EVALUATION OF THE EFFECT OF ISOMETRIC AND CLASSIC MASSAGE ON SELECTED PHYSIOLOGICAL AND BIOMECHANICAL PARAMETERS OF THE LOWER EXTREMITIES

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Abstract

Various forms of massage has been widely used in clinical practice. However, it is unknown whether which type of them is more effective. The aim of the paper was to determine the relationship between isometric and classic massage of the anterior part of the thigh and the following parameters: temperature of the surface of the muscles, bioelectrical activity, and muscle torque of the quadriceps femoris muscle. The study encompassed 40 women aged 19-23 years old. All participants had done thermal imaging, surface electromyography (sEMG), peak muscle torque of the extensor muscles of the knee joint. All tests and measurements were performed twice, i.e., before and after massage. The study involved conducting isometric massage (Group 1) and classic massage (Group 2) on the anterior part of the thigh (of the dominant limb). After both forms of massage, the temperature of the anterior surface of the thigh increased considerably ($p<0.001$). The temperature of the posterior part of the thigh and the lower leg also increased significantly. No significant differences were observed in the bioelectrical potential of the studied muscles. Furthermore, there were no significant differences in the muscle torques. However, the difference obtained in Group 1 was nearly significant ($p=0.091$). Isometric massage and classic massage cause a similar thermal reaction (measured through thermal imaging); however, isometric massage has a greater effect on the readiness for physical effort.

Key words: *isometric massage, classic massage, thermography, sEMG, peak torque*

Introduction

Massage is the most frequently used form of treatment in physical therapy and biological renewal. Therapeutic practices use all techniques of classic massage: stimulation techniques (wringing, kneading, and cupping), relaxation techniques (effleurage and shaking), and neutral techniques (friction) (Magiera & Walaszek, 2004; Benjamin & Lamp, 2005).

Classic massage has a widespread effect on the human body. It improves tissue nourishment, has a very strong effect on the nervous system (in particular, on the neuromuscular part), supports the circulatory system, relieves pain in muscles and joints, relaxes the body, and speeds up excretion (Magiera & Walaszek, 2004; Benjamin & Lamp, 2005).

Isometric massage is a variation of massage used to increase the strength and endurance of muscles. This kind of treatment is recommended both in the case of post-injury muscular atrophy and in training, as a complement to physical exercises. The treatment usually comprises three stages: the preparatory stage, the proper stage, and the final stage. The first stage involves preparing the massaged muscle through effleurage, friction, and kneading. The purpose of this stage is to induce hyperemia, stimulate the proprioceptors, and warm up the muscle tissues. The next stage involves energetic friction, kneading, and cupping an isometrically tensed muscle. The final stage, the aim of which is relaxation, involves effleurage, friction, gentle kneading, vibration, and shaking. In order to obtain the intended results of increased muscle mass, massage should be performed twice a day. Regularly performed isometric massage not only improves the strength of the massaged muscle, but it also improves the muscle's flexibility (Ratajczak & Płomiński, 2015).

Even though massage is considered to be one of the basic methods of preparation for physical effort and facilitating post-effort regeneration, the efficiency of massage is still a matter of discussion. Usually the assessment is based on the subjective feelings of an athlete or patient (Weerapong et al., 2005). From a scientific point of view, this is insufficient information.

The effect of changes in circulation may be observed in a quick and non-invasive manner by using infrared imaging. This method is effective, quick, and, first and foremost, entirely safe for the examined person (Costello et al., 2013; Chudecka & Lubkowska, 2015). It has also proven useful for the evaluation of the effectiveness of massage (Boguszewski et al., 2014; Adamczyk et al. 2016).

The measurement of muscle torque in isometric conditions is one of the most frequently used measurements of strength capabilities. The parameter is evaluated in the selected joint angle and is sometimes used to examine, e.g., athletes and patients in the early period after injury, surgery, and reconstruction within the musculoskeletal system when the application of isokinetics is impossible (Park et al., 2012; Lebrun et al., 2012).

The assessment of muscle torque allows for the changes in strength due to training, warm-up, and massage to be compared in stable conditions (Fu et al., 2012; Burnley et al., 2012).

Another examination evaluating the condition of a muscle is surface electromyography, which assesses the frequency of the stimulation of motor units comprising a given muscle (measurement of the frequency of a signal). The frequency of stimulation is affected by the nervous system. It influences the muscle strength generated and can be diagnosed along with the value of electric potential as a response to actions preparing for physical effort (Seiberl et al., 2012).

The two above-mentioned parameters of an sEMG signal, i.e., the frequency and value of electric potential, objectively evaluate the stimulation and tiredness of a muscle, and therefore, the preparedness of the muscle for physical effort due to the applied massage method (Seiberl et al., 2012).

The main research aim of the study was to determine the relationship between isometric and classic massage of the anterior part of the thigh and the following parameters of the quadriceps femoris muscles: peak muscle torque measured in static conditions, surface temperature, and bioelectrical potential.

Methods

The study encompassed 40 women aged 19-23 years old who were not engaged in competitive sports. Each participant was interviewed before the study about chronic diseases of the circulatory system and injuries to the lower limbs and spine that would preclude the assessment. Women without these diseases and injuries were included in the study. All participants were informed about the aim of the study and granted their written consent to take part in the study. The participants were randomly divided into two groups. Group 1 (n=18) underwent isometric massage of the quadriceps femoris muscles, and Group 2 (n=22) underwent classic massage of the quadriceps femoris muscles (Tab. 1). Participants were informed about the risks and provided their written informed consent. The study was approved by the Research Ethics Committee of University of Physical Education in Warsaw (No.SKE01-28/2012).

Tab. 1. Characteristic of examined persons (mean values ±SD)

group	age [years]	body height [cm]	body mass [kg]	BMI
Group 1 (n=18)	20.11 ±0.7	166.56 ±6.81	57.89 ±6.37	20.72 ±2.46
Group 2 (n=22)	19.82 ±0.99	166.68 ±6.59	57.19 ±6.53	20.55 ±2.14

There were measured: temperature of surface of lower limbs, maximum torque and surface electromyography in muscle quadriceps femoris. All tests were used twice – before and after the massage of muscles quadriceps femoris.

Camera Flir A 325 was used for thermographic pictures. The distance between the camera and the photographed object was marked as 0.5 m. The temperature of the room was in 22-24ºC range, while humidity 48-50%, and these parameters were in the so-called "Golden Standard". Before each thermometry, moisture was evaluated by means of a hygrometer (Ammer, 2008). Thermograms of the front (FS) and back (BS) surface of lower limbs for each subject were taken in a standing position. The regions of interest (ROI) on the front surface was scanned from the deflection in the hip joint to the ankle (excluding knee) and the back surface from the gluteal folds to the ankle (including popliteal fossa). The mean skin temperature (Tsk °C) from the examined ROI's was used for subsequent statistical analyses.

Examination with surface electromyography (sEMG) was conducted on the rectus femoris muscle of the dominant lower limb using a dual-channel NeuroTrac MyoPlus2 stimulator with NeuroTrac ETS 4.0 software (SENIAM, 2014). Electrodes were placed in accordance with the SENIAM (Surface Electromyography for the Non-Invasive Assessment of Muscles) protocol, which meets the European Recommendations for Surface Electromyography. The obtained result of the electromyographic examination was normalized by calculating the quotient of the bioelectrical activity of the resting rectus femoris muscle and its activity in tension (SENIAM, 2014).

Maximal torque was measured on the dynamometric Sumer UPR-02 arm-chair. The estimation of moments of powers one run on the dynamometric Sumer UPR-02 arm-chair with the software the Moment II. This measurement was taken in isometric conditions at the knee of a dominant limb bent to 75º and hip joints bent to 90º (the sitting position). The limb not under examination was freely let hang. The point of resistance fastenings was every time individually adapted to the examined and was situated on the tibia just above its upper ankle bone joint. By means of girdles with Velcro one stabilized hips and the chest, and the arms of the examined were crossed. The measurement lasted 20 seconds, and the person examined had a task to reach the highest moment of force and to hold it until the command "stop". For the analysis one used the maximum moment of force in the count on the kilogramme masses of the examined body (Hall & Getchell, 2014).

Isometric massage and classic massage (hand massage) were performed on the anterior surface of the thigh while the person being massaged lay on her back. Group 1 underwent isometric massage comprising three stages. The first stage (four minutes) involved preparing muscles for physical effort using classic techniques: effleurage, intensive friction, and kneading relaxed muscles. The second stage involved conducting a massage on isometrically tensed muscles (10-12 cycles, 30 seconds of tension and 30 seconds of relaxation), using friction, kneading, cupping, and vibration. In the third stage (2-3 minutes), the muscles were prepared for post-effort restitution using effleurage, gentle friction, longitudinal kneading, and shaking (Magiera & Walaszek, 2004; Benjamin & Lamp, 2005).

In Group 2, the treatment was performed in accordance with the methodology of classic massage using recommended techniques for obtaining neuromuscular stimulation and preparing muscles for physical effort. Therefore, effleurage was used in order to warm up the skin, make it more flexible, and increase the secretory functions of the sweat glands and sebaceous glands. Next, friction was applied in order to induce hyperemia of the massaged areas, increase the flexibility of the muscles, tendons, and the entire ligamentous and articular system, and eliminate muscular scleroses of different origins. Kneading was conducted in order to regulate muscle tone (through the mechanical stimulation of the proprioceptors) and increase the circulation of blood and lymph to facilitate tissue exchange in muscles (nutrition and the removal of products of metabolism). All techniques were conducted in a fluid, yet energetic, manner1. Both treatments were applied to the dominant limb for 12 minutes.

In order to analyze the empirical data, the following statistical tools were used: the arithmetic mean value with standard deviation, the Wilcoxon signed-rank test, and the Pearson correlation. The minimum level of significance was established at $p < 0.05$. The calculations were performed with the use of Statistica 10, the license for which was owned by the Medical University of Warsaw.

Results and discussion

After both forms of massage, the temperature of the anterior surface of the thigh increased considerably ($p<0.001$). The temperature of the posterior surface of the thigh and the lower leg also increased significantly. The temperature of the anterior surface of the lower leg increased considerably only in Group 2 (Table 2).

No statistically significant differences in the bioelectrical potential of the studied muscles were observed. Near-significant values were observed in the case of the vastus medialis muscle ($p=0.089$) and vastus lateralis muscle ($p=0.127$) in Group 1 (Table 3).

No statistically significant differences were observed in the case of muscle torque. However, the difference revealed in Group 1 was nearly significant ($p=0.091$) (Table 4).

The study found a significant positive correlation between the temperature of the surface of the anterior part of the thigh and the bioelectrical activity of the rectus femoris muscle after isometric massage ($r=0.59$, $p<0.01$). A reverse relationship was discovered in the case of persons who underwent classic massage; however, the negative correlation in Group 2 was not significant. The temperature of the surface of the thigh correlated positively with the peak muscle torque, but this correlation was not significant (Table 5).

Tab. 2. Temperature [°C] of surface of lower limbs before and after the massage

group	part of body	side	before	after	difference
Group 1 (n=18)	thigh	front	30.48 ±0.58	32.18 ±0.76	**0.000**
	shin		30.75 ±0.53	30.89 ±0.75	0.322
	thigh	back	30.53 ±0.65	31.54 ±0.83	**0.000**
	shin		30.40 ±0.66	31.16 ±0.83	**0.001**
Group 2 (n=22)	thigh	front	30.33 ±2.35	32.20 ±1.51	**0.000**
	shin		29.76 ±2.05	30.91 ±1.22	**0.009**
	thigh	back	30.63 ±2.15	31.94 ±1.55	**0.001**
	shin		30.28 ±2.01	31.41 ±1.34	**0.003**

Tab. 3. Bioelectric activity of examined muscles [μV]

group	muscle	before	after	difference
Group 1 (n=18)	vastus medialis	142.69 ±71.21	199.17 ±135.28	0.089
	rectus femoris	91.62 ±40.13	97.23 ±45.77	0.539
	vastus lateralis	95.30 ±39.99	116.42 ±80.14	0.127
Group 2 (n=22)	vastus medialis	80.09 ±28.46	80.14 ±31.09	0.932
	rectus femoris	89.90 ±25.24	92.73 ±28.61	0.655
	vastus lateralis	79.68 ±27.71	77.36 ±27.01	0.584

Tab. 4. Peak torque of quadriceps femoris [Nm]

group	before	after	difference
Group 1 (n=18)	173.81 ±75.67	187.70 ±68.45	0.091
Group 2 (n=22)	170.35 ±51.62	181.26 ±81.7	0.447

Tab. 5. Correlations between temperature and bioelectric activity and peak torque of rectus femoris [r]

group	correlations	before	after
Group 1 (n=18)	temperature and bioelectric activity	0,44*	0,59**
	temperature and peak torque	0,12	0,28
Group 2 (n=22)	temperature and bioelectric activity	-0,18	-0,23
	temperature and peak torque	-0,24	0,25

* p<0.05; **p<0.01

Discussion

The aim of the study was to determine the relationship between isometric/classic massage of the anterior part of the thigh and the temperature of the skin on the surface of the muscle, and between isometric/classic massage of the anterior part of the thigh and the selected physiological and biomechanical parameters. Despite a similar effect on temperature (and thus, on skin perfusion), isometric massage had, as expected, a greater effect on the strength and bioelectrical potential of the massaged muscle group.

The basic factors determining muscle strength include the length of a muscle (joint angle), the speed of muscle contraction, the number and kind of muscle fibers, the cross section of a muscle and the pennation angle it displays (the angle of muscle fibers in relation to the long axis of a muscle), and the degree of stimulation from the nervous system. In this context, physical fitness tests are usually conducted in order to evaluate the effectiveness of a training program and the effectiveness of individual exercises (Della et al., 2012; Diaz-Lara et al., 2014). Muscle strength is a value which cannot be measured in a direct manner. Measurements conducted in exercise rooms allow for the registration of the values of strength derivatives, such as velocity. Strength can be measured directly in clinical conditions by measuring muscle torque (F*r) in static conditions using the properties of a lever. This allows for the most accurate determination of the strength of a particular muscle or group of muscles responsible for a given movement (Lewandowska et al., 2011; Pędzich et al., 2012). This is why the method of measuring muscle torque may also be useful for determining the effect of physical treatment on the efficiency of muscles. In our own research, we confirmed the previous findings made by, e.g., Altamirano et al. (2012), which did not reveal a significant effect of warm-ups on peak muscle torque.

This paper is based on an assumption that the results of thermal imaging allow for the observation and evaluation of metabolic reactions that take place in active muscles (Romanovsky, 2007). The study observed that the applied forms of massage caused an increase of surface temperature in all regions of interest (ROI). The change was insignificant only on the case of the anterior part of the lower leg. This strengthens the previous observations concerning the effect of massage on circulation (Cabak et al., 2013; Boguszewski et al., 2014). However, the effect on the muscle's capability for physical effort does not have to be this explicit. The increase of skin perfusion, which is the result of mechanical pressure on tissues, simultaneously causes the outflow of blood from muscle (Hinds et al., 2004). The degree of these changes depends on the force of the stimulus and its duration (Kaciuba-Uściłko & Grucza, 2001). In the context of preparing for physical effort, such an effect may be unfavorable. Another explanation may be the fact that pre-effort massage may have a negative effect on muscles possibly because of the increased activity of the parasympathetic nervous system and the decreased ability to stimulate motor units. In turn, mental effects may indicate that massage has a positive role in some sports disciplines, especially in athletes with high temperamental reactivity (Arroyo-Morales et al., 2011).

Theoretically, the lack of increase in the frequency of stimulation may also indicate that massage is ineffective at stimulating the neuromuscular system for activity (Pereira et al., 2011; Ghasemi et al., 2012). On the other hand, studies prove that sports massage, and even self-massage, combined with warm-up exercises may be an effective treatment in preparing for physical effort. Sports massage has also been proven to have positive effects in athletes who participate in sports competitions, both in non-measurable disciplines (boxing) and in measurable disciplines (Beyleroglu et al., 2009; Boguszewski & Kwapisz, 2010; Galloway & Walt, 2004).

The increase of muscle torques also did not reach statistically significant values, although, in the case of Group 2, the values were near the threshold of $p<0.05$. Therefore, it can be assumed that the slight increase that was observed in both investigations, especially in the case of isometric massage, may to a greater extent be connected to a correct intermuscular coordination, and not to an intramuscular coordination. This would explain the improvement more in terms of the effect of learning an exercise, rather than the effect of massage on the physiological and biomechanical parameters of the lower limbs. Therefore, it seems that the knowledge of the potential effects of massage is still insufficient, which justifies the necessity of conducting further research (Weerapong et al., 2005).

Thermography has widespread potential applications in the monitoring of sports training. The research by Kenfick et al. (2010) proved that a very high skin temperature (which is often accompanied by dehydration) is a potential indicator of a significant load on the cardiovascular system For a person conducting training session or massage, it may be a signal to change the intensity or stop the activity, etc. Analyzing images from a thermographic camera allows one to, first and foremost, search for ways to improve sports results and therapy results (Adamczyk et al., 2014).

Conclusion

1. Isometric and classic massage both had a similar effect on the temperature of the surface of the muscles. Thermal imaging may be a safe method for evaluating the effectiveness of massage.
2. Isometric massage had a greater effect on peak muscle torque and the bioelectrical activity of muscles than classic massage, although the effect of massage on the capability for physical effort seems to be limited.
3. Research on the use of massage to support sports training and rehabilitation (also with thermographic methods) should be continued on a wider scale.

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