joint injuries, then she was excluded from an experiment as well as if the subject previously had health problems or trauma in the knee joint. Participants were questioned about age, fitness experience, weekly workouts and personal weight, as well as subjects were introduced with a local vibrostimulation and what effect it can provide, most of the subjects in the experiment had never heard of it. Based on the information obtained, 10% of the personal body weight was determined, this transformed to a resistance in kilograms on training machine, that was used to perform contraction – seated knee extension. Prior to executing the experiment, all its participants completed a unified warm-up procedure to ensure an identical level of conditions for all of participants, as well as to reduce the risk of injury during the experiment.

In total, three sets were done, each lasting for 30 seconds. Before the 2nd and 3rd set a vibrostimulation was performed in a recovery time with a low frequency of up to 50Hz to achieve a relaxing effect. Each subject was able to apply and adjust the frequency individually to achieve a relaxing, pleasant effect. Test subjects was explained before about feelings of relaxing effect of vibrostimulation. During the stimulation, as well as at the end of the experiment, the participants were questioned about the vibration senses in affected leg muscles. Most of participants admitted that for the first time feeling of local

vibration was not pleasant, but during the experiment the subjects concluded that the stimulated leg feels much relaxed, less tense. The test is carried out in a knee extension training machine, the motion was leg extension in knee joint. Training machine applies resistance with pneymatic principle, such excluding an inertia. During the exercise, the foreleg and the thighs muscles are included to execute an motion – a quadriceps femoris muscle group with vastus medialis, vastus lateralis, vastus intermedius and rectus femoris. For exercising this machine, the starting position is sitting on the machine, with the palms gripping the handles of the trainer to hold the body steady, the legs bent in the knees and the ankles remain under the fixating rollers. Procedure: 1. subject inhales and lifts the legs to a horizontal position; 2. subject exhale and lower legs to the starting position.

In the experiment, local vibrostimulation was implemented with the stimulating machine RE21 (vibrotode). Local vibration stimulation kit RE21 has different stimulation nozzles and each has its own effect and mode of action to different parts of the body. For example, a U-shaped nozzle has two heads that are parallel to each other at a distance of 3 cm, with a small surface area, giving a deeper impact on the vibrating surface. This nozzle provides a deep resonance effect that is amplified by both parallel-positioned heads and is used for high muscle mass vibration sessions by pushing the nozzle according the lymphatic flow. When performing a vibration session, the vibrotode is pressed by a force that did not cause discomfort to the athletes, and the pressure force was be given to the specialist who carries out the local vibrostimulation, taking into account the muscle mass to which stimulation is exposed. For example, the thigh quadriceps muscle will require more pressure on the vibrotode than the lower leg triceps surae muscle group. During the experiment, the author used local vibrostimulation with a narrow T-shaped nozzle of the vibrotode RE21. With this type of nozzle it was possible to achieve vibration effect deep over a larger area of the surface, the nozzle is also widely used for vertebra vibration stimulation, also on Achilles tendon, knee joint anterior cruciate ligament etc.

It should be taken into account that when acting on the joint, the frequency and amplitude, as well as the pressure force, must be correctly selected to avoid local damage. During the experiment, the author applied local vibrostimulation to a quadriceps femoris muscle with selected the nozzle, and the vibration complex RE21 was placed next to the subject and the subjects were allowed to adjust vibration frequency independently by themselves at a beginning of vibrostimulation sessions. The local vibration stimulation complex RE21 consists of a power supply unit with a potentiometer for frequency control, an on/off switch and a vibrotode. A separate switch regulates the rotation of the vibrotode engine, but it was not regulated in the author's experiment and was constant. The power supply unit also has a potentiometer that signals overload in the electrical circuit, the power supply unit is easy to handle behind the handle and weighs about

2.5 kg. During the experiment, the vibrotode was moved slowly in a straight line from the distal part of muscle to the proximal over a quadriceps femoris muscle surface, evenly pressed against the skin. The downforce with which the vibrotode was pressed on the surface was optimal without causing the subject a discomfort, as well as throughout the experiment it remained unchanged. Initially, the frequency was chosen to provide a relaxing feeling and not to cause excessive shock to the muscle.

Research results

Subjects on a pneumatic machine carried out a test exercise with a resistance of 10% of their body weight, for example, if the female body weight is 70 kg, the resistance will be 7 kg. The test set lasts for 30 seconds, during which the subject tries to as many repetitions as possible. The subject makes the first set without the effect of stimulation. In total, three sets of test exercise was done, with a stimulation after 1st and 2nd set of test exercise.

After test the subject answers the questions asked by the author and describes the feelings created by the vibration. At the beginning of the experiment, the local vibrostimulation was implemented at a frequency of 50 Hz and an amplitude of 1.5 mm, the vibration complex was positioned adjacent to the subject, so that each subject could individually adjust the frequency. When using vibrostimulation for the first time, subjects felt an itchy and a stinging sensation; however, with stimulation after the second set, the senses were no longer as intense as subjects were trended to raise the frequency, as comparing the first and second application of vibrostimulation frequency, an average increase of five hertz was observed.

The first set of knee extension was done without vibrostimulation and the average result was 20±1 repetitions. The second set, which was performed immediately after local vibrostimulation, showed an average increasement of 3 repetitions with a result of 23±2 repetitions. The data is statistically reliable and proves the effectiveness of local vibrostimulation after the second set. On the third set, an average increasement of 5 repetitions with a result of 25±2 was observed compared to the first one. The experimental t-test empirical value is 7,667 but the t-theoretical value is 2,262, the data is statistically reliable with significant increasement, data variation was 9%, and due to local vibrostimulation, the median result was improved on the stimulated leg.

Conclusions

Other researches shows, that in a voluntary contraction of a muscle more motion units can be involved than in a human controlled contraction via the somatic nervous system (Issurin & Tenenbaum, 1999), vibration training can

increase result in strength and speed expressions (Delecluse, Roelants, Diels, Koninckx, & Verschueren, 2005), so the vibration effect can be used to increase muscle strength.

The local vibrostimulation of the quadriceps femoris muscle showed an average increasement in both the second and third post-stimulation set. Result of stimulated leg was 25±2 times. Local vibration stimulation has a positive effect on the increasement of strength endurance. When comparing the first set (20±1 repetitions) with the third set (25±2 repetitions), the data show a mean increasement of results by 5 repetitions. The descriptive statistics data is statistically reliable and proves the effectiveness of local vibration on the stimulated leg, the empirical value of the t-test exceeds t-theoretical value. We can conclude that the application of local vibrostimulation with a subjects own chosen frequency can increase muscle strength endurance in local unilateral exercises even in several successive exercise sets.

This effect can be used in additional warm up (if it is necessary for an athlete), at the same time increasing athletes physical abilities. Then physician can rely on vibration caused soft tissue oscillations from vibrotode to solid surface (usually bone), creating a resonation, therefore more soft tissue can be affected (Михеев, 2007), but also this research shows, that each part of our body can have their own resonating frequency, even each subject can have their own resonating frequency for their muscles (according to strength and anthropometrical parameters of muscle). Therefore we used subject self-controlled frequency adjustment.

Also, local vibration can be used in rehabilitation, if subject is unable to contract his muscles for some reason, but a muscle tissue motion is required for rehabilitation process in joints (Захарченко, 2011).

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