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Original Article

The effect of 8-weeks Self-Myofascial Release Therapy on Joint Position Sense and Dynamic Balance in Athletes with Hamstring Shortness

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ABSTRACT

Background: Increased joint stability as well as the ability to maintain balance during typical daily activities and exercise is an important factor in improving performance and preventing injury. The purpose of the present study was to investigate the effect of eight-weeks of Self-Myofascial Release therapy (SMR) on knee joint position sense (KJPS) and dynamic balance (DB) in collegiate male athletes with hamstring shortness (HS).
Methods: In this quasi-experimental study (randomized control trial), 24 collegiate male athletes with HS were randomly selected and randomly divided into experimental (n=12) and control (n=12) groups.
KJPS was measured with an isokinetic dynamometer and DB using the Y balance test before and after 8 weeks of SMR. The results were analyzed by SPSS software version 22 as well as dependent T-tests and covariance analysis. The significance level was considered 95% and alpha equal to or less than 0.05.
Results: The outcomes of the dependent t-test showed that dynamic balance test scores (in all three directions of anterior, Posteromedial, Posterolateral and overall Y-score) increased in the SMR group compared to the control group (P=0.001) but no significant difference was observed in KJPS values between the two groups (P=0.493).
Conclusion: Based on the results, it seems that SMR foam rolling is not suitable for increasing KJPS accurateness of athletes with a short hamstring, but these exercises can be used to improve dynamic balance.

Introduction

Hamstring muscles are known to be one of the most important muscles in the body due to their crossing two joints and connectivity to the pelvic bone. The hamstring muscle group including semimembranosus, semitendinosus and Biceps femoris muscles and shortness of them are common in today's world like that found in an athlete population [1-3].

In muscles that are prone to shortness due to their flexor nature such as the hamstring muscle, shortness of muscle develops without any specific pathological cause and is only due to the continuous movement of the muscle in its full range of motion [4]. Shortening of this muscle directly affects knee function and indirectly affects hip and ankle joint function [4].

Balance is a key component in the performance of sports skills and daily activities. The ability to maintain balance during routine daily activity and exercise is an important factor in preventing injury. Any disturbance in the balance pattern can decrease performance and increase the likelihood of injury to the body [5].

A wide range of postural responses in humans are created in response to disturbing balance factors. These responses are called hip, ankle, and stride strategies which maintain balance.

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One of the most important muscles in the hip and ankle strategy is the hamstring muscle, which, as a postural muscle along with other posterior muscles, maintains balance by shift modification of the center of gravity position [5].

Therefore, it seems that any dysfunction of this muscle can affect balance. It is logical that a decrease in balance can reduce the performance of the athlete and cause injury [5]. Similarly, Zagyapan et al showed in their study that hamstring shortness causes postural changes that affect balance [6].

The sensory-motor system consists of a complex relationship between the sensory and neuromuscular systems [7]. This system combines all the sensory information obtained from the visual, vestibular, and peripheral mechanical receptors to balance the joints [7]. The information is processed by the central nervous system (CNS) to control muscle activity and joint stability.

Proprioception is believed to be an important aspect of this process and provides information on muscle length, tendon tension, joint position, joint movement as well as deep vibrations on the joint [8].

In general, Proprioception can be defined as the process of obtaining and processing sensory information received from mechanical receptors that are located specifically on the muscles, tendons, joints, and skin tissue and they are used to maintain joint stability and to control muscle activity [7-9].

A recent research has shown that the tissues within the knee joint can also contribute to the provision of information, sensory afferents and hence, functional stability with joint activation and synchronized movements as well as roles in protective reflections [10].

Precision of proprioception is considered as one of the important factors related to accurateness of skill and risk of injury in sports activity [11]. Based on the research literature, functional hamstring shortness can affect proprioception of the knee joint. Szlęzak et al. in their study indicated that decreasing the accuracy of proprioception of the knee joint is associated with shortness of thigh muscle [12].

There are several methods and techniques to increase the accuracy of proprioception [13, 14] and balance improvement [15, 16].

Self-Myofascial Release (SMR) is a flexibility technique which is used to inhibit overactive muscle fibers. The most common method of SMR is the use of foam rolling [17].

SMR Foam Rolling (FR) has gained a lot of interest and popularity in this field recently due to its easy access and use to increase flexibility and Range of Motion (ROM) as well as applying a massage-like effect on muscles and fascia.

It is likely that the complications which follow shortness of hamstring including the error rate of proprioception accuracy and balance, are reduced in the case of the muscle length increase due to exercise.

It is claimed that SMR using foam rolling corrects muscle imbalance, relieves stress, improves muscle performance and increases ROM [18].

Foam rolling has been implemented in several exercise and rehabilitation programs to help soft tissue flexibility, increase ROM and optimize musculoskeletal function. But the issue of whether SMR can enhance the accuracy of proprioception and improve balance by restoring the ROM and normal length of the shortened hamstring muscles is under debate.

Therefore, given the relatively high prevalence of hamstring shortness, especially among athletes, and its role in maintaining balance as well as its close relationship with the proprioception of joints and also the need for more attention to the factors preventing damage during sports and daily exercise, the purpose of the present study was to investigate the effect of 8 weeks of SMR using a foam roller on KJPS and DB of college-aged male athletes with hamstring shortness.

Methods

The research design is quasi-experimental (RCT) with two groups using pre-test and post-test process in both groups and applying variables to one (experimental) group.

Prior to the Pre-test phase, a familiarization session was held for all participants where anthropometric measurements were collected and individuals with hamstring shortness were selected. Active Knee Extension Test (AKET) was used to evaluate hamstring shortness. Individuals with AKET angles less than 150 degrees were considered as samples [19].

During the familiarization session, participants signed a written informed consent form and completed a health status questionnaire. Then, AKET test, Y balance test and isokinetic dynamometer were introduced to them. Afterwards, they were randomly divided into experimental (n=12) and control (n=12) groups.

There were no differences in anthropometric and age-related parameters between the two groups in the pretest (Table 1). In the pretest process, all participants completed the KJPS tests using the isokinetic and DB devices with the Y balance test. The experimental group was then instructed on the protocol and how to perform SMR with

Table 1: Participant's characteristics at baseline testing. [A]

Variable	Experimental Group (N=12)	Control Group (N=12)	P
Age (y)	24.75±2.09	25.08±1.88	0.711
Height (cm)	180.50±4.90	181.33±3.67	0.326
Weight (kg)	77.08±7.02	78.58±4.90	0.530
Leg length (cm)	93.17±4.42	94.08±4.29	0.679
BMI(kg/m^2) [B]	23.64±1.62	23.89±1.20	0.129

[A] Values are presented as mean±standard deviation. [B] Body mass index (kg. m-2)

Figure 1: Starting point from the top of the Ischial Tuberosity

Figure 2: End of movement to popliteal fossa

a foam roller. After an 8-week intervention period, joint position sense and dynamic balance were re-measured for each group. Twenty-four collegiate athletes with hamstring shortness as well as anthropometric characteristics reported in Table 1 were selected and evaluated.

The study inclusion criteria were as follows; subjects with hamstring shortness at least in their dominant limb, being an athlete (5 training sessions per week) and members of a soccer, volleyball and/or basketball team. All athletes had been engaged in a minimum of five years of continuous sports activity and regular team practice [20], no history of problems such as arthritis and ligament injuries and meniscal damage. Subjects were excluded from the study based on the following criteria; failure to fully implement the SMR training program (at least three intermittent sessions or two continuous sessions) and not participating in the pre-test or post-test.

Participants had no previous experience with foam rolling. The study was approved by the Ethics Committee(ID: IR.UT.SPORT.REC.1398.045), and the test stages as well as training steps and also the potential benefits and risks of the research were explained to subjects before signing informed consent forms to participate in the study. The registration code in in Iranian Registry of Clinical Trials is IRCT20191214045729N1.

Protocol

In the present study, a foam roller with specifications of FitPlus Premium High Density 6-inch diameter × 12-inch Foam Roller, USA) was used for SMR [21].

Participants were asked to release the hamstring muscles of the dominant leg according to the protocol. The dominant leg was also considered to be the limb to hit the ball.

Subjects began by placing the rolling foam roller under the hamstring muscles of the dominant leg and passing the opposite leg over it. Individuals started by rolling the foam from the Ischial Tuberosity (Figure 1) and completed it by moving to the popliteal fossa (Figure 2).

Subjects were told to support their body weight with their hands which were positioned at the back and they were trained to manipulate the pressure applied to the rolling foam and allow as much pressure as possible between the hamstring muscles and the rolling foam.

The rolling foam was moved at an approximate rate of 1 second backward (from ischial Tuberosity to popliteal fossa) and 1 second forward (popliteal fossa to ischial tuberosity) [21]. Protocol time was controlled by the researcher and verbal feedback was provided when it was needed [21]. The SMR protocol has been designed to target hamstring muscles based on previous studies [22-25] and a pilot study (Table 2).

Active Knee Extension Test (AKET) was used to measure the length of hamstring muscles. This test is one of the validated tests with excellent intrarater reliability (ICC=0.87-0.94) and validity is 0.86 to measure hamstring flexibility [26, 27].Angles were measured using a universal Goniometer [19].

Table 2: Protocol of exercise

Sessions / Week	First	Second	Third	Rest*
1	3†×15‡ (s)	3×20(s)	3×25(s)	30 s
2	3×25(s)	3×30(s)	4×25(s)	30 s
3	4×25(s)	5×25(s)	4×30(s)	30 s
4	4×30(s)	6×25(s)	5×30(s)	30 s
5	5×30(s)	7×25(s)	6×30(s)	30 s
6	6×30(s)	8×25(s)	7×30(s)	30 s
7	7×30(s)	8×30(s)	8×30(s)	30 s
8	7×30(s)	8×30(s)	8×30(s)	30 s

Frequency of exercise: 3 sessions per week (24 , 25), Intensity of exercise: At least 25% of the patient's body weight (21, 26). Pressure levels up to pain threshold were also recommended (27), * Break time between sets (seconds), † Number of sets per session, ‡ Workout time (seconds)

The procedure is shown in Figure 3. Y dynamic balance test was used to measure balance in the present study [28]. The researchers reported excellent Interrater reliability (ICC=0.97- 0.99) and Intrarater (test-retest) reliability were moderate to excellent (ICC=0.68- 0.90) [28]. Also the results of the previous research indicated that the Y balance test is a valid measure (values 0.05-0.72) in the assessment of dynamic balance [29].

Figure 3: Active Knee Extension test

As shown in Figure 4, the subjects stood on a stationary platform in the center of the Y balance kit with their dominant foot. The subject then attempted to move the indicators plate of all three anterior, posteromedial and posterolateral directions with their other foot as far away as possible. The subject's score was calculated based on the corresponding formula [28].

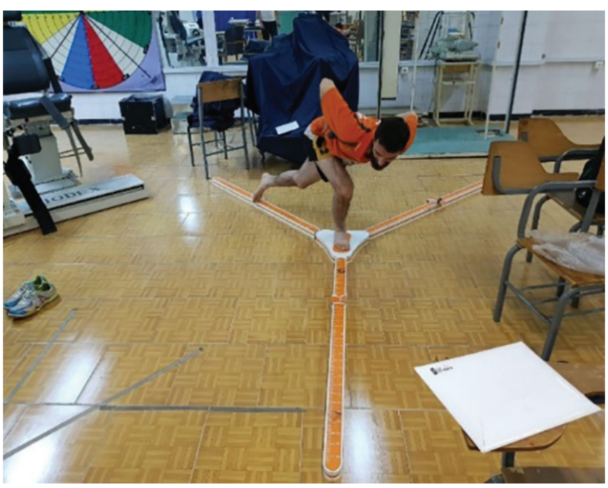

Figure 4: Y Balance test

Isokinetic dynamometer with specifications of Biodex Multi-Joint System 4 Pro (Biodex Medical Systems, Inc., Shirley, NY) was used to measure KJPS. High intraclass correlation coefficients values (ICCs=0.96) and excellent validity of 0.99 were reported for the Biodex System [30, 31].

The subject was placed on the device as shown in Figure 5. The dynamometer lever and the axis of rotation were adjusted according to the manual of (Biodex Pro, Applications/Operations, Biodex Medical Systems, Inc., Shirley, NY). The knee joint extension range was selected between 0-90 degrees and an angle of 45 degrees as the target angle [32]. The subject was asked to reconstruct the target angle with a closed-eye knee extension and press the record button in case of locating at the closest point to the target angle (Figure 5). This motion was repeated 3 times on the dominant leg and the error rate of the joint reconstruction was reported by the device software [12].

Figure 5: Knee Joint Position Sense test

Data analysis was performed using SPSS software-version 22. For this purpose, the Shapiro-Wilk test was used to determine the normality of the data. Moreover, Paired sample T-test was used to compare the results of pre-test and post-test in groups. Univariate analysis of covariance was used to compare the results of the experimental and control groups. The level of significance used for statistical analysis was also chosen to be 95% (α=0.05).

Results

The descriptive statistics of the pretest and post-test dependent variables related to dynamic balance and knee joint position sense in the experimental and control groups are presented in Table 3.

Paired t-test results showed that there was a significant difference in the overall score of the Y balance test in the dynamic balance of the experimental group relative to pretest in all three anterior, posteromedial and posterolateral directions after 8 weeks of SMR ($P \geq 0.05$) in a way that SMR was more than in the pre-test in the three noted directions in addition to the overall Y test score after 8 weeks($P \geq 0.05$) but no significant difference was observed between pretest and post-test in the control group ($P \leq 0.05$) (Table 4).

The ANCOVA test results also indicated that there was a significant difference between DB of experimental and control groups after controlling for the pre-test effect (blindness) in all three directions and total score of Y balance test in post-test ($P \geq 0.05$) (Table 4).

On the other hand, the results of paired T-test showed

Table 3: Mean and standard deviation of KJPS and DB scores in both groups

	Variable	Time	Experimental Group SD [A]±Mean	Control Group SD±Mean
Direction [c]	KJPS [B] (degree)	Pre Test Post Test	3.30±2.01 3.37±1.80	3.25±2.13 3.19±2.11
	Composite	Pre Test Post Test	81.55±4.13 84.86±3.03	80.44±4.66 80.61±4.16
	Anterior	Pre Test Post Test	67.33±4.86 70.00±4.43	66.58±5.03 67.00±4.17
	Posteromedial	Pre Test Post Test	88.83±8.26 92.50±5.33	87.50±9.00 87.83±8.43
	Posterolateral	Pre Test Post Test	88.50±8.59 92.08±6.18	87.25±8.89 87.00±7.64

[A] Values are presented as mean±standard deviation. [B] KJPS: Knee Joint Position Sense test (mean absolute error values). [C] Y Balance test Normalized reach was calculated as reach distance/limb length (anterior superior iliac spine to medial malleolus) × 100

Table 4: Paired t-test and ANCOVA results to investigate DB and KJPS in each group

	Variable	Group [A]	Paired Differences [B]	T	Df	P [C]	P [D]	Eta squared
Direction [F]	KJPS [E] (degree)	EG CG	0.07±0.43 0.05±1.01	-0.60 0.19	11 11	0.559 0.846	0.656	0.010
	Composite	EG CG	3.30±1.50 0.16±2.24	-7.59 -0.25	11 11	0.001* 0.802	0.001*	0.564
	Anterior	EG CG	2.66±0.88 0.41±3.05	-10.40 -0.47	11 11	0.001* 0.646	0.008	0.293
	Posteromedial	EG CG	3.66±3.25 0.33±2.34	-3.90 -0.49	11 11	0.002* 0.633	0.001*	0.446
	Posterolateral	EG CG	3.58±3.17 0.25±3.57	-3.90 0.24	11 11	0.002* 0.813	0.001*	0.427

[A] EG=Experimental group; CG=control group. [B] Mean±Standard Deviation. [C] P values were obtained by Paired-Samples T Test. [D] p values were obtained by Univariable Analyze of Covariance (2 times × 2 groups). [E] Knee Joint Position Sense (mean absolute error values). [F] Y Balance test Normalized reach was calculated as reach distance/limb length (anterior superior iliac spine to medial malleolus) × 100. *P≤0.05 significant difference within groups from baseline to post intervention

that there is no significant difference relative to pre-test in both experimental and control groups in terms of the mean absolute error of knee joint reconstruction at an angle of 45 degrees after 8 weeks of SMR ($P \leq 0.05$), so that no meaningful change was observed in the average of three-time measurement of knee joint position sense after 8 weeks of SMR relative to pretest ($P \leq 0.05$) (Table 4). Results of ANCOVA test to examine intergroup differences showed that there was no significant difference between the experimental and control groups in the post-test after controlling for the pretest effect (blindness) at KJPS ($P \leq 0.05$) (Table 4).

Discussion

According to the results of the present study, 8 weeks of SMR with FR on shortness of hamstring muscles did not change the accuracy of KJPS. Although there were no changes in KJPS during the pre-test and post-test stages, scores on the Y balance test increased in all three anterior, posteromedial and posterolateral directions and the overall score increased.

By analyzing the results of the present study, it seems that application of SMR with FR on shortened hamstring muscles can improve the DB of individuals.

The quality of the balance control process is often used as a measure of lower extremity performance which is particularly important in athletes since the relation between sports injuries and balance is of particular importance in sports activities in addition to the issue of increasing athletes' functional ability [33]. If an athlete has good balance, they can also prevent minimal injury while maintaining good performance and achieving the best results.

Therefore, any factor affecting the balance of athletes can also influence the performance process and the outcome. In the present study, muscle shortness on the one hand and exercise effects on the other hand can be effective factors in balance.

One of the issues that had to be considered was the debate of SMR and the effects of such exercises on balance and the results of the present study showed that SMR improved the DB of people with hamstring shortness.

As said previously, a wide range of postural responses are generated in humans, in response to disturbing balance factors. One of the most important muscles in the hip and ankle strategy is the hamstring muscle which maintains balance as a postural muscle [5]. Therefore, it seems that any dysfunction of this muscle can affect balance.

It has been seen in the research literature that changes in muscle length can lead to postural disorders that can affect one's balance, which is why Zagyapan & et al showed that shortened flexor hip and hamstring muscles cause a change in posture that affects a person's balance [6].

Based on the literature, it can be concluded that shortness of hamstring muscle may be one of the reasons affecting one's optimal balance maintenance and it may be presented as a balance disorder. Given the direct relationship between muscle flexibility and balance maintenance, it seems natural that resolving the problem of reduced flexibility can be effective in controlling balance. Lack of flexibility can play an important role in the compatibility loss of muscle synergy, planning and nervous system problems. Hence, effective training programs in increasing length such as SMR can position hip, knee and hip joints in relatively better conditions with an increase in muscle flexibility. Moreover, they can be an effective strategy in the improvement of balance by enhancing muscle contraction patterns and muscle synergy adaptations.

Accordingly, one of the main reasons for improving balance presented in the present study is probably the increase in shortened muscle length due to SMR, which has been proved in previous studies [23, 34, 35] as well as in the current pilot study. In line with the results of the present study, Aslan et al. showed that stretching exercises can effectively improve the hamstring muscle shortness and balance of students with tightness of hip flexors [16].

It is likely that the psychological effect also contributes to this increase in balance in addition to the physical aspect. It is likely that incorporating these techniques is a factor in generating excitement that can result in improved balance.

Since the present study is probably one of the first studies in this field, the lack of SMR-induced changes in the obtained results in terms of knee joint position sense in this research cannot be compared to others.

Regarding the lack of impact of SMR on proprioception, the results are in line with Lederman's theory who stated that these types of passive exercises do not have a profound effect on proprioception [36]. These outcomes were also consistent with the results of Aslan et al and Moradi et al.

Aslan et al. concluded in a study that, following PNF and Dynamic stretching exercises, no significant improvement in knee joint position sense was found [16]. In a study, Moradi et al. investigated the instant effect of static stretch of Quadriceps femoris, hamstring and Gastrocnemius muscles on the knee joint position sense. According to the results, there was no significant difference between the mean error of knee joint position sense before and after static stretching [37].

Also David et al. in a study titled "The Effect of Foam Rolling of the Hamstrings on Proprioception at the Knee and Hip Joints" concluded that foam rolling improved knee joint position sense for at least 20 minutes post-intervention, and did not decrease hip joint position sense or knee joint force sense [38].

The pattern of SMR techniques and the dominant contribution of these techniques are passive because the muscle itself is not involved and it is being released, thus it leads to reducing the sensitivity of the muscle spindles and arousal and the sending of less information to the receptors.

Therefore, these techniques do not appear to have a significant effect on the accuracy of the proprioception. According to Lederman, the type of techniques used in the present study may even reduce the accuracy of the proprioception [36].

Also, low sample size or lack of adaptation can be considered as reasons for the lack of impact of the SMR on proprioception. Among other possible causes of lack of influence of SMR on KJPS, it can be noted that the muscle spindle is responsible for the joint's sense of position in the middle domain and the other receptors in this domain remain still [39]. Myofascial Release of the hamstring muscles inhibits it during the release range.

The results of physiological studies have shown that muscle spindle activity increases only during exertion of pressure and as muscle length increases and muscle tightness decreases, the activity of muscle spindle is also decreased.

Therefore, it is expected that an increase in angle reconstruction error up to 45 degrees can be seen by inhibiting muscle throughout the range but the present study rejects the outcomes of this hypothesis.

Conclusion

Based on the results, 8 weeks of self-myofascial release therapy increased DB in athletes with short hamstring shortness. There was no change in the KJPS following the FR protocol. What is apparent about hamstring muscle is that it is one of the most important muscles in the body which plays a role in influencing body structures, maintaining balance. In addition, it is the origin of many musculoskeletal disorders. Therefore, it is recommended that athletes incorporate SMR into their exercise program for improvement of balance as well as prevention and correction of other impairments, injuries and problems caused by muscle shortening in people with hamstring shortness.

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No potential conflict of interest was reported by the authors.

Conflict of Interest: None declared.

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