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Effectiveness of One-Time Self-Massage Using a Foam Roller in Reducing Functional Limitations of the Musculoskeletal System

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foam rolling, warm-up, FMS, injury prevention, functional assessment

Abstract
Introduction: Foam rolling is becoming one of the most popular treatments performed to prevent injuries in sport.
Objective: The aim of this study is to determine the effect of a single-session, self-massage with a roller on functional limitations of the musculoskeletal system.
Material and methods: The study included 101 persons (69 women and 32 men) aged 19 to 23. Group 1 consisted of 55 people who received training in self-massage with a roller. Group 2 comprised 46 participants who constituted the control group. All patients performed the Functional Movement Screen (FMS), without a warm-up and next (after one week), carried out FMS once again after the warm-up with foam rolling (Group 1) and a traditional warm-up (Group 2).
Results: Significant improvement in the overall total FMS test score was observed after both forms of warm-up (exercises + rolling, exercises). The largest differences in Group 1 were noted in the Deep Squat and Hurdle Step tests ($p \leq 0.001$). In Group 2, a significant difference was found in exercise 6: Trunk Stability ($p \leq 0.001$).
Conclusion: The roller-assisted warm-up had a particularly positive effect on the results of global movement tasks requiring postural muscle capacity and a high level of flexibility (Deep Squat and Hurdle Step). Using a roller in the initial part of the training is therefore fully justified.

INTRODUCTION

Massage is one type of physiotherapy treatment that involves elastic deformation of tissues. It is a set of movements exerting pressure on the tissues and involves the use of specific movements, at the right pace and with the right force according to the course of the muscles, tissues, blood and lymphatic vessels, from their periphery to the heart. Massage should be performed rhythmically, without stretching the skin with the unaided hand[1,2,3,4]. Self-massage is a technique performed by the patient themselves. The principles to be followed when performing self-massage, the physiological basis, indications, and contraindications are identical to those of classic massage. It is important that the massaged muscles are as relaxed as possible. In order to achieve this relaxation, it is necessary to choose an appropriate starting position[5,6].

Self-massage with a roller is a type of massage carried out using, among others, so-called rollers. Rolling the muscles with a foam roller (FR, foam rolling) is one of the SMR, self-myofascial release, techniques. It involves independently using a tool to apply direct pressure to a specific muscle or muscle group[7,8]. The action of SMR is based on applying targeted, direct stimulus, with low contact force. In studies, it has been 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[9]. 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, categorised as an active form of exercise, supports post-exercise recovery, prolongs and increases muscle congestion which, in turn, greatly facilitates muscle activation and recovery[10,11,12,13]. It also has a beneficial effect on restoring normal movement ranges in adjacent joints[12]. Another positive FR effect is that it activates the parasympathetic nervous system and stimulates endor-

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phins release. This has a psychological effect leading to, among others, reducing pain[13].

Self-myofascial release is used as a method to help reduce functional limitations. Improper movement patterns are often perpetuated as a result of specialised sports training. Musculo-fascial imbalance is a common cause of postural defects, pain and musculoskeletal injuries[14,15,16,17]. Determining the rapid impact of myofascial release on the quality of movement is an interesting issue. The effect could be different depending on, for example, gender. In sports training, the appropriate performance of motor tasks without increasing undesirable compensations is significant from the point of view of preventing body injuries.

STUDY AIM

Not all scientific studies on the effects of rolling converge. Nevertheless, FR has become one of the most popular SMR techniques. Therefore, it is necessary to further explore this activity on scientific grounds. Thus, the aim of this study is to determine the effect of a single session of self-massage with a roller on functional limitations of the musculoskeletal system. Additional objectives of the study were formulated in the following research questions:

1. What are the differences between the effect of warm-up exercises + foam rolling and warm-up exercises?
2. What are the differences between particular tasks of FMS results performed with warm-up exercises + foam rolling and warm-up exercises?
3. What is the difference between FMS results with and without a warm-up?
4. What are the differences between foam rolling effects in women and men?

MATERIAL AND METHODS

The study included 101 persons (69 women and 32 men) aged 19 to 23. Group 1 (Roller) consisted of 55 individuals who received training in self-massage with a foam roller. Group 2 (Exercises) comprised of 46 people who constituted the control group (Table 1). All participants were interviewed before the research was conducted. The interview screened for existing cardiovascular and respiratory system conditions and past musculoskeletal injuries that might impede test performance. Healthy persons without the cited conditions and injuries qualified for the study. Qualification for the research included the assessment of myofascial structures by a physiotherapist. All tests were performed in the presence and with the help of a physiotherapist.

All examined participants were educated in FMS methods. Functional Movement Screen consists of seven exercises assessing basic movement patterns: 1. Deep Squat; 2. Hurdle Step; 3. In-Line Lunge; 4. Shoulder Mobility; 5. ASLR – Active Straight Leg Raise; 6. Trunk Stability Push-Up; and 7. Rotation Stability. Each task is assessed on a four-point scale from 0 to 3 points (3 points are granted to a person who has performed the movement pattern correctly, 2 points to a person who has performed the movement pattern with compensation, 1 point to a person who is not able to perform a movement pattern, 0 to persons who experience pain while performing the pattern or during a provocation test. A total of 21 points can be scored by the person being tested. The FMS test is performed before the exercises, prior to the warm-up. The evaluation is done in two planes, sagittal and frontal. The tested person performs a given movement task three times, and the investigator assesses the best result. If there are doubts as to the correctness of the pattern, a lower grade is obtained. Each side is assessed separately[18,19]. Subjects with a 0 note were clinically examined by physiotherapist. Two persons were qualified for orthopaedic consultation. The results were analysed for all groups and also for women and men separately.

The subjects performed the Functional Movement Screen test twice. The first time the test was performed, as recommended by the authors[18,19], it was done without a warm-up. Then, after one week, the subjects were randomly divided into two groups and the test was repeated. In Group 1, the test was performed after a warm-up consisting of exercises and self-massage with a roller. Those in Group 2 performed the repeat test after a warm-up comprising only exercises. The warm-up exercise protocol was the same in both groups. Aerobic exercises: running (and running exercises: skips, backward running, crossover gait, etc.) and dynamic stretching exercises (circles, bends, twists)[6,20] were used. The warm-up lasted approximately 10 minutes.

Group 1 performed self-massage with a roller immediately after the warm-up exercises. The applied rollers were 33 cm (13 in) long and 14 cm (5.5 in) in diameter. Five positions were used in the intervention: 1) forward support or forward support on forearms with straight lower limb under self-massage; 2) same position but with rolled lower limb bent at hip and knee, abducted and set in external rotation; 3) side support with straight

Table 1

Biometric characteristics of research groups

Gender	Group	Number of people	Age [years]	Body mass [kg]	Body height [cm]	BMI [kg/m²]
Women	1 (Roller)	37	20.65±1.18	64.81±10.32	167.65±5.47	22.58±2.72
	2 (Exercises)	32	20.94±1.37	63.64±10.12	167.57±4.92	22.19±2.55
Men	1 (Roller)	18	20.33±0.77	78.92±7.86	181.08±3.68	24.20±2.88
	2 (Exercises)	14	20.43±1.09	81.30±14.99	182.60±5.44	24.21±3.98

lower limb massaged; 4) back support with straight lower limb under self-massage; and 5) lying on the back (forearms crossed on chest). In each situation, the roller was positioned perpendicular to the axis of the massaged body part or limb. In the first position, the quadriceps muscle of the thigh was massaged. The second position was to massage the adductor muscles. In lateral support, the lateral head of the quadriceps, the tensor fascia lateralis and the gluteus medius muscles were massaged. In supine position, massage of the posterior thigh muscle group and massage of the lower leg muscles, mainly the triceps calf muscle, were performed. In position five, lying on the back on a roller, the back muscles were massaged. In each position, the self-massage was performed for 45 seconds, followed by 15 seconds of rest, which was also the time to change position. Both lower limbs were covered, the whole intervention was repeated once. The total intervention time was approximately 12 minutes. Participants were instructed on the correct sensations, i.e. tissue relaxation, a slight feeling of pain was possible. Severe pain and inability to relax during the procedure were unacceptable[12,21].

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

Statistical analyses were conducted using Statistica version 12. The scores were statistically analysed. Normality of distribution was determined via the Shapiro-Wilk test. Differences between the results of individual measurements were calculated using the Wilcoxon Pair Order Test. Differences between groups were evaluated using the Mann-Whitney U test. The analyses were performed for all groups (both genders) and also separately for women and men. Statistical significance was set for all statistical procedures at $p \leq 0.05$.

RESULTS

Significant improvement in the overall total FMS test score was observed after both forms of warm-up (exercises + foam rolling and exercises). The largest differences in Group 1 were noted in the Deep Squat and Hurdle Step tests ($p \leq 0.001$). In Group 2, a significant difference was found in exercise six: Trunk Stability Push-Up ($p \leq 0.001$) (Table 2). In the first measurement (without warm-up), the twelve exercises performed by Group 1 subjects were scored 0. In the second measurement, there were four such results (among women only). In Group 2, similar correlations were observed. The test without a warm-up resulted in ten, 0-point scores. After the warm-up, this number was also reduced to four.

Considering the gender breakdown, both women and men showed statistically significant improvement in the overall FMS score after both warm-up variants ($p \leq 0.001$ for women and $p \leq 0.05$ for men). Among women, the biggest differences were observed in the following tests: Deep Squat, Hurdle Step and In-Line Lunge for Group 1 and Trunk Stability Push-Up for Group 2 (Table 3). Among men, these were respectively: Deep Squat and Active Straight Leg

Table 2

FMS results without warm-up (pre-test) and after warm-up (post-test)

Group	Test	Deep Squat	Hurdle Step	In-Line Lunge	Shoulder Mobility	Active Straight Leg Raise	Trunk Stability Push-Up	Rotary Stability	Total
Roller	Pre-test	1.93±0.63	2.04±0.58	2.22±0.66	2.73±0.65	2.25*±0.75	1.56±0.99	2.02±0.36	14.73±2.11
	Post-test	2.18±0.61	2.40±0.63	2.35±0.58	2.71±0.53	2.35*±0.64	1.69±0.96	2.07±0.25	15.75±1.91
	Differences	***0.000***	***0.000***	*0.196*	*0.659*	*0.168*	*0.090*	*0.261*	***0.000***
Exercises	Pre-test	2.07±0.62	2.04±0.59	2.33±0.72	2.74±0.68	2.54*±0.72	1.57±1.03	2.02±0.49	15.41±2.45
	Post-test	2.17±0.59	2.20±0.58	2.40±0.70	2.80±0.45	2.59*±0.65	2.00±0.98	2.11±0.47	16.17±2.07
	Differences	*0.133*	*0.070*	*0.135*	*0.323*	*0.420*	***0.001***	*0.253*	***0.000***

* $p \leq 0.05$ differences between groups.

Table 3

FMS results without warm-up (pre-test) and after warm-up (post-test) in women

Group	Test	Deep Squat	Hurdle Step	In-Line Lunge	Shoulder Mobility	Active Straight Leg Raise	Trunk Stability Push-Up	Rotary Stability	Total
Roller	Pre-test	1.89±0.70	1.95±0.57	2.19±0.74	2.89±0.31	2.54*±0.56	1.14±0.81	2.00±0.24	14.59±2.22
	Post-test	2.11±0.57	2.41±0.64	2.46±0.61	2.84±0.37	2.57*±0.55	1.27±0.81	2.03±0.16	15.68±2.01
	Differences	***0.009***	***0.000***	***0.023***	*0.160*	*0.711*	*0.096*	*0.571*	***0.000***
Exercises	Pre-test	2.03±0.59	2.00±0.62	2.37±0.76	2.78±0.61	2.78*±0.49	1.34±0.98	2.06±0.35	15.47±2.51
	Post-test	2.09±0.58	2.16±0.57	2.41±0.74	2.91±0.30	2.81*±0.41	1.75±1.05	2.16±0.45	16.28±2.23
	Differences	*0.488*	*0.134*	*0.536*	*0.103*	*0.572*	***0.007***	*0.263*	***0.000***

* $p \leq 0.05$ differences between groups.

Table 4

FMS results without warm-up (pre-test) and after warm-up (post-test) in men

Group	Test	Deep Squat	Hurdle Step	In-Line Lunge	Shoulder Mobility	Active Straight Leg Raise	Trunk Stability Push-Up	Rotary Stability	Total
Roller	Pre-test	2.00±0.49	2.22±0.55	2.28±0.46	2.37±0.98	1.67±0.77	2.44±0.70	2.06±0.54	15.00±1.91
	Post-test	2.39±0.69	2.39±0.61	2.33±0.47	2.39±0.71	1.89±0.58	2.61±0.62	2.17±0.38	15.94±1.71
	Differences	***0.004***	*0.269*	*0.668*	*0.668*	***0.041***	*0.269*	*0.331*	***0.022***
Exercises	Pre-test	2.14±0.66	2.14±0.53	2.21±0.63	2.64±0.84	2.00±0.88	2.07±0.98	1.93±0.73	15.29±2.41
	Post-test	2.36±0.63	2.29±0.61	2.37±0.47	2.67±0.65	2.07±0.83	2.57±0.51	2.00±0.55	16.07±1.69
	Differences	*0.052*	*0.336*	*0.336*	*0.583*	*0.583*	***0.027***	*0.671*	***0.043***

Raise for Group 1 and Trunk Stability Push-Up for Group 2 (Table 4). In both male groups, not a single score of 0 points was recorded in the second measurement.

DISCUSSION

In our own research, it is shown that warm-up assisted self-massage with a roller can increase the functional capacity of the musculoskeletal system. Rolling prior to training increases proprioceptive abilities of the joints, which contributes to better training effects and thus, better sports performance, and is also part of injury prevention[12,22,23]. Markowski et al.[24] claim that rolling enables better fascia hydration and improves elasticity and resilience. By incorporating the roller into the warm-up, joint mobility can be improved[20]. In research studies, it has been demonstrated that the use of rollers in the warm-up before training does not reduce strength, power or agility. However, it should be noted that the studies were performed on a small number of subjects. The effect of pre-exercise rolling on knee joint range of motion was assessed. The quadriceps muscles of the thigh were rolled. The range of movement in the knee joint increased by ten degrees, however, the effect decreased with time. Ten minutes after the first measurement, another measurement was taken, and the range of movement had decreased by two degrees compared to the first measurement (it was eight degrees more than before the first measurement)[25]. It can therefore be concluded that a roller-assisted warm-up is justified even if, according to the aforementioned study, the range of movement in the joint has increased in the short-term.

In our study, FMS scores were higher in both groups after the warm-up, so the participants performed the exercises more efficiently. Greater mobility in the joints may have been one of the contributing factors. For preventive purposes, it is important to demonstrate the likelihood of injury and existing musculoskeletal dysfunctions. This is possible through the use of the FMS (Functional Movement Screen) test. This is a screening test used to highlight weaknesses in the kinematic chains. It is also applied to assess the movement patterns and functional performance of athletes[18,19]. This study allows to confirm the predictive function of the authors' FMS test. Chorba et al.[26] investigated the effect of compensatory movement patterns on the predisposition to injury among young female athletes. Thirty-eight female collegiate team sports athletes took part in the study. A significant correlation was found between a low FMS test score and the occurrence of injury. The same conclusions were reached by Kiesel et al.[27] and Garrison et al.[28]. These researchers also demonstrated that scores lower and equal to 14 points predispose to future injury[27,28].

Each of the individual tests that make up the FMS test provide relevant information. This is evidenced by research. The Deep Squat test alone can be a predictive test. The same conclusions were reached in the study by Clifton et al.[29]. These authors have demonstrated that there may be correlations between the Deep Squat test score and the total FMS test score. Athletes with a low score on this test were more likely to have scores below 12 from FMS assessment. The Deep Squat test may be an indicator of further disturbances in kinematic chains and the need for further testing to assess the likelihood of injury[29].

The differences between women and men in functional fitness are noticed in almost every sports group. Women have a higher level of global mobility[30,31]. In our research, it has been shown that specific physical treatment (foam-rolling) caused positive effects in women – especially in global tasks (Hurdle Step, In-Line Lunge). This confirmed by other studies, e.g. regarding self-massage[6]. Also, long-term corrective intervention brought the expected results in female athletes[16].

The limitation of the research is subjective assessment of functional fitness. The scores were awarded by the researcher. However, the research in this work was conducted by a qualified team with extensive experience in the field of functional assessment. The FMS test is a frequently used research tool that has been described in the literature numerous times. It is used for athletes, across all disciplines. It allows functional assessment of movement patterns and predisposition to injury, conditioned by the sport in question[31,32,33].

We realise that a one-time intervention will not leave long-lasting effects, but it could be a method to improve quality of movement during training sessions.

New techniques and methods are constantly being sought that can improve the process of sports training and post-exertional recovery. More and more tools or devices (e.g. for

massage) are appearing on the market. Thus, there arises a perceived need for more research to be carried out in order to broaden the knowledge of training methods such as self-myofascial release and to compare it with other methods. The effect of using roller massage in combination with stretching is also unknown. It is also worth noting the effects of myofascial autoflexion in studies on persons who already have experience with the technique, as well as in those who are new to it.

CONCLUSIONS

1. There were no significant differences between the global level of functional fitness in group performing the traditional warm-up and that with foam rolling. Both methods could have influence on quality of movement during training sessions.
2. The roller-assisted warm-up had a particularly positive effect on the results of global movement tasks requiring postural muscle capacity and a high level of flexibility (Deep Squat and Hurdle Step). Using a roller in the initial part of training is therefore fully justified.
3. Both groups had significantly higher total FMS scores after the warm-up, demonstrating the validity of performing warm-up exercises prior to beginning physical activity and adapting these exercises to the effort (training) being performed.
4. The effect of foam rolling in women concerned global exercises (Deep Squat, Hurdle Step, In-Line Lunge), while in men, higher mobility in lower limbs was observed.

Conflict of interest

The authors have no conflict of interest to disclose.

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