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The effects of foam rolling applied to delayed-onset muscle soreness of the quadriceps femoris after Tabata training

Dariusz Boguszewski[1], Agata Krawczyk[2], Marlena Dębek[2], Jakub Grzegorz Adamczyk[3]

[1] Department of Individual Sports, Józef Piłsudski University of Physical Education, Warsaw, Poland; [2] Department of Rehabilitation, Medical University of Warsaw, Poland; [3] Department of Theory of Sport, Józef Piłsudski University of Physical Education, Warsaw, Poland

Abstract

Study aim: The aim of the present study was to assess the effect of roll-over self-massage on the occurrence of symptoms of delayed post-workout muscle soreness after Tabata training.

Material and methods: The research involved 81 people, randomly divided into two groups. A series of three roller self-massages was applied by members of Group 1 (n = 33). Persons assigned to control Group 2 (n = 48) did not undergo any procedures supporting the post-workout recovery. All participants performed training of lower limb muscles, according to the Tabata protocol. Then the frontal surface of the thighs was tested with a thermal imaging camera. The intensity of pain was measured (by the Visual Analogue Scale – VAS) after 24, 48 and 72 hours.

Results: The highest average pain level in Group 1 was recorded at the second measurement, i.e. 24 hours after training, and in Group 2 after 48 h. In the study group, a significantly lower result was observed on each successive day. The differences between the groups in pain levels measured 48 and 72 hours after exercise were statistically significant ($p < 0.05$).

Conclusion: Self-massage with a roller accelerated muscle regeneration. It can therefore be an effective procedure to support post-workout recovery, especially for athletes during the start period.

Key words: Foam rolling – HIIT – Self-massage – DOMS – Post-exercise recovery

Introduction

Delayed onset muscle soreness (DOMS) is found both in recreational athletes after intensive training, usually involving eccentric muscle work, and in people who are training regularly or professionally, who add new exercises to their training programmes or return to training after a longer break. DOMS can also affect the performance of athletes. As a result of the occurrence of muscle soreness and damage to the muscles and connective tissue, the mechanics of joints and changes in the functioning of the muscles may change. The following may also reduce training capacity: weakened proprioception, overestimation of strength capacity, reduced range of movement, decreased strength and power, changes in the ratio of agonistic and antagonistic muscles, changes in recruitment patterns or increased risk of injury, all occurring in the course of DOMS. By means of adaptation, athletes can then create compensation patterns that cause a decrease in their sports performance [13, 26].

The role of physiotherapy in this case is to optimise the recovery processes. Treatments are designed to reduce the severity of symptoms, but also to enable athletes to train more often and improve their performance. The most commonly used treatments to minimize the ailments associated with DOMS include sauna and classical and cryotherapy massage [2, 4, 7, 27, 32].

Nowadays, various self-massage methods are gaining more and more popularity. One of them is the foam rolling technique – myofascial release. The action of self-myofascial release (SMR) is based on applying a targeted direct stimulus with low contact force. Studies have shown that this stimulates the Golgi tendon organs, which detect a change in muscle fibre tension and cause them to relax. As a result, normal muscle tissue function is restored, and abnormal fascial tensions are eliminated [3, 12]. Using the effect of compression on the muscle and fascia, self myofascial release presents a number of important results: it improves muscle recovery, increases flexibility, and improves muscle performance. Foam roller self-massage,

Author's address Dariusz Boguszewski, Department of Individual Sports, The Józef Piłsudski University of Physical Education, Marymoncka 34, 00-968 Warsaw, Poland dariusz.boguszewski@awf.edu.pl

categorised as an active form of exercise support and post-exercise recovery, prolongs and increases muscle congestion, which, in turn, greatly facilitates muscle activation and recovery. The tool used in it is widely available. More and more research on its use has begun to emerge. Authors often compare its action to manual massage or other physical treatments [1, 3, 6, 22, 24, 28]. One potential application of rolling is to support post-workout recovery, so the aim of the present study was to assess the effect of roll-over self-massage on the occurrence of symptoms of delayed post-workout muscle soreness after high intensity interval training (Tabata formula).

Material and methods

Characteristics of examined people

The research involved 81 people (54 women and 27 men) aged 19–24 years, randomly divided into two groups (Table 1): Group 1, n = 33 (research) and Group 2, n = 48 (control).

Research tools

The research tool was the Visual Analogue Scale (VAS) to assess pain severity, with a range of values from 0 to 10, where 0 means no pain and 10 means maximal pain. A thermal imaging camera (FLIR A325, FLIR Systems, Sweden) was used for all infrared (IR) measurements (temperature of lower limb surface) [19]. In addition, heart rate measurements were taken (before and after training) along with the subjective effort intensity evaluation on the Borg scale – after training (the range of values 6–20) [9]. Our own survey was used to collect biometrical data.

Research protocol

All participants performed a 5-minute warm-up and then (after 1 minutes) interval training of lower limb muscles, according to the Tabata protocol. The effort duration was 20 seconds and the break time was 10 seconds, which was repeated in eight series, with four minutes of intensive training in total [30, 31]. A jumping squat exercise was used for this purpose. The persons taking part in the study were instructed on the correct exercising technique.

Prior to exercise, each participant had his or her resting heart rate measured on the radial artery, repeated after training and used for subjective evaluation of exercise. After the physical effort, the participants of the study evaluated the level of the performed effort on the Borg scale (6–20).

Before the training intensity of pain on the quadriceps femoris muscle in the dominant limb was assessed (by VAS). Then pain at the quadriceps femoris muscle level was checked after 24 hours, 48 hours and 72 hours.

The frontal surface of the thighs (dominant limb) was tested with a thermal imaging camera. The camera had a measurement range from –20 to +350°C, an accuracy of ±2°C or ±2%, a sensitivity below 0.05°C, an infrared spectral band of 7.5–13 μm, a refresh rate of 60 Hz, and a resolution of 320–240 pixels of the focal plane array. It had a valid certificate and was calibrated for repeatability and accuracy of measurements according to the Glamorgan protocol [5]. Each measurement was made with the device positioned perpendicularly to the tested surface. The distance between the camera and the person examined was 2.5 m. The ambient temperature was 22–24°C, while the humidity was within 48–50%. The measurement with a thermal imaging camera was taken before (participants could have a 10-minute rest before all procedures) and immediately after the physical exercise (Fig. 1 and 2), and 24, 48 and 72 hours later in all participants.

Group 1, consisting of 33 people, performed the self-massage with a roller immediately after the training and for the next two days. A 33 cm long roller with a 14 cm diameter was used for this purpose. Respondents used smooth foam rollers of medium density.

Three positions were used in the procedure. The first position was plank on forearm with an upright lower limb undergoing self-massage. Then in the same position, but with the rolled lower limb bent at the hip and knee joints, lifted to the side and set in external rotation and side support with the lower limb upright, self-massage was performed. The treatment covered the anterior, medial and lateral surfaces of the thigh. In the first position the upper limbs were used to move the body forwards and backwards with a roller set perpendicularly to the long thigh

Table 1. Characteristics of examined people

Group	Gender	Number of people	Age [years]	Body weight [kg]	Body height [cm]	BMI
1	Women	20	21.40 ± 1.61	58.90 ± 7.14	166.09 ± 5.15	21.19 ± 1.58
	Men	13	21.61 ± 1.78	85.80 ± 7.49	184.11 ± 6.5	25.31 ± 2.08
2	Women	34	20.62 ± 1.41	62.93 ± 12.78	167.57 ± 6.12	22.49 ± 4.07
	Men	14	20.84 ± 1.47	77.64 ± 10.13	177.89 ± 6.62	24.48 ± 2.48

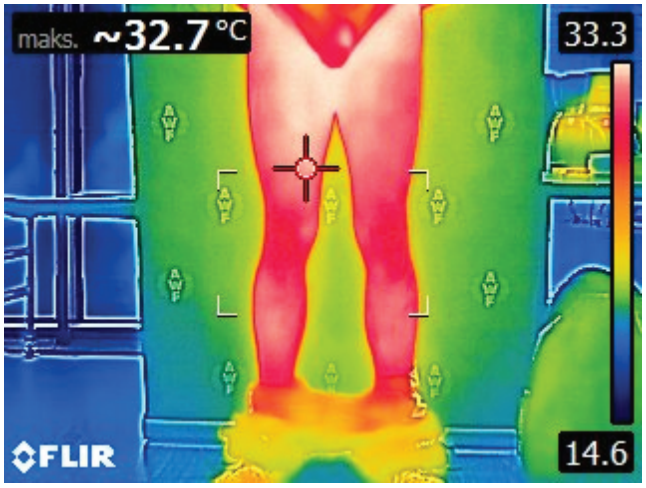


Figure 1. Temperature of lower limbs surface before the training

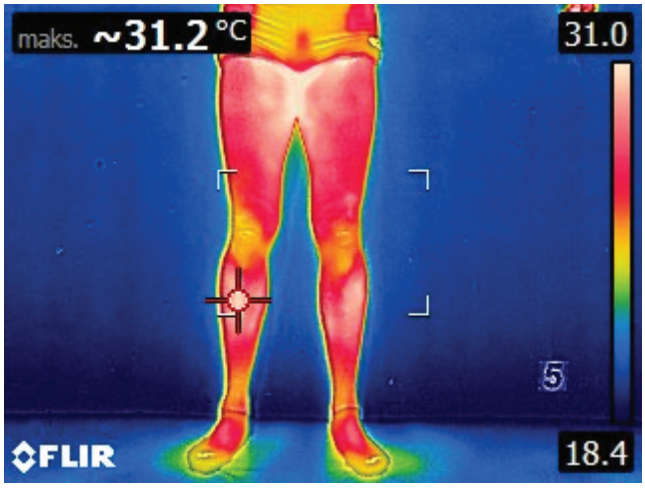


Figure 2. Temperature of lower limbs surface after the training

axis. Movement from a height just below the front upper hip progressed smoothly and slowly with constant pressure on the body surface, to its distal part, over the kneecap. In the second position (on the back) the roller was again perpendicular to the long axis of the thigh, starting from the proximal part of the muscles; the participants carried the body weight on the roller to the side, finished the movement just above the medial femoral condyle and returned to the initial position. The third position, in side plank by means of the lower support leg extending forward. The roller was positioned perpendicularly to the long axis of the thigh, and the rolling started in proximal part of femur and ended just above the lateral femur [6, 11]. In each position, the self-massage was carried out for 45 seconds, followed by 15 seconds of rest, which was also the time to change position. It covered both lower limbs, and everything was repeated once. The total treatment time was 6 minutes. The participants were instructed on the correct sensation, i.e. tissue relaxation. It was also possible to feel slight pain. Severe pain and impossibility to relax during the procedure were unacceptable.

Group 2 – control (n = 48) did not undergo any procedures supporting the post-workout recovery.

Ethics

The study was conducted in accordance with the Declaration of Helsinki.

The study was approved by the Research Ethics Committee of the Józef Piłsudski University of Physical Education in Warsaw (No. SKE 01-38/2023).

Statistical methods

Statistical analyses were conducted using Statistica version 12. The scores were statistically analysed. Normality of distribution was determined by Shapiro-Wilk test. Changes in VAS scores results were examined using Friedman's ANOVA test with post-hoc testing via Fisher's least significance difference. Between-group differences were assessed using the Mann-Whitney U test. Differences between the results of individual measurements were calculated using the Wilcoxon pair order test. Statistical significance was set for all statistical procedures at $p \leq 0.05$.

Results

Figure 3 shows the changes of pain intensity during 3 days after the training. The highest average pain level in Group 1 was recorded at the second measurement, i.e. 24 hours after training, in Group 2 at the third. In the study group, a significantly lower result was observed on each successive day (Fig. 3). The differences between the groups in pain levels measured 48 and 72 hours after exercise were statistically significant ($p < 0.05$). Women reported higher levels of pain than men 24 hours after training; they were lower on subsequent days, but the differences were not significant (Table 2).

The changes of thigh muscle surface temperature were significant in both groups (Table 3). The measurements of temperature did not reveal significant differences between the groups in measurements taken before and after the training and 24 and 48 hours later. Significant differences were found 72 hours after the training – the temperature measured in members of Group 1 was significantly lower ($p = 0.048$). The highest temperature was noted 48 hours after the training in women and men from Group 1, and 72 hours after the training in women and men from Group 2 (Table 3).

The training effort induced a similar cardiovascular response: an increase in heart rate at over 130 beats per minute. The intensity of effort on the Borg scale was also assessed in a similar manner (Table 4).

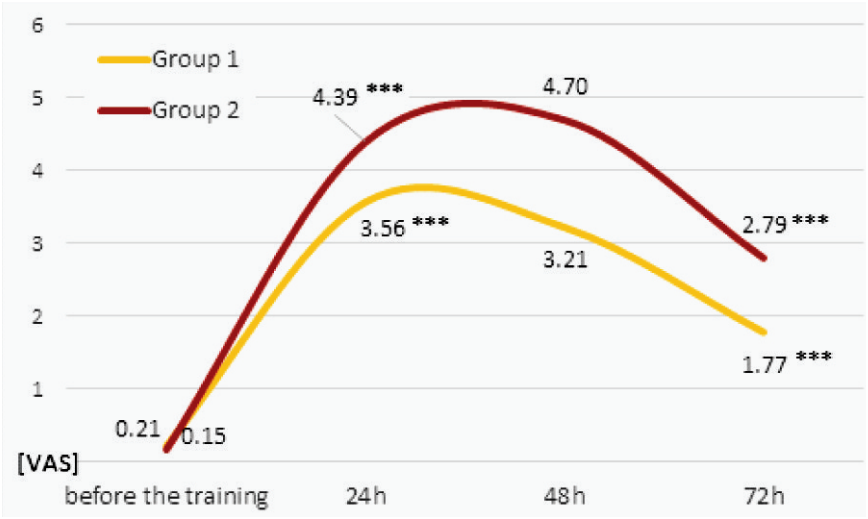


Figure 3. Intensity of pain

(***p < 0.001 – differences between current and previous measurement)

Table 2. Intensity of pain in examined groups

Group	Group	Before the training	24 h	48 h	72 h	Differences [p]
Women	1	0.30 ± 0.89	3.63 ± 2.17	2.90* ± 2.26	1.53 ± 1.90	<0.001
	2	0.13 ± 0.21	4.56 ± 2.64	4.66* ± 2.21	2.56 ± 2.44	<0.001
Men	1	0.08 ± 0.31	3.46 ± 1.65	3.69 ± 2.51	2.15 ± 1.86	<0.001
	2	0.21 ± 0.47	4.00 ± 1.98	4.79 ± 2.86	3.32 ± 2.79	<0.001

* p < 0.05 – differences between groups

Table 3. Temperature of surface of the front of thigh in examined groups

Group	Group	Before the training	After the training	24 h	48 h	72 h	Differences [p]
Women	1	30.33 ± 0.56	28.85 ± 0.80	30.23 ± 0.71	30.38 ± 1.06	30.19 ± 0.92	0.009
	2	30.83 ± 0.81	28.81 ± 0.74	30.83 ± 0.84	30.85 ± 1.17	30.96 ± 1.22	0.009
Men	1	30.75 ± 1.07	29.15 ± 0.90	30.47 ± 0.89	30.57 ± 0.82	30.25 ± 1.10	<0.001
	2	30.80 ± 0.74	28.88 ± 0.58	30.93 ± 0.67	31.17 ± 1.41	31.15 ± 1.08	0.011

Table 4. Heart rate and Borg Scale results in examined groups

Group	Group	HR before the training	HR after the training	Borg Scale results
Women	1	76.63 ± 7.54	133.11 ± 15.78	15.23 ± 1.48
	2	77.75 ± 9.11	134.75 ± 21.80	14.78 ± 1.64
Men	1	77.75 ± 9.11	134.75 ± 16.90	14.78 ± 0.88
	2	78.86 ± 10.09	138.67 ± 23.59	15.17 ± 0.75

Discussion

Delayed muscle soreness is a common problem, affecting mainly physically active people. The importance of this issue is evidenced by the number of studies performed, which demonstrate more and more newer forms of counteracting the effects of this phenomenon [1, 8, 18, 20]. In scientific publications various solutions have been reported, such as supplementation with herbs, omega-3 acids, pomegranate juice, ginger, infrared light exposure, massage, whole-body vibration, kinesiotaping, self-massage with a roller and others [11, 14, 15, 16, 17, 23].

Our results confirm the opinions presented in the literature on pain reduction in the course of DOMS as a result of roller application [22, 26]. Macdonald et al. [22] also noted lower intensity of muscle soreness after rolling during the whole study. It used a longer self-massage time than in our own research, 60 seconds per muscle group, and the treatment area was extended to the posterior thigh muscle group and gluteal muscles. Additionally, the following parameters were improved: muscle activation and jump height, which was not taken into account in our study. Romero-Moraleda et al. [29] used a one-time self-massage 48 hours after the effort, using a similar methodology to the authors mentioned above. Moreover, the pain was reduced and the maximum isometric contraction of the straight thigh muscle was increased [29].

It is difficult to compare the results of the studies taking into account the application of rolling in the course of DOMS because of the methodological differences, which concern the time allocated to one position, the muscle groups covered by the self-massage and the ways of inducing delayed muscle soreness. Hence more research on this subject is needed, in order to determine the optimal time and pattern of these treatments.

The Tabata squat exercise used in our own research proved to be effective in inducing delayed-onset muscle soreness. In the quoted literature, however, exercises used by the authors for this purpose were: strength training with free weights, strength exercises on a machine with resistance regulation, as well as squats, training with an isokinetic dynamometer or jumping off the platform and jumping up again – all exercises with a specified number of repetitions and series, time or performed to the subjective feeling of tiredness [10, 21, 22, 25]. In both groups, similar pulse values were noted after physical effort, and in the subjective assessment of the participants it was described as intense, in the control and study groups. Therefore, people in both groups performed a similar intensity of physical activity, which has an impact on the severity of the symptoms associated with DOMS.

The results obtained in this study confirm that the use of roller self-massage can help reduce delayed muscle soreness after physical effort. An important limitation of the present research was the relatively small group of participants. It would be worthwhile to expand research on this subject with a larger group of people of both genders. The usefulness of this method when applied on a regular basis with longer observation times should also be evaluated. It would also be worth comparing manual massage to automatic roller massage, both their mechanisms of operation and short – and long-term effects. Additionally, it is important to include in future studies the impact on changing the range of motion. In order to increase the reliability of rolling, it would be advisable to use laboratory tests that confirm or exclude the influence on the endocrine system or markers of inflammation or muscle damage.

Conclusions

1. Self-massage with a roller accelerated muscle regeneration. It can therefore be an effective procedure to support post-workout recovery, especially for athletes during the competition period when they are subject to maximum effort with small rest breaks.
2. Rolling helped faster reduction of pain caused by supramaximal effort. The analgesic effect of massage is one of its main advantages. That is why self-massage with a roller can be used more widely in sports, wellness and rehabilitation.
3. Among the people from the control group, higher values of limb surface temperature were observed in the days following exercise, but the differences were not significant. This phenomenon requires further observation.
4. The obtained results form the basis for continuing research with the participation of a larger group of subjects and using other (objective) research tools.

Conflict of interest: Authors state no conflict of interest.

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