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Influence of radial shockwave on the mechanical properties of quadriceps femoris muscle fibres of a football player: case study

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Key words: Radial Shockwave Therapy (RSWT), tensomyography (TMG), sport physiotherapy

Abstract

Radial Shockwave Therapy (RSWT) is a physical procedure often used in sports physiotherapy. Most often, the Radial Shockwave Therapy is used to loosen tight muscle strands, stimulate connective tissue, relax the fascia, treat superficial trigger points, and trigger metabolic changes in muscle fibers. The database of scientific literature lacks reports on the impact of RSWT on the muscular properties of muscles in football players. The purpose of this case report is to assess the impact of RSWT on the mechanical parameters of muscle fibres of quadriceps muscles: (Dm) – displacement of muscle, (Tc) – Time of contraction. RSWT was applied to a healthy football player on the quadriceps muscle of the thigh, finishing the lower right and left. The tensiomyography (TMG) was used to evaluate the mechanical properties of muscles fibres. The tensiomyography (TMG) was performed, followed by radial shockwave therapy (RSWT), second TMG after RSWT procedure and third TMG measurement after 5 hours from the second measurement. The tensiomyography (TMG) detected changes in the parameters of muscle work after the use of RSWT and is a useful tool to assess the impact of physical on muscle work.

INTRODUCTION

The quadriceps muscle plays a crucial role in the extension of the knee and its stabilization. Due to the different functions of the heads of the quadriceps femoris, one can distinguish predominance of fatigue-resistant fibers and fast twitch muscle fibers in the belly. Therefore, the medial head of the quadriceps muscle (vastus medialis) will play a different function than the straight head (rectus femoris). During physical therapy with a player, paying attention to the function of the muscle is crucial in the selection of different physical agents (PAs). An additional factor which should be taken into account, while choosing the said physical agents are the proper mechanical parameters of the quadriceps muscle. Time of contraction (Tc) and displacement of muscle (Dm) determine the quality of its contraction during exertion.

The parameters describing the mechanical properties of muscles are Time of contraction (Tc) as well as the Displacement of muscle fibers (Dm) [1-5]. The quadriceps femoris muscle is one of the most important muscles for football players [6]. The proper mechanical parameters of the quadriceps femoris muscles have a direct impact on the knee of the football player, that is often at risk of injury [1, 4, 7, 8].

Tensomyography (TMG) is a non-invasive method of assessing the mechanical properties of muscles [1]. This procedure was introduced to clinical in Slovenia as early as the 90's, by medical and technical scientists. Since then, tensomyography (TMG) has become an objective and non-invasive method of evaluating the mechanical properties of muscle fibres [1, 9].

This procedure is not only used to monitor the work of players' muscles in various sports, but also to monitor the rehabilitation process. The main objective of tensomyography (TMG) is the early detection and prevention of muscle asymmetry around a certain joint, monitoring certain mechanical parameters of muscle, detecting and preventing incorrect muscle work, which could result in an injury, the assessment of muscle stiffness, assessment and the optimization of the rehabilitation process and sports training [10-15]. However, the most important aim of tensomyography (TMG) is the prevention of injury [16]. Tensomyographical assessment is used worldwide in order to evaluate the impact of PAs on the parameters of muscle contraction [17-19].

Scientific studies conducted by Calvo and Murray [18-19] confirm that, tensomyography (TMG) may be applied in order to evaluate the impact of various physical methods on muscles' mechanical properties. So far, various techniques of massage and electrotherapy

have been tested. Radial Shockwave Therapy (RSWT), which is often used prior or following a training session, has not yet been scientifically tested in TMG studies[22]. The shockwave is an impulse of a pneumatic mechanical wave with special characteristics. It is characterized by jump change in pressure, high amplitude and non-periodicity. The kinetic energy of the projectile created by compressed air is transferred to the transmitter at the end of the applicator and further into the tissue [22, 23]. The procedure has a biological impact on tissues, for example increasing the permeability of cellular membrane, new blood vessel formation, stimulation of collagen production, reversal of chronic inflammation and the dispersion of pain mediator (substance P), release of trigger points (TP) [22- 24]. Therefore, RSWT has a direct impact on tissue regeneration. It allows to locate and treat superficial trigger points (TP), relax tense muscle fibers and has an analgesic effect [22, 25-28].

The aim of the research was the analysis of the impact of the widely used dose of Radial Shockwave on the parameters of muscle contraction: Time of Contraction (Tc) and the Displacement of muscle fibers (Dm) in particular heads of the quadriceps femoris muscle in a football player, both in his dominant and contralateral lower extriemity. The analysis was conducted directly after the treatment and five hours after the treatment.

MATERIAL AND METHODS

Football player age 18, weight 68kg, height 176cm (BMI 22), with a dominant right leg, training football for the past 9 years. Playing as a wing-midfielder. An injury of the quadriceps femoris muscle has been excluded in the tested subject. The study was conducted during a training-free time, during the break between the autumn and spring games. In the beginning an evaluation of the contraction of the rectus femoris and the iliopsoas muscles was conducted bilaterally. During the first test the player was lying supine, calves out of the couch, the examiner pulled one of the lower limbs towards the players chest. Under evaluation was the angle between the couch and the contralateral lower extremity. The test was conducted bilaterally. The evaluation of the contraction of the iliopsoas muscle was conducted in the same position, however the angle of the external rotation of the contralateral lower extremity during elevation was evaluated. The test was conducted bilaterally. A contraction of the examined muscles was observed in neither of the muscles.

Later, an evaluation of the mechanical properties was conducted of the following muscles: vastus lateralis of quadriceps femoris (VL), vastus medialis of quadriceps femoris (VM), rectus femoris (RF) of both the left and right lower extremities. The measurement of the mechanical properties of the muscle was conducted with tensomyography (TMG) prior

to RSWT. The following parameters were assessed: time of contraction (Tc) and Dislocation of the muscle (Dm). The aim of the conducted studies was to assess the initial mechanical parameters of the quadriceps femoris in the tested subject. The subject was lying supine on the couch with his head supported. The tested lower extremity was positioned at an angle of 120 degrees on a special wedge placed beneath the knee ensuring a proper positioning of the lower extremity. Electrodes were placed on each of the heads of the quadriceps femoris muscle according to the guidelines keeping a 5 cm distance between each of them. The size of the electrodes was chosen according to the size of each of the heads. A sensor collecting the parameters of mechanical work of the muscle was placed between the electrodes. The accuracy of the sensor was 1μm with a controlled initial pressure of $1,5 \times 10^{-2}$ N/mm².

An electrical impulse causes a radial dislocation of the sensor from the muscle and the collection of the results of the changes in the mechanical properties of the muscle. The placement of the electrodes and the sensor were marked with a black marker in order to properly repeat further examinations in exactly the same locations. In order to trigger muscle contractions a rectangular impulse with duration pulse 1 ms was used. The separations between pulses was 20 ms (standard parameters for electrostimulation of a normal muscle).

After the first TMG examination a RSWT was conducted with the following parameters:

- 3,2 bar
- 8 Hz frequency, 5000 pulses
- Time of procedure: 8,22 s.

A convex applicator, dedicated to working out large muscle bellies was used. A massage with the applicator was conducted along the muscle fibres across all the heads of the quadriceps muscle.

After the RSWT a second assessment of mechanical properties (Tc and Dm) of the quadriceps muscle was conducted. The aim of this assessment was the evaluation of changes which occur directly after the RSWT. Another evaluation was conducted 5 hours after the RSWT.

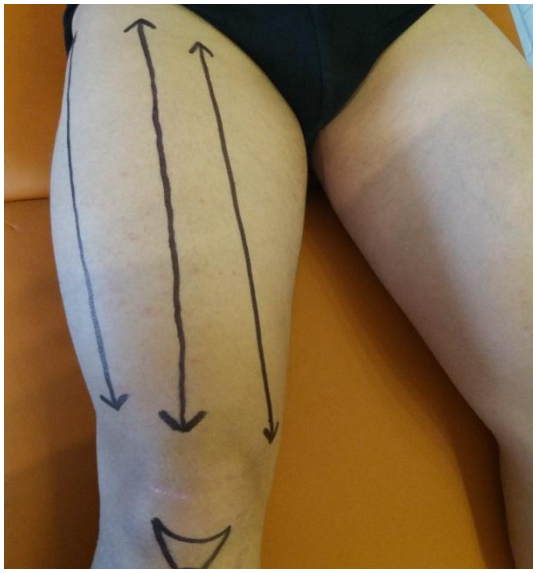

Fig .1. Appliaction of Radial Shock Wave Therapy of the muscle quadriceps.

RESULTS

Comparing the percentage changes taking place during the contraction of the straight head of the rectus femoris (RF) after the application of RSWT (Fig. 2) on the left side, one can observe an 8% decrease in Tc, however, on the right side (dominant) one can observe a 7% increase. During the second evaluation 5 hours after the treatment Tc on the left side deteriorated even more (16%) in comparison to the initial state, on the right side however decreased by 3%, but it never reached the initial state.

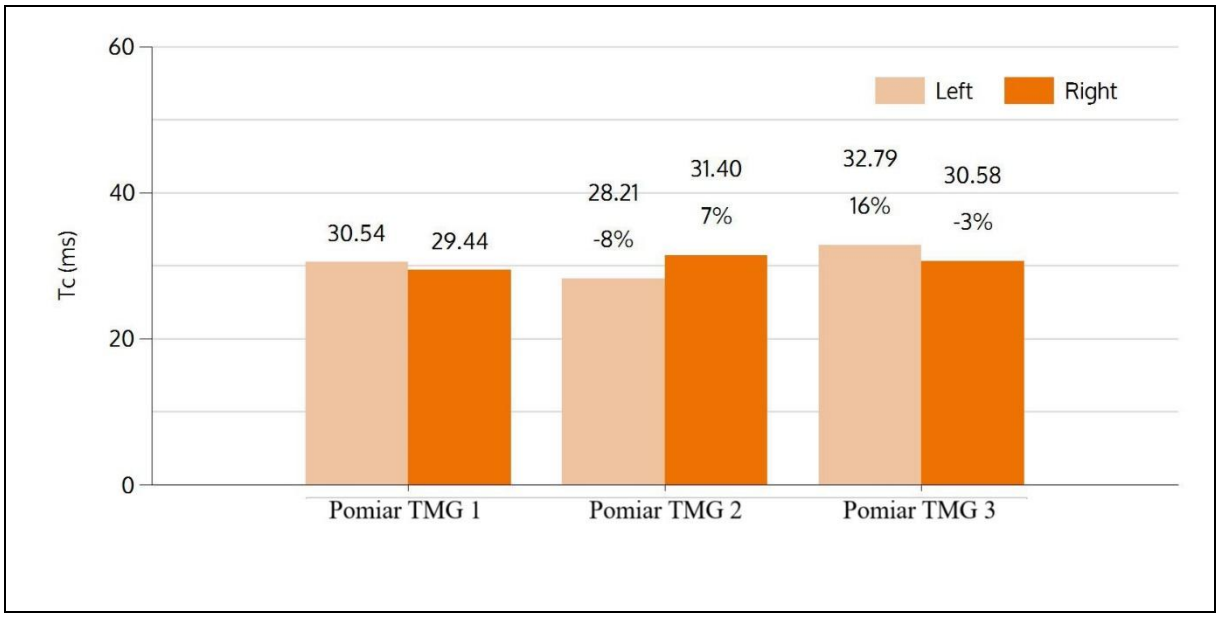

Fig.2. The comparison of the percentage results of the TMG changes in Tc of the rectus femoris on the right and left side.

Analysing the changes found in the parameter Dm after the RSWT in the left and right muscle (Fig.3.) a slight 2% increase which indicates the slight relaxation of the muscle fibres. After a 5 hour period a further increase in Dm was detected, 1% on the left and up to 12% on the right side which means a bigger relaxation on the right side.

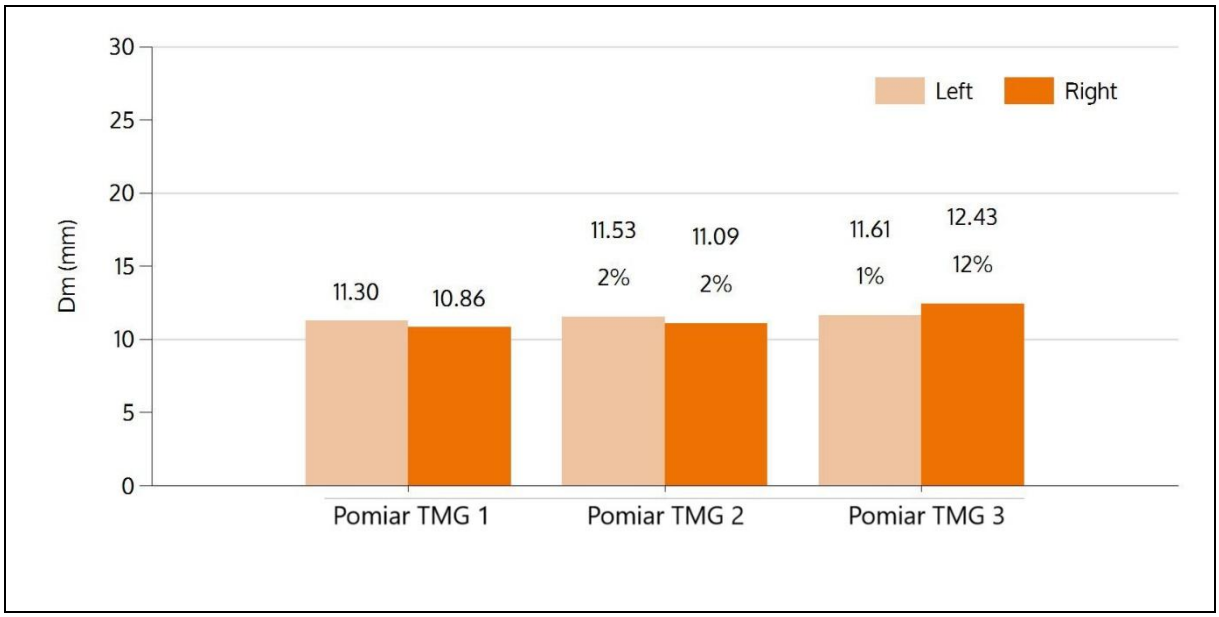

Fig.3. The comparison of the percentage results of the TMG changes in Dm of the rectus femoris (RF) on the right and left side.

Comparing the percentage changes taking place during the contraction of the vastus medialis (VM) of the quadriceps femoris after the application of RSWT (Fig. 4) on the left side, one can observe a 1% increase in Tc, on the right side (dominant) one can observe a 1% decrease. During the second evaluation 5 hours after the treatment Tc on the left side increased dramatically up to 13% in comparison to the initial state, on the right side there was a slight increase only by 2% comparing to the initial state.

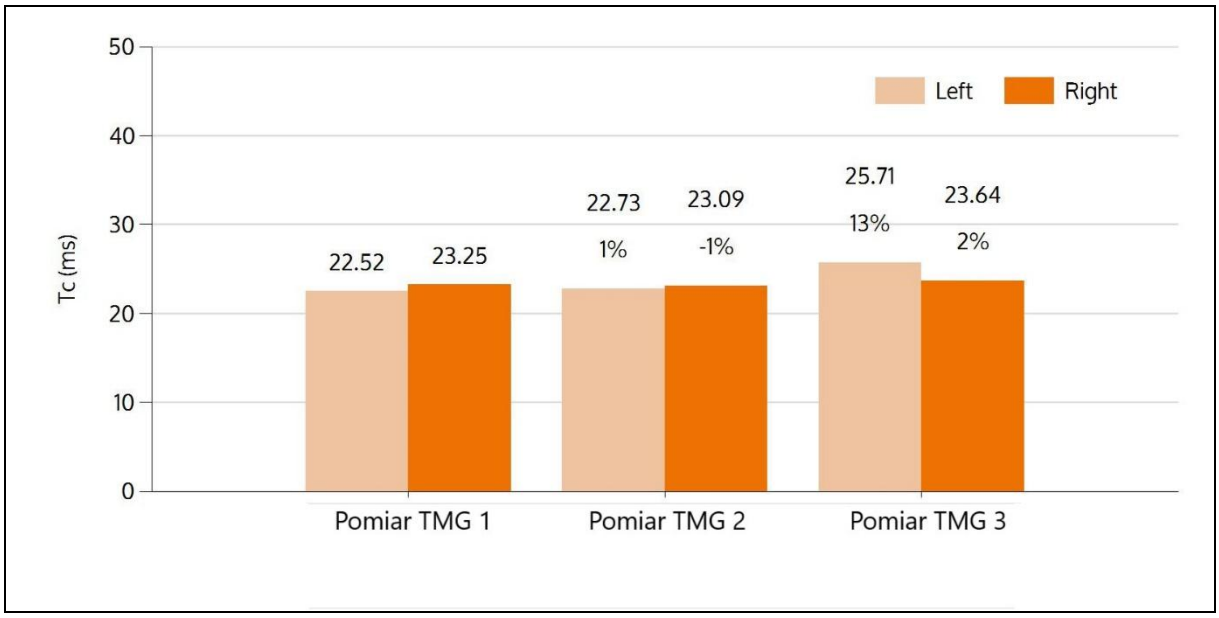

Fig.4. the comparison of the percentage results of the TMG changes in Tc of the vastus medialis (VM) of quadriceps femoris on the right and left side.

Analysing the changes found in the parameter Dm after the RSWT in the left and right muscle (Fig.5.) a 16% decrease on the left side and 7% decrease on the right side compared to the initial state which may indicate the increase of muscle stiffness. After a 5 hour period the situation improved slightly but the parameters did not return to the initial state.

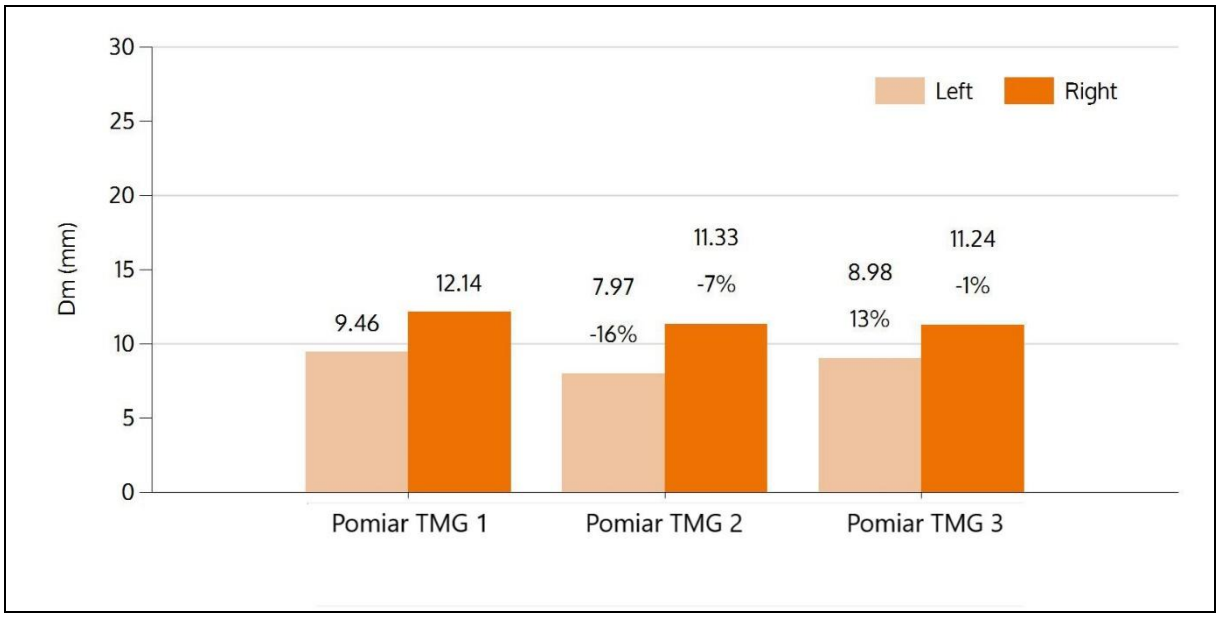

Fig.5. The comparison of the percentage results of the TMG changes in Dm of the vastus medialis (VM) of quadriceps femoris on the right and left side.

Comparing the percentage changes taking place during the contraction of the vastus lateralis (VL) of the quadriceps femoris after the application of RSWT (Fig. 6) on the left side, one can observe the same phenomenon as in the rectus femoris (RF) of the quadriceps muscle, so the decrease in Tc, on the left side (dominant) up to 16% and 7% on the right side. During the second evaluation 5 hours after the treatment Tc on both sides remain shortened in comparison to the initial state.

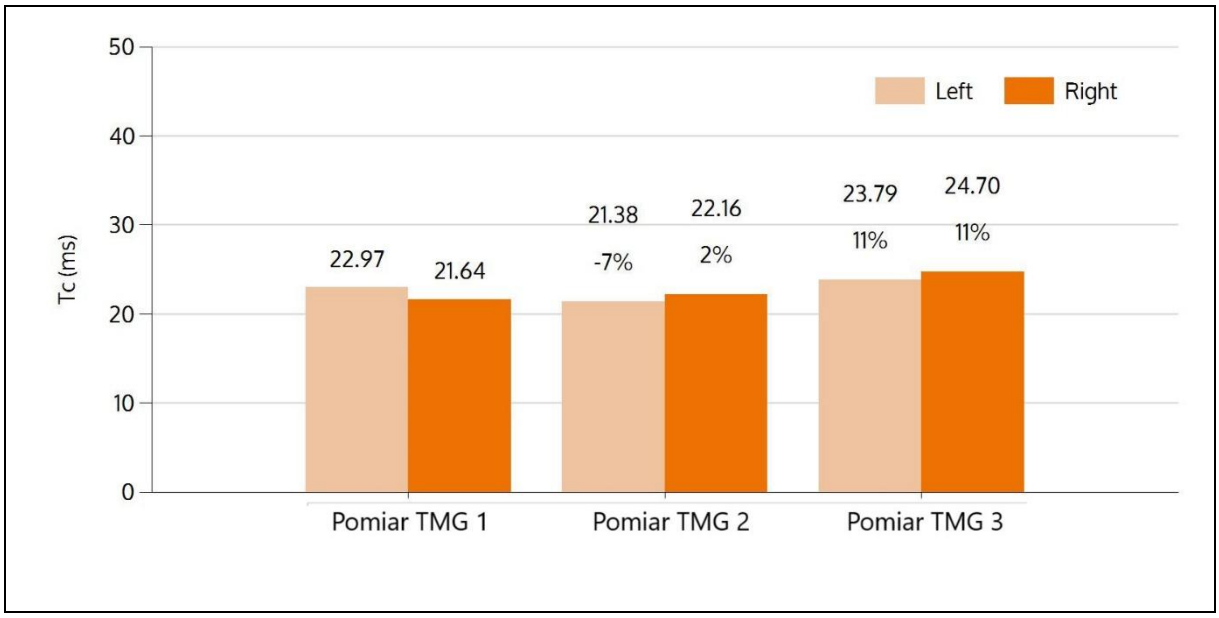

Fig. 6. The comparison of the percentage results of the TMG changes in Tc of the vastus lateralis (VL) of quadriceps femoris on the right and left side.

Analyzing the changes found in the parameter Dm after the RSWT in the left and right vastus lateralis of quadricept femoris (Fig.7.) a 14% increase on the left side and 6% decrease on the right side compared to the initial state. After a 5 hour period a 10% decrease was observed bilaterally, however on the right side the Dm after 5 hours was smaller than that during the initial state.

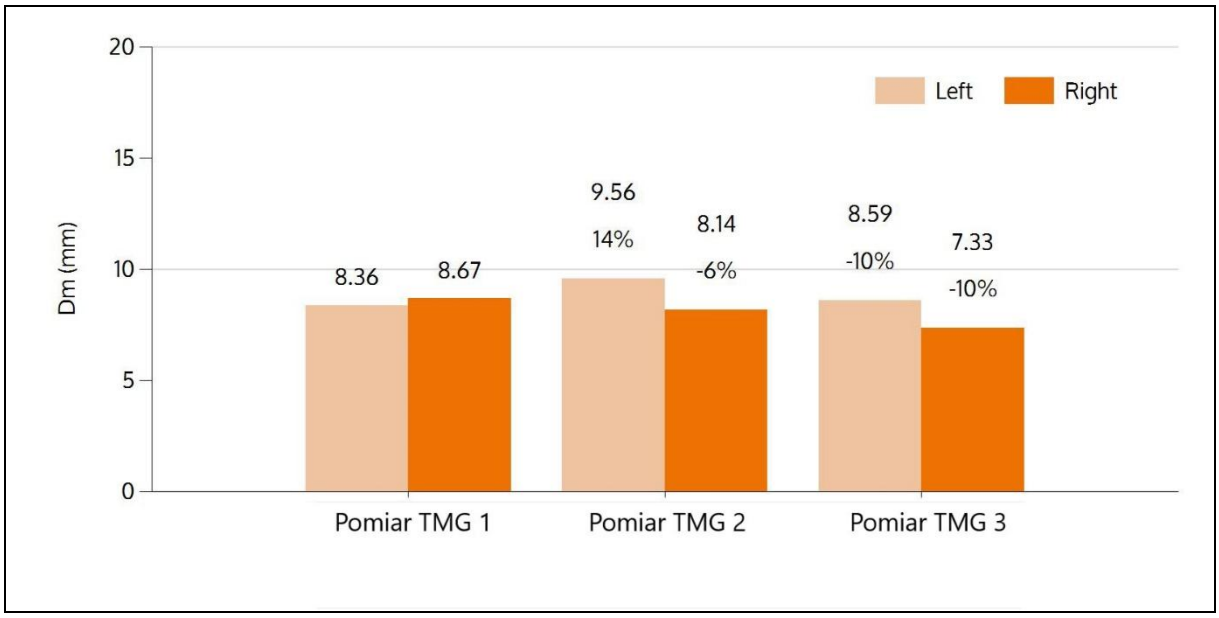

Fig.7. The comparison of the percentage results of the TMG changes in Dm of the vastus lateralis (VL) of quadriceps femoris on the right and left side.

DISCUSSION

The results confirm that radial shockwave therapy (RSWT) is an intensive physical agent which has an impact on mechanical properties of muscle fibres. Because of its relaxant effect, this procedure is frequently used in sport physiotherapy [29]. From a therapist's point of view, information on the influence of RSWT on mechanical properties of muscle fibres are of the great importance because quadriceps femoris in a football player plays a crucial role in functional stabilization of the knee [6,30].

The scientific research has proven, that the parameter - time of contraction (Tc) describes the quality of muscle contraction, its symmetry, the profile of muscle fibers indirectly (slow twich fibres, fast twich fibres), muscle condition (relax, tense) [31,32]. Parameter of displacement of the muscle (Dm) however, provides information on morphological properties of muscle fibres, muscle stiffness, muscle tonus (loose, weak) [1,33]. These parameters have been a subject of many scientific research in football players so far [1,31-34].

Having observed the changes in mechanical properties of the muscle under the influence of RSWR, one can deduct that tensomyography (TMG) can reflect these changes. The analysis of the initial stage has proven that the Time of contraction (Tc) of vastus medialis (VM) and lateralis (VL) of quadriceps femoris is shorter than rectus femoris (RF), Time of contraction (Tc) of rectus femoris and vastus medialis of quadriceps femoris

is shorter in left dominant lower extremity. On the left side, however (in a lower non dominant limb), Time of contraction (Tc) of vastus lateralis is the shortest. It may result from the different character of muscle contraction in these bellies both on left and right side of the sportsman.

After having applied RSWT Time of contraction (Tc) on the right side increased directly after the therapy, and remained prolonged in rectus femoris (RF) and vastus lateralis (VL), up to 5 hours since the time of therapy. On the other hand, in vastus medialis (VM) Tc was shortened insignificantly directly after the therapy and after 5 hours it was prolonged. On the left side the observed changes had even greater range. Deterioration of time of contraction was observed especially in a less trained muscle.

Further changes have been observed in the parameter of Dislocation of muscle (Dm) under the influence of RSWT. A slight increase of dislocation of muscle has been observed in rectus femoris (RF) which stayed up to 5 hours especially on the right side. This change suggests the relaxation of the muscle. On the other hand, the shortening of dislocation of muscle (Dm) was observed in vastus medialis (VM), this change continued up to 5 hours especially on the left side. This change suggests the increase in muscle stiffness. Changes in vastus lateralis (VL) had a different course depending on a dominant side. Muscle stiffness increased on the right side and relaxation was observed on the left.

Rectus femoris (RF) produces low-level sustained contraction and fatigues slowly. The muscle can be exposed to long and great load, the process of recovery, however, is longer. The observed changes may suggest lack of proper dynamic of dislocation of muscle (Dm) which in perspective of slow twich fibres (like in rectus femoris) may result in its weakness and dysfunction.

Rectus medialis of quadriceps femoris has predominantly fast twich fibres which can provide brief and forceful contraction. It produces a large force for short periods and recovers longer than muscle with slow twich fibres. One may deduct, that the applied dosage of RSWT has a negative impact on Time of contraction (Tc) of vastus medialis quadriceps femoris. This may result in its dysfunction during activity. In both right and left muscles the increase in muscle stiffness comparing to the initial stage has been observed.

CONCLUSIONS

Our observation has confirmed the influence of Radial Shockwave Therapy (RSWT) on the mechanical properties of muscle fibres. Results of the therapy applied to a football player (wing-midfielder) have shown the deterioration of the mechanical parameters of muscle contraction on both sides, but especially on the left. Relaxation of rectus femoris was observed, on the other hand, stiffness of vastus medialis and lateralis. Based on the single procedure in one football player one may observe certain tendencies, which require confirmation on a greater number of subjects. Due to tensomyography (TMG) one can monitor the condition of the muscle after physical therapy, however, further conclusions may be drawn studying various dosages of RSWT on a bigger population.

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