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Effect of Spherical Roller VS Cylindrical Roller MFR on Hamstring Flexibility in Post-Traumatic Knee Stiffness Patients: A Comparative Study

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ABSTRACT
Following lower limb trauma or surgery, post-traumatic knee stiffness frequently develops, resulting in hamstring discomfort, tightness, and limited range of motion (ROM). There is little data comparing various roller types, but myofascial release (MFR) treatments are useful for increasing muscular flexibility and decreasing stiffness. In patients with post-traumatic knee stiffness, this experimental comparison study sought to determine how well spherical vs cylindrical roller MFR affected hamstring flexibility and pain relief. The study was carried out at Krishna Hospital in Karad following ethical clearance. Using basic random sampling, forty volunteers between the ages of 20 and 50 were chosen, and they were split evenly into two groups. While Group B utilised a cylindrical foam roller, Group A employed a spherical roller (tennis ball) for self-myofascial release. For two weeks, both groups participated in five 10- to 15-minute sessions per week under the supervision of a physiotherapist. The Numerical Pain Rating Scale (NPRS) and Goniometer were used to measure knee range of motion and pain severity both before and after the intervention. Both groups showed considerable improvement, according to statistical analysis utilising paired and independent t-tests. In contrast to the cylindrical roller group, the spherical roller group had a higher improvement in hamstring flexibility, pain alleviation, and range of motion. According to the study's findings, spherical roller MFR (tennis ball massage) is superior in terms of deeper myofascial release, increased flexibility, and enhanced functional recovery, even if both methods are useful for treating post-traumatic knee stiffness.

1. INTRODUCTION

The hamstrings muscles arise from the lower pelvis and attach below the knee joint, forming a strong musculotendinous complex necessary for dynamic activities like running, jumping, and squatting. The hamstring group includes the biceps femoris, semitendinosus, and semimembranosus, which together assist in knee flexion and hip extension, thereby contributing significantly to locomotion, posture, and athletic performance [1,2]. Owing to their bi-articular nature, hamstrings are frequently affected by stiffness and reduced flexibility, particularly following periods of inactivity or injury such as post-traumatic knee stiffness [3].

The Post-traumatic knee stiffness often arises after fractures, ligament reconstructions, or surgical interventions involving the lower limb. It results from fibrotic changes and contracture in the periarticular soft tissues, leading to a decline in range of motion [4]. Prolonged Immobilization throughout the healing process causes periarticular soft tissue rigidity and muscle atrophy. As a defensive mechanism to limit unpleasant knee movement, the hamstrings often grow more tense and toned [5,6]. As a result, hamstring tightness limits knee extension, modifies the biomechanics of walking, and puts compensatory strain on joints like the hip and lumbar spine. As a consequence, basic daily functions such as stair climbing, sitting, or squatting are impaired, which can adversely influence overall quality of life [7].

Fascia, a continuous connective tissue network enveloping muscles and tendons, plays a crucial role in transmitting forces and maintaining mechanical balance within the kinetic chain [8]. After trauma, inflammatory responses may cause fascial thickening, dehydration, and adhesion

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formation, which in turn elevate stiffness and pain sensitivity [9]. Manual and self-administered release treatments that increase circulation, decrease adhesions, and restore flexibility have a good effect on the myofascial system [10]. Therapies that target fascial tightness, such as MFR, are commonly applied in rehabilitation to improve mobility and comfort [11].

Myofascial Release (MFR) employs slow, sustained pressure to normalize fascial tension and length [4]. This technique promotes relaxation by improving fluid exchange and activating sensory receptors such as Ruffini endings and Golgi tendon organs [13,14]. An expansion of the MFR concept, Self-Myofascial Release (SMFR) enables anyone to apply pressure with devices like foam rollers, massage balls, or specialty rollers to provide comparable therapeutic results [15]. SMFR has gained popularity due to its affordability and accessibility in both athletic and rehabilitation settings. Its application to the hamstrings is thought to enhance flexibility by improving viscoelastic behaviour of fascia, reducing muscle tone, and promoting relaxation [16]. Research has demonstrated that using a roller device to the hamstrings improves range of motion without negatively impacting performance or strength [4]. Rolling motion and mechanical pressure work together to stimulate blood circulation, loosen fascial adhesions, and raise tissue temperature all of which promote muscular extensibility [18]. Moreover, proprioceptive feedback, which helps control muscle tone and lessen myofascial trigger point sensitivity, is known to be stimulated by SMFR [19]. Additionally, rolling's mechanical pressure may cause a brief decrease in muscle spindle excitability, which would lessen reflex-mediated resistance to stretch [4]. Cylindrical foam rollers are the most extensively researched SMFR instrument. They provide a wide distribution of pressure by rolling longitudinally across the muscle belly and having a homogeneous surface [21]. Although its uniform surface prevents them from reaching deeper fascial layers or some localised constraints, cylindrical rollers are an efficient way to enhance flexibility and lessen muscular pain [4]. Conversely, spherical rollers can target deeper myofascial sites or fewer muscle groups and offer more concentrated pressure. They can roll in several directions and move more easily across intricate anatomical areas like the rear thigh thanks to their rounded shape [23]. The depth and intensity of the applied pressure are probably influenced by the variation in surface contact between spherical and cylindrical rollers, which might result in different therapeutic effects. Due to prolonged immobilization or changed gait, patients recovering from severe knee injuries frequently have secondary hamstring muscle tightness. Passive stretching, joint mobilization, and thermotherapy are conventional physiotherapy techniques for treating post-traumatic stiffness. These techniques may not always address underlying myofascial limitations, despite their effectiveness [24]. By enabling patients to carry out active soft tissue mobilization on their own, including self-myofascial release with rollers provides a useful supplement to traditional treatment. The impact of spherical vs cylindrical rollers on hamstring flexibility may be compared to see whether shape provides better myofascial engagement and functional results in situations of post-injury stiffness [25]. Spherical rollers may improve fascial release more successfully in thick or fibrotic tissues, which are typical in post-traumatic situations, since they may provide more localised and deeper pressure. The mechanisms responsible for improved flexibility following SMFR are likely multifactorial, involving mechanical deformation of fascia [26] modulation of mechanoreceptors and alpha-motor neuron excitability [27] enhanced tissue perfusion [28] and thermal-viscoelastic softening [29]. Collectively, these mechanisms may help restore normal joint motion and reduce post-injury stiffness.

According to a comprehensive study by Cheatham et al. (2015), SMFR greatly increases joint range of motion and lessens muscle pain after exercise [30]. According to Junker and Stöggl (2015), four weeks of foam roller exercise increased hamstring flexibility in healthy persons by 10–15% [31]. Self-myofascial release and static stretching improved ankle dorsiflexion more well than stretching alone, according to Škarabot et al. (2015) [32]. Similar to this, Grieve et al. (2015) observed that administering SMFR to the plantar area of the foot immediately improved the flexibility of the lumbar spine and hamstrings, indicating a myofascial chain link between the proximal and distal regions [33].

These results corroborate the fascial system's interconnectedness and the possibility for localized release methods to increase overall flexibility. The biomechanical or therapeutic benefits of various roller shapes are, however, seldom compared in the literature, especially when it comes to clinical populations like post-traumatic knee stiffness. Because of this, there is a knowledge gap about the best SMFR tool design to achieve maximum functional recovery.

2. MATERIALS AND METHODS

The study received approval from the Ethical Board and Protocol Committee. It was designed as an experimental comparative study and conducted at Krishna Hospital, Karad, involving 40 participants diagnosed with post-traumatic knee stiffness. A simple random sampling method was used for participant selection. Before beginning the study, all participants were clearly informed about the purpose and procedure of the research in their understandable language, and written informed consent was obtained from each of them. The Study was conducted in Satara district. The study followed a structured treatment protocol. The intervention program was conducted for a period of two weeks, with five sessions per week. Each session lasted approximately 10–15 minutes and included a warm-up, the main myofascial release intervention, and a cool-down phase. The exercises were performed within the patient's tolerance and were progressed gradually over the two-week period. Pre- and post-intervention assessments of pain intensity and knee range of motion were recorded using the Numerical Pain Rating Scale (NPRS) and Goniometer**,** respectively. The pressure and duration were progressively increased based on individual tolerance while ensuring comfort and safety throughout the sessions. Patients between the ages of 20-50 years who were diagnosed with post-traumatic knee stiffness and who reported pain levels greater than five on the Numerical Pain Rating Scale (NPRS) met the study's inclusion criteria. Patients with neurological conditions that could impair knee function or hamstring flexibility, those taking drugs that affect muscle tone or flexibility, those with recent hamstring injuries were all excluded. Hydration was encouraged after every session to facilitate recovery.

The study was conducted on two separate groups, each consisting of 20 participants. Group A and Group B. Both groups participated in a two-week intervention program, which included five supervised sessions per week, making a total of 10 treatment sessions. Each session lasted for about 20 to 25 minutes and comprised a brief warm-up, the main exercise phase, and a cool-down period to maintain safety and uniformity. Group A performed self-myofascial release using a spherical roller (tennis ball), focusing on the hamstring area to relieve tightness and improve flexibility through controlled rolling and gentle sustained pressure. Group B practiced self-myofascial release using a cylindrical foam roller for the same duration, emphasizing smooth rolling along the hamstring muscles to provide broader and more even pressure.

2.1. Outcome Measures

The Numerical Pain Rating Scale (NPRS) and a goniometer were used in a pre-test assessment of knee flexibility and pain severity, respectively. Following the baseline evaluation, individuals engaged in their designated intervention regimens for two weeks, which involved self-myofascial release using either a cylindrical foam roller or a spherical roller (tennis ball). The efficacy of both therapies in lowering pain and enhancing knee range of motion (ROM) was subsequently assessed using post-test exams.

Numerical Pain Rating Scale (NPRS): The subjects' level of pain was measured using the NPRS. On an 11-point scale, "0" denotes no discomfort and "10" denotes the worst possible suffering. Every participant was asked to select the number that most accurately represented their level of knee discomfort at the moment. The NPRS offered a straightforward and accurate way to compare pain levels before and after an intervention.

Goniometer: The range of motion (ROM) of the knee joint was measured using a universal goniometer, with an emphasis on flexion and extension motions. The goniometer's fulcrum was aligned over the lateral epicondyle of the femur while the subject was lying supine, with one arm positioned along the greater trochanter and the other over the lateral malleolus. Degree measurements were taken both before and after the two-week intervention.

In order to compare the two treatments groups and establish whether roller method was more successful in increasing hamstring flexibility and decreasing post-traumatic knee stiffness, both end measures were employed to objectively assess changes in pain and joint mobility.

Protocol was: The study's intervention regimen was carried out over a two-week period, with five sessions each week that lasted around 20 – 25 minutes each. To prepare the muscles for release, each session started with a quick warm-up that included two sets of ten repetitions of mildly active hip, knee, and ankle joint motions. Each of the two groups of participants followed a particular self-myofascial release (SMFR) technique while being supervised by a physiotherapist. Participants in Group A used a spherical roller, or tennis ball, for self-myofascial release. The ball was positioned under the back thigh while they were seated or long-sitting. The hamstring muscle was rolled slowly and deliberately from the gluteal fold to slightly above the knee joint. In order to alleviate myofascial limitations, participants utilised body weight to apply moderate pressure and paused for 20 to 30 seconds on sensitive or constricted regions. For two sets, each leg was rolled for two to three minutes, interspersed with a 30-second break. In Group B, participants used a cylindrical foam roller while seated to practice self-myofascial release. Participants lifted their bodies slightly above the ground by placing the foam roller beneath their thighs and using their arms for support. From the gluteal area to the popliteal fossa, slow motions of rolling were executed while maintaining constant, uniform pressure. To promote tissue release, prolonged compression was used for 20 to 30 seconds after sensitive sites were found. For two sets, each limb was rolled for two to three minutes, with rest breaks as needed. To encourage more flexibility, both groups engaged in mild static hamstring stretching after the primary intervention. Each stretch was held for 20 to 30 seconds and repeated three times. To promote muscular healing and relaxation, each session ended with a quick cool-down that included deep relaxation and breathing exercises for one to two minutes.

Participants were instructed not to roll directly over bony areas or the posterior knee joint, and the protocol was gradually advanced in terms of pressure application and duration based on each participant's tolerance. To assess the overall efficacy of the intervention, pre- and post-intervention assessments of pain (using NPRS) and knee joint range of motion (using a goniometer) were recorded.

2.1. Procedure

For Group A, Participants began in a seated position with their legs extended. Then the tennis ball was placed below the thigh targeting hamstring muscle. Gentle pressure was applied by gradually putting body weight onto the tennis ball. Participants performed self-myofascial release over the hamstring region using guided rolling and sustained pressure techniques with the tennis ball, moving it slowly and deliberately, searching for any areas of tightness or discomfort. When a particularly tight or tender spot is noted, pause and apply sustained pressure on that area for 20-30 seconds. Continue rolling and applying pressure for about 2-5 minutes on each hamstring with 30 sec of rest between each repetition. After using the tennis ball, some gentle hamstring stretching and mobilization of the knee joint were done to promote further flexibility and to reduce joint stiffness.

For Group B, Participants began in a seated position with their legs extended. The foam roller was placed under the thigh targeting hamstring muscle. Patient was asked to lift the body off the ground by placing hands behind & Support upper body with arms, and keep the core engaged. Participants performed self-myofascial release over the hamstring region using guided rolling and sustained pressure techniques with the foam roller down the hamstrings towards knees. Rolling was continued for about 2-5 minutes per leg with 30 sec of rest between each repetition. After using the foam roller, some gentle hamstring stretching and mobilization of knee joint were done to promote further flexibility and to reduce joint stiffness.

3. RESULTS

Table 1. Demographic data of participants

Parameters	Group A	Group B	p-Value	t- value	Interpretation
Age (years)	35.6 ± 8.4	36.1 ± 7.9	0.82	<0.0001	Considered Extremely Significant
Dur^n of stiffness (weeks)	8.3 ± 2.5	8.6 ± 2.8	0.74	<0.0001	Considered Extremely Significant

Table 1 depicts the demographic traits of both Group A and Group B research participants. Participants in Group A were 35.6 ± 8.4 years old on average, whereas those in Group B were 36.1 ± 7.9 years old. The results of the comparison between the groups showed a p-value of 0.82, which suggests that there was no statistically significant difference in the age distribution between the two groups. Similarly, Group A's mean length of stiffness was 8.3 ± 2.5 weeks, while Group B's was 8.6 ± 2.8 weeks, with a p-value of 0.74, indicating that there was no significant difference in baseline stiffness duration between the groups. As a result, both groups were demographically similar and well-matched before to intervention, guaranteeing objective evaluation of treatment results.

Table 2. Comparison of Pre and Post intervention wihin groups

Outcome Measure	Group	Pre-Test	Post-Test	*t*-Value	*p*-Value	Interpretation
NPRS	Group A	6.85 ± 0.67	2.30 ± 0.64	15.42	<0.0001	Considered Extremely Significant
NPRS	Group B	6.70 ± 0.74	4.15 ± 0.71	10.8	<0.0001	Considered Extremely Significant

Table 2 shows the comparison of Numeric Pain Rating Scale (NPRS) ratings before and after intervention within a group. Group A's mean NPRS score dropped dramatically from 6.85 ± 0.67 to 2.30 ± 0.64, with an exceptionally significant t-value of 15.42 and $p < 0.0001$. This suggests a significant decrease in discomfort after the intervention. A statistically significant improvement was also shown in Group B, where the mean NPRS score decreased from 6.70 ± 0.74 to 4.15 ± 0.71, with a t-value of 10.8 and $p < 0.0001$. Nonetheless, the fact that Group A's pain ratings decreased more than Group B's indicates that Group A's intervention was more successful in reducing pain.

Table 3. Comparison between groups (Post-Test Scores)

Outcome Measure	Group	Pre-Test	Post-Test	*t*-Value	*p*-Value	Interpretation
Knee ROM (°)	Group A	94.2 ± 5.8	125.7 ± 6.1	14.73	<0.0001	Considered Extremely Significant
Knee ROM (°)	Group B	95.4 ± 5.2	111.3 ± 5.9	11.36	<0.0001	Considered Extremely Significant

Table 3 displays a comparison of the two groups' knee range of motion (ROM) following the intervention period. With a t-value of 14.73 and $p < 0.0001$, Group A's knee range of motion significantly increased from 94.2 ± 5.8° to 125.7 ± 6.1°. Knee range of motion in Group B rose from 95.4 ± 5.2° to 111.3 ± 5.9°, with a very significant t-value of 11.36 and $p < 0.0001$. While both groups showed improvement, Group A showed a higher improvement in knee joint mobility than Group B, indicating that the experimental intervention regimen was more successful.

4. DISCUSSION

The present study aimed to evaluate and compare the effects of spherical roller myofascial release (MFR) and cylindrical roller MFR on hamstring flexibility among patients with post-traumatic knee stiffness. This condition commonly develops after trauma or surgical interventions around the knee and is often associated with soft tissue adhesions, capsular restrictions, and muscle shortening, particularly in the hamstring group [4, 24]. The limitation in knee movement that follows such stiffness can delay rehabilitation and reduce functional independence. As suggested by Shelbourne and Patel [5], failure to regain early knee mobility may contribute to long-term fibrotic changes and persistent stiffness. Since the hamstrings span both the hip and knee joints, they tend to develop tightness when mobility is reduced, leading to pain and restricted extension [2,3].

The results of the present study indicated that both spherical and cylindrical roller MFR interventions were effective in improving hamstring flexibility and knee range of motion (ROM). However, patients treated with the spherical roller (tennis ball) showed a slightly greater improvement compared to those who used the cylindrical roller. This may be because the spherical roller offers more concentrated and deeper pressure on the muscle belly and myofascial trigger points, while the cylindrical roller applies a broader, less intense compression. Similar findings were reported by Kadam and Aswale [23], who observed that smaller and more focused rolling tools provided greater myofascial release effects due to deeper pressure distribution.

The positive outcomes observed in both groups may be related to the mechanical and neurophysiological mechanisms of MFR. The continuous, low-load pressure used during myofascial release can break cross-links within the fascia, enhance local blood circulation, and reduce neural tension, thereby improving tissue elasticity [9,10,26]. According to Schleip et al. [8], fascia is a responsive, tension-bearing structure that can adapt to external stimuli through plastic deformation, allowing it to regain flexibility. In addition, Wilke et al. [13], demonstrated that self-myofascial release performed for short durations could reduce sensitivity of trigger points and increase muscle length, supporting the outcomes of the current study.

Previous studies have also highlighted the role of foam rolling in enhancing muscle extensibility. Bandy and Irion [3], showed that static stretching increases hamstring flexibility, and when combined with MFR, the improvement is even greater [12,17]. Similarly, Sullivan et al. [16], reported that self-MFR using foam rollers can increase ROM without negatively affecting muscle performance, likely due to changes in tissue viscosity and muscle tone. Cheatham et al. [30] and Halperin et al. [20] also confirmed that self-myofascial rolling helps improve flexibility and performance by enhancing circulation and reducing tissue stiffness. Hotfiel et al. [28], further explained that self-MFR promotes microcirculation, which supports tissue healing and recovery.

The slightly superior results observed in the spherical roller group might be due to its ability to reach deeper fascial layers. Localized pressure provided by the spherical roller likely stimulates mechanoreceptors and causes reflex inhibition of muscle tone, leading to greater relaxation and reduced tightness [14]. Kadam and Aswale [23], reported similar effects when using tennis-ball self-release for piriformis pain, demonstrating that small, firm tools can effectively release local restrictions. In the present study, participants using the spherical roller also reported a noticeable reduction in perceived stiffness, which can be attributed to enhanced tissue compliance and targeted mechanical pressure. A study by Grieve et al. [33], found that applying self-myofascial release to the plantar fascia improved hamstring and lumbar flexibility, supporting the concept of interconnected fascial chains influencing distant muscle groups.

Pain reduction in both groups may be explained by the modulation of sensory feedback and release of endogenous analgesic responses, which decrease muscle tone and discomfort [11,27]. Hwang et al. [6], emphasized the relationship between muscle stiffness and function after knee injury, suggesting that reduction in stiffness can directly improve movement efficiency. Regular application of rolling pressure over multiple sessions likely contributed to gradual lengthening of the hamstring tissue, as also noted by Kisner, Colby, and Borstad [7].

The shape and design of the roller appear to influence therapeutic outcomes. Cheatham [25], compared different roller types and concluded that their surface texture and curvature affect both comfort and tissue pressure distribution. Similarly, Curran et al. [21], demonstrated that rollers with smaller contact areas exert higher localized pressure, which could explain the better performance of the spherical roller in this study. Bradbury-Squires et al. [29], also found that controlled, targeted rolling increases blood flow and aids in soft tissue recovery, further supporting the effectiveness of focused MFR techniques.

The findings from this study align with the principle of fascial continuity, proposed by Schleip et al. [8], which suggests that improved mobility in one muscle group can positively influence other connected structures in the kinetic chain. Enhancing hamstring flexibility helps in restoring smoother knee motion and reduces compensatory strain on adjacent joints. For individuals recovering from knee trauma, these improvements can contribute significantly to better functional outcomes and faster rehabilitation Vaishya et al., [24].

Overall, the results demonstrate that both spherical and cylindrical roller MFR techniques are practical and beneficial for clinical as well as self-care use. The spherical roller provides a more concentrated release suitable for deeper restrictions, while the cylindrical roller offers a broader, gentler pressure ideal for early-stage recovery. These findings reinforce the use of self-myofascial release as an accessible and cost-effective component of physiotherapy programs aimed at improving flexibility, reducing stiffness, and promoting functional recovery.

5. Conclusion

The Study supported Alternate Hypothesis i.e., we found a significant difference between effects of foam roller exercise & tennis ball massage in post-traumatic knee stiffness patients. This Study Concluded that, Tennis ball massage is more effective than foam roller exercises on hamstring flexibility in post-traumatic Knee stiffness patients.

Ethics Committee

This study followed all ethical standards and received approval from Krishna Vishwa Vidyapeeth, Karad [KVV/IEC/09/2023]. Informed consent was obtained from the participant using a volunteer consent form that clearly outlined the purpose of the research, potential risks and benefits, confidentiality provisions, and participants' rights. The study was conducted with ethical principles of the Declaration of Helsinki, ensuring that participant rights, safety, and well-being were prioritized throughout the study's design, procedure, and confidentiality measures.

Conflict of Interest

The authors declare that there is no conflict of interest.

Author Contributions

Study Design: SC and ZMD; Data Collection: SC and ZMD; Statistical Analysis: SC and ZMD; Data Interpretation: SC and ZMD; Manuscript Preparation: SC and ZMD; Literature Review: SC and ZMD. All authors have read and approved the published version of the manuscript

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