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The effect of different kinds of instant fascial release techniques for improvement of range of motion and muscle stiffness

PhD Thesis

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Abstract

Title: The effect of different kinds of instant fascial release techniques for improvement of range of motion and muscle stiffness

Objectives: This research aims to critically evaluate the effectiveness of immediate fascial release techniques such as tissue flossing (TF) and foam rolling (FR), on range of motion (ROM), viscoelastic properties of the muscle, dynamic stabilization and jump performance among athletes and fitness enthusiasts.

Methodology: Cross-over design of the study, where all participants underwent three types of conditioning: tissue flossing, foam rolling or control. The study used a comprehensive methodology that included an active knee extension test, a Y-balance test, jump performance was measured using force plates and viscoelastic properties of Biceps Femoris (BF), Rectus Femoris (RF) and Vastus Lateralis (VL) of both legs were used to assess the impact of TF and FR conditionings. Participants were measured before conditioning and respectively in 2nd and 15th minute after conditioning activity. Two-way repeated measures ANOVA was used to evaluate the data.

Results: Tissue flossing and foam rolling significantly improved ROM in both legs when compared to the control group, however no significant differences occurred between any of the conditions. Jump height experienced a significant drop post-intervention in the FR group, while no changes were observed for TF and the control group. Braking Rate of Force Development showed significant improvement in the TF group when compared pre and post max value. Dynamic stability improved significantly in both legs for the TF group and in the left leg for the FR group, with no changes observed in the control group. ANOVA analysis revealed no significant differences between the interventions in measurements of viscoelastic properties, and none of the interventions showed significant improvements when compared to the control condition. However, TF had significantly decreased muscle stiffness in right VL, both RF whereas FR significantly decreased muscle stiffness and muscle tone in all muscles.

Keywords: Tissue flossing, foam rolling, viscoelastic properties, myofascial release, performance

Introduction

Fascial release techniques have been increasingly used by athletes, fitness enthusiasts, and healthcare professionals to improve range of motion and reduce muscle stiffness (1). Fascia is a connective tissue that surrounds and supports muscles, organs, and other structures in the body. It is responsible for transmitting force and movement between different parts of the body and plays an important role in movement and mobility (2). However, when fascia becomes restricted or damaged, it can lead to stiffness, pain, and reduced mobility.

Immediate fascial release techniques aim to alleviate these symptoms by applying pressure to the fascia and surrounding tissues to release tension and restore mobility. These techniques include tissue flossing, foam rolling, instrument-assisted soft tissue mobilization (IASTM), and others. While these techniques have gained popularity in recent years, their effectiveness in improving range of motion and reducing muscle stiffness remains a subject of debate.

This paper will explore the effects of different types of immediate fascial release techniques on range of motion, muscle stiffness and jump performance. We will examine the benefits and limitations of tissue flossing (TF) and foam rolling (FR) and compare their effectiveness in improving mobility and reducing stiffness. By understanding the mechanisms and effects of each technique, we can gain a better understanding of how to use fascial release techniques to optimize physical performance and reduce the risk of injury.

Hypothesis and aims of study

The primary objective of this study is to examine the impact of an innovative technique called tissue flossing, when applied to the thigh, on the jump performance of athletes whose sports involve jumping. Additionally, the study aims to evaluate how this technique affects viscoelastic properties of the muscle, dynamic balance, and ROM.

Another objective of this research is to compare tissue flossing with the commonly used self-myofascial release technique using a foam roller. The goal is to determine which method is more suitable for incorporating into athletes' warm-up routines, aiming to enhance performance and prepare for competition or practice.

Null hypothesis 1: Tissue flossing applied to the thigh will not affect jump performance, brakingRFD, and ROM.

Null hypothesis 2: Tissue flossing will not yield greater improvements in jump performance, ROM, dynamic stability, viscoelastic properties of the muscle, and brakingRFD compared to foam rolling.

Null hypothesis 3: Both the foam rolling and tissue flossing conditionings will not demonstrate significant improvements when compared to the control conditioning.

Alternative hypothesis 1: Tissue flossing applied to the thigh will improve jump performance, brakingRFD, and ROM.

Alternative hypothesis 2: Tissue flossing will yield greater improvements in jump performance, ROM, dynamic stability, viscoelastic properties of the muscle, and brakingRFD compared to foam rolling.

Alternative hypothesis 3: Both the foam rolling and tissue flossing conditionings will demonstrate significant improvements when compared to the control conditioning.

The hypotheses were based on previous studies indicating the improvement of ROM, RFD and knee exertion after thigh application of tissue flossing (3, 4). However, most of them target only one limb or target different joint (3, 5, 6). As there is research which compares effect of tissue flossing and foam rolling on Triceps Surae, which indicates significant decrease in Achilles tendon stiffness and CMJ performance after tissue flossing application (7) such a comparison is missing for other parts of the body. Since quadriceps and hamstring muscles have significant impact on jump performance (8, 9) there is a reason to conclude that this improvement should occur also after tissue application.

Furthermore, according to a study conducted by Jones et al. (10) it was suggested that tissue flossing could potentially yield similar benefits to BFR training. Therefore, it is reasonable to speculate that, like BFR, tissue flossing may enhance jump performance when applied during lunges exercises, as indicated by Doma et al. in 2020 (11).

Experimental methods

Subjects

The research sample used in this study consisted of 30 healthy handball players (30 men) with 8-10 years of experience in handball, from Dukla Sport Club in Prague. Subjects were aged from 15-18 years old, practicing handball on high level, with practices 4 times per week. 29 participants indicated right as dominant leg only one had left as dominant leg. Subjects were recruited on the basis that they were healthy, injury-free for at least 3 months. Participants were given clear instructions not to engage in lower body resistance exercises for a period of 24 hours prior to the testing to prevent fatigue. They were advised to maintain their regular dietary and sleep routines. Participants had the freedom to withdraw from the experiment at any point and were fully informed about the advantages and potential risks associated with their participation before giving their written consent. The expected results of the study were not disclosed to the participants. The research was approved by the UK FTVS Ethics Committee under number 177/2020.

Experimental procedures

Before beginning the measurements, the participants were randomly assigned to the protocols in a randomized order. Each participant completed all of the protocols, experiencing each one in a predetermined sequence unknown to the participants. At the beginning of the first session, the subjects underwent a familiarization process with the protocol. A certified physiotherapist then measured the leg length, and markers were placed on the body for VL (vastus lateralis), BF (biceps femoris), and RF (rectus femoris) muscles on both legs, following the guidelines provided by SENIAM. The participants were instructed to keep the markers placed on their bodies throughout the entire measurement period and to correct them after each shower. Following the placement of markers, the subjects underwent body composition measurements using a TANITA device from Japan. The subjects were kept blinded and did not have access to information regarding which specific protocol would be performed. Additionally, the subjects were instructed to refrain from engaging in any lower limb exercises for 24 hours prior to each session. The measurements were conducted over a period of 2 weeks, with at least a 24-hour and maximum 5 days break between each measurement for the participants.

The measurements were conducted in the Training Adaptation Laboratory, located in the Faculty of Physical Education and Sport at Charles University. Throughout the entire measurement period, the room temperature was recorded three times a day: at the beginning, middle, and end of the measurements. Most of the time, the temperature in the room fluctuated around 22 degrees Celsius, with two instances where it reached 25 degrees Celsius. Unfortunately, the researcher was unable to affect the temperature due to the absence of air conditioning in the laboratory. The humidity level in the room was maintained at approximately 50-60%.

Protocol included 3 conditioning: FR- foam rolling, TF- Tissue flossing and CON- control. All conditionings lasted same amount of time: approximately two minutes. Before each measurement, the subjects followed a standardized warm-up routine. These standardized warm-up exercises were performed by the subjects before each measurement session. After a one minute rest period, Myoton measurements were taken. The measurements began with the subject lying in a prone position with a roller placed under the knees for the measurement of the RF and VL muscles on the right leg. Then, the RF and VL muscles on the left leg were measured. Subsequently, the subject was rotated to a supine position with a roller placed under the ankles, and the measurement of the BF (biceps femoris) muscle was initiated, starting from the right leg, and concluding on the left BF muscle. Following the Myoton measurements, the participants had active knee extension angle evaluated. Subjects laid prone on the table and flexed their knee and hip to 90°. During the test, the subjects manually monitored the position of their femur and ensured it remained at a 90° flexion angle throughout. They then straightened their right leg to its maximum extent while keeping the foot relaxed. This position was held for a duration of 5 seconds. A standard SAEHAN goniometer was placed over the pre-marked lateral joint axis, with its arms aligned along the femur and fibula. The knee joint angle was then measured and recorded in degrees using the goniometer. The angle measurement was calculated by subtracting the recorded knee joint angle from 90 degrees. This calculation was performed to determine the amount of knee extension in degrees from the 90-degree reference point. This method is considered as a reliable method of hamstring muscle length (12). Firstly, the measurement was performed on the right leg, and then the same procedure was repeated on the left leg. Then participants proceeded to the force plates (Hawking Dynamics). They were instructed to perform three Countermovement Jumps (CMJ) with their hands on their sides. The rest period between each jump was 15 seconds. The subjects were specifically instructed to exert maximum effort in order to achieve the highest possible jump height. Verbal motivation was provided by the researchers throughout the jumping protocol. After completing the jumps, the subjects proceeded to the Y Balance Test. They removed their shoes and began the measurement by standing on their left leg with their hands at their sides. They then moved into the anterior direction, followed by the posteromedial and posterolateral sides. Once they successfully completed three attempts of each direction on the left leg, they switched to standing on their right leg and repeated the test. Maximum value of each side was taken for the calculations. The participants were already familiar with the Y Balance Test, as it was included in their warm-up routine under the guidance of the head coach.

The intervention initiated right after premeasurements. On three different occasions participants underwent either tissue flossing (TF), foam rolling (FR) or control (CON) conditioning. The post-measurements were conducted in the following order: starting from the 2nd minute after the intervention, and then starting from the 15th minute after the intervention. The same order as the pre-measurements was maintained, beginning with the assessment of muscle stiffness using MyotonPro on the RF, VL, and BF muscles, followed by the measurement of active knee extension angle. Subsequently, jump performance was evaluated, and finally, dynamic stabilization was assessed. Participants were instructed to engage in walking during the rest period between the warm-up and intervention, as well as between the intervention and post-measurements. Similarly, during the intervals between post-measurements, participants were asked to continue walking.

Practical procedures

Tissue Flossing intervention

Participant seated on the edge of the table with legs resting on chairs with knees slightly bended. Tissue flossing was performed using green Sanctband Comprefloss band 5 cm x 3,5 m by two trained therapists with previous experience in tissue flossing methods. The floss band was wrapped around the area just above the distal third between the anterior superior iliac spine (ASIS) and patella, serving as an anchor point as suggested in other study (3). With maintained tension, the band was stretched to 1.5 times its natural length. The researcher then proceeded to wrap the thigh from distal to proximal, ensuring a 50% overlap with each subsequent wrapping of the band over the previous part. Both legs were wrapped simultaneously, with monitoring of the pressure using Kikuhime pressure sensor.

Once the floss was applied, the participants performed 10 bodyweight squats, ensuring that they reached a 90-degree knee flexion angle. The squats were performed with a specific tempo of 2 seconds for the eccentric phase, 1 second at the bottom position, 2 seconds for the concentric phase, and 1 second at the top position in accordance with a metronome. After completing the squats, the participants proceeded to perform 10 dynamic lunges on each leg, alternating between legs. Once the exercises were completed, the tissue band was removed, and the participants were instructed to walk. The entire application procedure took approximately 2 minutes to complete.

Foam rolling application

The participants were instructed to position their lower limb in the designated position and place as much of their body weight as possible onto the foam roller. They were then instructed to move back and forth on the foam roller in the same area where the tissue flossing was applied, specifically the distal third between the ASIS and patella. For the anterior thighs, the participants assumed a plank position. The treated leg was placed on the foam roller device, while the foot of the non-treated leg remained off the ground. In the case of the hamstrings, the participants sat on the floor with the foam roller positioned under their hamstrings. They placed their hands on the ground to the side and kept their feet in the air. Each quadriceps (staring from right and then left) was rolled for 30 seconds, followed by the hamstrings firstly on the right and left side, also for 30 seconds each. The duration of 30 seconds was chosen because it is similar to the total time of tissue flossing application, and previous studies have shown that it is sufficient to produce positive results in terms of hip range of motion and jump performance (13-15).

Control condition

In the control conditioning, the participants followed a protocol similar to Tissue Flossing, but with one key difference: their thighs were not flossed with a band. The participants began by warming up and then performed 10 bodyweight squats, ensuring that they reached a 90-degree angle at the knee flexion. These squats were executed with a specific tempo: 2 seconds for the eccentric phase, 1 second at the bottom position, 2 seconds for the concentric phase, and 1 second at the top position, all guided by a metronome. Once the squats were completed, the participants proceeded to perform 10 dynamic lunges on each leg, alternating between legs.

Data collection

Collection of the data started in this measurement from pre measurement which started one minute after warm up. Data was collected always in the same order starting from Myoton measurements, then proceeding to active knee extension, evaluating jump performance on force plates and dynamic stability on Y-balance test.

Data Analysis

All data was analysed using SPSS (version 25.0; SPSS, Inc., Chicago, IL), organization of the date and graphs were created using MATLAB software. A Shapiro-Wilk test was used to test the normal distribution of the data, and Mauchly's test was used to test for the assumption of sphericity. If the p-value obtained from Mauchly's Test is below .05, it indicates a violation of the assumption. In such cases, the Greenhouse-Geisser correction is applied to address this violation. Two-way ANOVAs (3 X [FR; TF; CON] X 3 time points [pre, post1, post2] were used to investigate the influence of foam rolling and tissue flossing on viscoelastic muscle properties and dynamic stabilization and jumping performance. When a significant main effect or interaction was found, post hoc tests with Bonferroni correction were used to analyze the pairwise comparisons. The magnitude of mean differences was expressed with standardized effect sizes. The effect of the conditioning was calculated by Cohen's d effect size considering 0.2, 0,5, and 0,8 as small, medium, and large effect sizes, respectively (16). Thresholds for qualitative descriptors of partial eta square were interpreted as: $\eta2 = 0.01$ a small effect, $\eta2 = 0.06$ a medium effect, $\eta2 = 0.14$ a large effect (17). Results are reported as the mean with standard deviations. Statistical significance was set at $p < 0.05$.

Results

The study involved a total of 30 participants, all of whom successfully completed the study. Certified physiotherapists conducted AROM analyses for all measurements and also assessed the viscoelastic properties.

ROM results

All conditionings for ROM rejected null hypotheses of normal distribution of the data, indicating that results are normally distributed. Two-way ANOVA indicated that there was statistically significant difference between pre and post measurements for right leg ($F_{(2,174)}$=13.198; $p < 0.001$; $\eta 2 = 0.132$) and between the time of measurement and intervention ($F_{(4,174)}$ = 4.8; $p < 0.002$; $\eta 2 = 0.099$) with no differences between the interventions and control group ($F_{(2,87)}$ = 0.169; $p = 0.845$; $\eta 2 = 0.004$). Post hoc analysis revealed significant difference ROM improvement from pre to post1 and post2 measurement but not from post1 to post2. When compared pre and maximum post value no significant difference between all interventions ($F_{(2,87)}$ = 0.363; $p = 0.697$). However, significant difference between pre and max post for tissue flossing and for foam rolling was found ($p < 0.001$). The effect size, as measured by Cohen's d, when compared pre and post max was for CON d = 0.31, FLOSS d = 1.21, FR d = 0.8 for right leg. For left leg repeated measures ANOVA shows statistically significant differences between pre and post measurements ($F_{(2,174)}$ = 12.452; $p < 0.001$; $\eta 2 = 0.125$) and between the time and intervention protocol ($F_{(4,174)}$ = 6.178; $p < 0.001$; $\eta 2 = 0.124$). However no significant interaction was found between the interventions ($F_{(2,87)}$ = 0.003; $p = 0.997$; $\eta 2 = 0$). Post hoc analysis revealed significant difference ROM improvement from pre to post1 and post2 measurement but not from post1 to post2. Paired T-test revealed significant difference for pre and post1 and pre to post2 for tissue flossing conditioning ($p < 0.001$) for both left and right leg. For FR paired T-test showed significant improvement in ROM from pre to post1 for both left and right leg ($p < 0.001$, $p = 0.02$ respectively) and from pre to post2 for right leg ($p = 0.036$). No significant changes in control conditioning. When compare pre and maximum post values there was not observed significant difference between any of the interventions ($F_{(2,87)}$ = 0.101; $p = 0.904$), however significant difference between pre and max post for tissue flossing and for foam rolling was found ($p < 0.001$)(Table 1). The effect size, as measured by Cohen's d, when compared pre and post max was for CON d = 0.25, FLOSS d = 1.47, FR d = 0.95.

Table 1 The mean ± standard deviation (SD) values for the range of motion (ROM). CON- Control condition, FLOSS- tissue flossing condition, FR- foam rolling condition

Intervention	Side	Pre	Post1	Post2
CON	Right	64.53 ± 10.22	64.03 ± 10.88	64.4 ± 12.24
	Left	63.47 ± 12.56	62.83 ± 12.2	62.73 ± 13.59
FLOSS	Right	60.37 ± 10.9	65.5 ± 11.36	65.63 ± 10.58
	Left	59.27 ± 10.72	64.7 ± 11.7	64.4 ± 11
FR	Right	60.7 ± 10.19	64.07 ± 9.96	63.7 ± 10.01
	Left	61.1 ± 10.73	64.67 ± 11.54	63.07 ± 10.72

Viscoelastic properties results

Vastus Lateralis (VL)

Left lower limb

The 2-way ANOVA indicated that there was no statistically significant difference between interventions on stiffness ($F_{(2,87)} = 0.5$; $p = 0.608$; $\eta2 = 0.011$) and muscle tone on the left leg ($F_{(2,87)} = 0.564$; $p = 0.571$; $\eta2 = 0.013$) . There were significant effects of interventions on time on: muscle tone ($F_{(4,174)} = 11.289$; $p < 0.001$; $\eta2 = 0.115$) and on stiffness ($F_{(4,174)} = 6.748$; $p < 0.001$; $\eta2 = 0.134$) and differences between pre and post measurements on muscle tone ($F_{(2.174)} = 4.559$; $p = 0.002$; $\eta2 = 0.095$) and on stiffness ($F_{(2.174)} = 15.509$; $p < 0.001$; $\eta2 = 0.151$). Post hoc analysis showed a significant decrease in muscle tone in all times of the measurement. Respectively from pre to post1, to post2 and from post1 to post2 ($p = 0.041$, $p < 0.001$, $p = 0.044$). For stiffness post hoc revealed significant difference between pre and post2, and post1 and post2 measurements ($p < 0.001$) no main difference occurred between pre and post1 ($p = 0.062$). Paired T-test revealed significant decline in muscle tone and muscle stiffness for FR from pre to post1 ($p < 0.001$) and from pre to post2 ($p = 0.001$, $p < 0.001$, respectively). The effect size, as measured by Cohen's d, when compared pre and post max was for CON d = 0.15, FLOSS d = 0.52, FR d = 0.56 for muscle tone and CON d = 0.03, FLOSS d = 0.5, FR d = 0.76 for muscle stiffness.

Right Lower Limb

For VL on right lower limb repeated measures ANOVA shows statistically significant differences between pre and post measurements ($F_{(2,174)} = 16.897$; $p < 0.001$; η2 = 0.163) for muscle tone and for stiffness ($F_{(2,174)} = 36.366$; $p < 0.001$; η2 = 0.295). Main effect was observed of intervention on time ($F_{(4,174)} = 4.961$; $p = 0.001$; η2 = 0.102) for stiffness, however not in muscle tone ($F_{(2=4,174)} = 2.29$; $p = 0.67$; η2 = 0.05). Post hoc indicate main difference between pre and post2 measurements and post1 to post2 on both stiffness and muscle tone ($p < 0.001$), but no significant difference between pre and post1 in both measurements: muscle tone ($p = 0.184$) (Fig. 21) and stiffness ($p = 0.318$). For post1 measurements TF statistically significantly differed from FR ($p = 0.046$) where TF acutely increased stiffness (Mean difference 5.233). However, this increase in stiffness wasn't statistically significant ($p = 0.627$). Paired T-test shows significant difference for TF conditioning for muscle tone in stiffness in both from pre to post2 ($p = 0.005$, $p = 0.001$, respectively) and from post1 to post2 ($p < 0.001$). For FR T-test revealed significant difference in both: muscle tone and stiffness from pre to post1 ($p = 0.015$, $p < 0.001$, respectively) and pre to post2 ($p = 0.002$, $p < 0.001$, respectively). The effect size, as measured by Cohen's d, when compared pre and post max was for CON d = 0.03, FLOSS d = 0.23, FR d = 0.35 for muscle tone and CON d = 0.03, FLOSS d = 0.31, FR d = 0.59 for muscle stiffness.

Rectus Femoris (RF)

Left lower limb

The results of the 2-way ANOVA revealed that there were no significant differences between the interventions in terms of stiffness ($F_{(2,87)} = 0.845$; $p = 0.433$; η2 = 0.019) and muscle tone on the RF left leg ($F_{(2,87)} = 0.476$; $p = 0.623$; η2 = 0.011). However, significant effects of interventions were observed over time for muscle tone ($F_{(4,174)} = 3.863$; $p = 0.005$; η2 = 0.082) and for stiffness ($F_{(4,174)} = 7.693$; $p < 0.001$; η2 = 0.15). Additionally, there were significant differences between pre- and post-measurements in terms of muscle tone ($F_{(2,174)} = 6.589$; $p = 0.002$; η2 = 0.07) and stiffness ($F_{(2,174)} = 26.693$; $p < 0.001$; η2 = 0.235). Post hoc shows significant decline for frequency from pre to post2 measurement ($p = 0.003$) and for stiffness ($p < 0.001$) but no main differences between pre to post1 and post1 to post2 for both muscle tone ($p = 0.619$; $p = 0.061$) and stiffness ($p = 0.7$). For CON there was no statistically significant changes in muscle tone between the measurements. For FLOSS was significant drop in muscle tone from post1 to post2 ($p < 0.001$) whereas for FR were statistically significant changes from pre to post1 and post2 ($p = 0.19$, $p = 0.012$ respectively. Paired T-test shows significant decrease in muscle tone and stiffness for FR from pre to post1 ($p = 0.012$, $p < 0.001$, respectively) and from pre to post2 ($p = 0.004$, $p < 0.001$, respectively). For tissue flossing conditioning there was significant increase in muscle tone from pre to post1 ($p = 0.027$), however from post1 to post2 was significant drop in muscle tone ($p < 0.001$). For muscle stiffness no main effect on pre to post1 measurement was found, but significant drop from post1 to post2 and pre to post2 was found ($p < 0.001$, $p = 0.002$, respectively). The effect size, as measured by Cohen's d, when compared pre and post max was for CON d = 0.14, FLOSS d = 0.51, FR d = 0.25 for muscle tone and CON d = 0.14, FLOSS d = 0.37, FR d = 0.71 for muscle stiffness.

Right lower limb

No statistically significant interaction was found between the interventions for tone in right leg for RF ($F_{(2,87)} = 0.363$; $p = 0.697$; $\eta 2 = 0.008$) or stiffness ($F_{(2,87)} = 1.08$; $p = 0.344$; $\eta 2 = 0.024$). Moreover, there were no statistically significant main effect of intervention and time for frequency ($F_{(4,174)} = 1.826$; $p = 0.126$; $\eta 2 = 0.04$), yet there was a main effect of time in both: frequency and stiffness ($F_{(2,174)} = 23,691$; $p < 0.001$; $\eta 2 = 0.214$ and $F_{(2,174)} = 30.238$; $p < 0.001$; $\eta 2 = 0.258$ respectively). Additionally, there was significant main effect of intervention on time for stiffness ($F_{(4,174)} = 5.58$; $p < 0.001$; $\eta 2 = 0.114$). The post hoc analysis showed a significant decline in frequency from pre to post2 measurement ($p < 0.001$) and for post1 to post 2 ($p < 0.001$), similarly for stiffness there is a significant decline from pre to post2 and from post1 to post2 ($p < 0.001$) but not from pre to post1 ($p = 0.344$) but no main differences between pre to post1 for muscle tone ($p = 0.194$). For TF paired T-test shows significant drop in muscle tone and stiffness from pre to post2 ($p = 0.001$, $p < 0.001$, respectively) and from post1 to post 2 ($p = 0.001$, $p < 0.001$, respectively). For FR paired T-test revealed significant decline in muscle tone and stiffness from pre to post1 ($p = 0.024$, $p = 0.006$, respectively) and pre to post2 ($p = 0.003$, $p < 0.001$, respectively). The effect size, as measured by Cohen's d, when compared pre and post max was for CON d = 0.04, FLOSS d = 0.13, FR d = 0.24 for muscle tone and CON d = 0.13, FLOSS d = 0.5, FR d = 0.26 for muscle stiffness.

Biceps Femoris (BF)

Left lower limb

No statistically significant interaction for muscle stiffness ($F_{(2,87)} = 0.234$; $p = 0.792$; $\eta 2 = 0.005$) or tone ($F_{(2,87)} = 0.153$; $p = 0.856$; $\eta 2 = 0.004$), was found. Moreover, there were no statistically significant main effects of intervention on time on muscle stiffness or tone (tone ($F_{(4,174)} = 0.659$; $p = 0.582$; $\eta 2 = 0.016$; $F_{(4,174)} = 0.541$; $p = 0.66$; $\eta 2 = 0.012$, respectively) . Although there was statistically significant effect of time on muscle tone ($F_{(2,174)} = 6.319$; $p = 0.005$; $\eta 2 = 0.068$) and on stiffness ($F_{(2,174)} = 6.263$; $p = 0.005$; $\eta 2 = 0.067$) . Post hoc indicate significant decline in tone only from pre to post2 measurement ($p = 0.012$), for stiffness there was significant decline form pre to post1 and post2 ($p = 0.017$, $p = 0.029$), but not from post1 to post2. Paired T-test shows significant decline for FR from pre to post1 ($p = 0.01$, $p = 0.004$) and from pre to post2 ($p = 0.028$, $p = 0.045$) for both muscle tone and stiffness respectively. The effect size, as measured by Cohen's d, when compared pre and post max was for CON d = 0.09, FLOSS d = 0.04, FR d = 0.25 for muscle tone and CON d = 0.06, FLOSS d = 0.04, FR d = 0.3 for muscle stiffness.

Right lower limb

There were no statistically significant interactions found for muscle stiffness ($F_{(2,87)} = 0.317$; $p = 0.729$; $\eta 2 = 0.007$) or tone ($F_{(2,87)} = 0.098$; $p = 0.907$; $\eta 2 = 0.002$). Additionally, the intervention did not have a statistically significant main effect on muscle stiffness or tone over time (tone: $F_{(4,174)} = 0.734$; $p = 0.558$; $\eta 2 = 0.017$; stiffness: $F_{(4,174)} = 0.774$; $p = 0.543$; $\eta 2 = 0.017$). However, there was a statistically significant effect of time on muscle tone ($F_{(2,174)} = 4.806$; $p = 0.009$; $\eta 2 = 0.052$) and stiffness ($F_{(2,174)} = 4.516$; $p = 0.012$; $\eta 2 = 0.049$). Post hoc analysis indicated a significant decline in tone only from the pre-measurement to the second post-measurement ($p = 0.022$). Same for stiffness, where was a significant decline only from the pre-measurement to second post-measurements ($p = 0.016$). For FR paired T-test shows significant decline in muscle tone and stiffness from pre to post1 ($p = 0.003$, $p = 0.002$, respectively) and from pre to post2 ($p = 0.005$, $p = 0.001$, respectively) (Table 2 and 3). The effect size, as measured by Cohen's d, when compared pre and post max was for CON d = 0.01, FLOSS d = 0.27, FR d = 0.23 for muscle tone and CON d = 0.01, FLOSS d = 026, FR d = 0.27 for muscle stiffness.

Table 2 The mean ± standard deviation (SD) values for muscle tone [Hz]. Con- Control conditioning, FLOSS- tissue flossing conditioning, FR- foam rolling conditioning, Bic Fem c l - Biceps Femoris Caput longum, Rect – Rectus, Vastus lt- Vastus Lateralis

	Muscle	Frequency [Hz]			
		Pre	Post1	Post2	Post_Max
CON	Bic Fem c l left	16.53 ± 1.53	16.43 ± 1.64	16.34 ± 1.76	16.62 ± 1.72
	Bic Fem c l right	16.72 ± 1.66	16.51 ± 1.42	16.4 ± 1.71	16.74 ± 1.57
	Rect Femoris left	15.13 ± 0.73	14.93 ± 0.99	14.94 ± 0.99	15.22 ± 0.97
	Rect Femoris right	15.56 ± 0.99	15.5 ± 1.02	15.09 ± 0.99	15.5 ± 0.99
	Vastus lt left	17.35 ± 2.26	17.24 ± 2.12	16.96 ± 1.85	17.48 ± 2.13
	Vastus lt right	17.53 ± 1.74	17.29 ± 2.02	16.83 ± 1.61	17.57 ± 1.95
FLOSS	Bic Fem c l left	16.5 ± 1.96	16.3 ± 1.64	16.09 ± 1.55	16.44 ± 1.62
	Bic Fem c l right	16.44 ± 1.8	16.49 ± 1.77	16.44 ± 1.8	16.63 ± 1.78
	Rect Femoris left	15.16 ± 0.83	15.43 ± 0.93	14.97 ± 0.97	15.52 ± 0.92
	Rect Femoris right	15.6 ± 0.97	15.6 ± 0.93	15.13 ± 0.98	15.71 ± 0.83
	Vastus lt left	17.28 ± 1.97	17.49 ± 2.18	16.95 ± 2.08	17.69 ± 2.21
	Vastus lt right	17.7 ± 1.99	17.84 ± 2.22	16.89 ± 2	18.04 ± 2.06
FR	Bic Fem c l left	16.42 ± 1.8	16.08 ± 1.72	16.1 ± 1.69	16.24 ± 1.75
	Bic Fem c l right	16.63 ± 1.56	26.28 ± 1.66	16.63 ± 1.58	16.49 ± 1.69
	Rect Femoris left	15.24 ± 1.14	14.92 ± 0.84	14.86 ± 0.88	15.08 ± 0.84
	Rect Femoris right	15.5 ± 0.89	15.17 ± 0.95	15.09 ± 0.89	15.33 ± 0.93
	Vastus lt left	17.25 ± 2.1	16.43 ± 2.12	16.53 ± 2.12	16.7 ± 2.16
	Vastus lt right	17.38 ± 2.2	16.62 ± 1.69	16.5 ± 1.78	16.89 ± 1.79

Table 3 The mean ± standard deviation (SD) values for stiffness [N/m]. Con- Control conditioning, FLOSS- tissue flossing conditioning, FR- foam rolling conditioning, Bic Fem c l -Biceps Femoris Caput longum, Rect – Rectus, Vastus lt- Vastus Lateralis

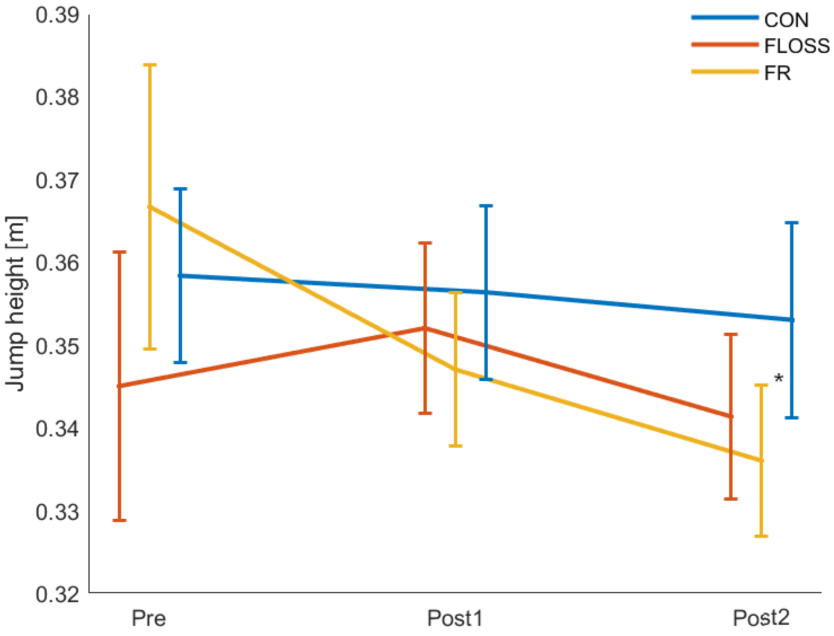
	Muscle	Stiffness [N/m]			
		Pre	Post1	Post2	Post_Max
CON	Bic Fem c l left	305.9 ± 43	301.7 ± 46.48	301 ± 51.98	307.33 ± 51.73
	Bic Fem c l right	308.37 ± 44.85	301.37 ± 38.41	300.9 ± 46.86	307.97 ± 43.45
	Rect Femoris left	261.33 ± 18.21	260.73 ± 21.98	256.1 ± 21.63	262.83 ± 21.22
	Rect Femoris right	266.93 ± 22.47	264 ± 24.23	258.53 ± 20.81	265.5 ± 23.44
	Vastus lt left	327.57 ± 51.47	325.6 ± 46.24	316.83 ± 38.48	328.2 ± 45.55
	Vastus lt right	332.12 ± 38.17	330.37 ± 42.81	314.17 ± 33.91	331.23 ± 42.17
FLOSS	Bic Fem c l left	302.27 ± 53.72	296.4 ± 46.41	292.37 ± 43.03	300 ± 46.26
	Bic Fem c l right	296.97 ± 46.34	295.83 ± 48.79	294.8 ± 42.81	300.93 ± 48.61
	Rect Femoris left	264 ± 21.34	267.37 ± 23.46	257.03 ± 20.27	269.57 ± 22.4
	Rect Femoris right	267.63 ± 22.57	271.4 ± 23.77	258.73 ± 21.51	274.13 ± 22.57
	Vastus lt left	323.57 ± 38.22	330.7 ± 49.04	315.33 ± 45.26	334.6 ± 49.81
	Vastus lt right	331.77 ± 36.84	337 ± 43.37	315.7 ± 33.49	341.63 ± 40.22
FR	Bic Fem c l left	301.87 ± 50.34	290.17 ± 45.87	293.17 ± 45.87	295.33 ± 45.36
	Bic Fem c l right	202.5 ± 39.74	294 ± 44.63	291.87 ± 39.45	299.6 ± 45.11
	Rect Femoris left	263.4 ± 20.07	253 ± 17.02	252.13 ± 20.82	255.87 ± 18.8
	Rect Femoris right	262.67 ± 20.9	256.17 ± 20.42	255.17 ± 21.45	260 ± 20
	Vastus lt left	325.8 ± 45.1	306.43 ± 38.84	308.97 ± 43.64	313.4 ± 42.62
	Vastus lt right	326.4 ± 40	311.23 ± 34.31	308.6 ± 34.9	316.67 ± 34.83

Jumping performance

Jump height

Two-way ANOVA didn't reveal statistically significant changes in jump height ($F_{(2,174)} = 2.614$; $p = 0.098$; $\eta2 = 0.029$). Only significant drop for FR occurred from pre to post2 measurements ($p = 0.05$). Other results didn't indicate any significant changes. When compared pre with maximum post value for there was no significant difference between any of the interventions ($F_{(2,87)} = 0.309$; $p = 0.735$) (Fig 1). The effect size, as measured by Cohen's d, when compared pre and post max was for CON d = 0.15, FLOSS d = 0.13, FR d = 0.25.

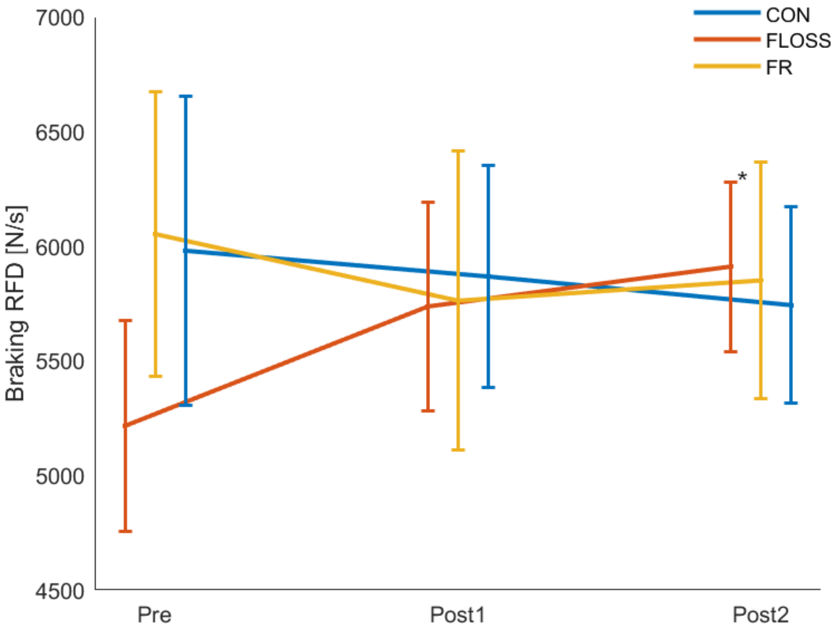
Fig 1. The mean ± standard error (SE) values for Jump Height [m]. Con- Control conditioning, FLOSS- tissue flossing conditioning, FR- foam rolling conditioning



Braking Rate of Force Development (RFD)

No significant main effect on braking rate of force development was observed ($F_{(2,176} = 0.044$; $p = 0.919$; $\eta2 = 0.057$) for any of the interventions. When compared pre with maximum post value there was no significant difference between any of the interventions ($F_{(2,87)} = 0.186$; $p = 0.831$), however there was significant difference between pre and maximum post value for tissue flossing (p = 0.016) (Fig 2). The effect size, as measured by Cohen's d, when compared pre and post max was for CON d = 0.11, FLOSS d = 0.57, FR d = 0.09.

Fig 2 The mean ± standard error (SE) values for Braking Rate of Force Development (RFD) [m/s]. Con- Control conditioning, FLOSS- tissue flossing conditioning, FR- foam rolling conditioning



Dynamic stability

No significant main effect was observed for right lower limb (F(2,174) = 1.102; p = 0.307; η2 = 0.013). Moreover, there were no statistically significant main effects of intervention and time on dynamic stability on right leg (F(4,174) = 1.173; p = 0.318; η2 = 0.026). When compared pre with maximum post value for right leg there was no significant difference between any of the interventions (F(2,87) = 0.151; p = 0.86), however there was significant difference between pre and maximum post value for tissue flossing (p = 0.01).

There was statistically significant main effect on left lower limb ($F_{(2,174)}$ = 5.048; p = 0.007; η2 = 0.055). Additionally, there was statistically significant effect of intervention on time ($F_{(4,174)}$ = 2.699; p = 0.032; η2 = 0.058). Post hoc revealed significant effect between pre and post2 (p

= 0.007) measurement but not between pre and post1 nor between post1 to post2 (p = 0.2, p = 0.674 respectively). However no statistically significant difference occurred between interventions ($F_{(2,87)}$ = 0.337; p = 0715; η2 = 0.008). FR shows statistically significant improvement in Composite Score for non-dominant leg form pre to post2 (p < 0.001). Paired T- test indicates significant difference for FR from pre to post2 measurements (p = 0.007) and from post1 to post2 (p = 0.013) for left leg. When compared pre with maximum post value for left leg there was no significant difference between any of the interventions ($F_{(2,87)}$ = 0.273; p = 0.762), however there were significant difference between pre and maximum post value for tissue flossing (p = 0.013) and for foam rolling (p < 0.001). For right leg the effect size, as measured by Cohen's d, when compared pre and post max was for CON d = 0.41, FLOSS d = 0.28, FR d = 0.22, for left leg: CON d = 0.41, FLOSS d = 0.44, FR d = 0.59.

Hypothesis evaluation

After evaluating the results, we can confirm or reject the individual hypotheses.

Alternative hypothesis 1: Tissue flossing applied to the thigh will improve jump performance, brakingRFD, and ROM.

Alternative hypothesis was confirmed only for the ROM. Tissue flossing didn't positively affect jump performance however improved brakingRFD when compared pre and post max results. Moreover, it had statistically significantly improved hamstring ROM (F(2,58) = 18.099; p < 0.001; η2 = 0.384).

Alternative hypothesis 2: Tissue flossing will yield greater improvements in jump performance, ROM, dynamic stability, viscoelastic properties of the muscle, and brakingRFD compared to foam rolling.

Alternative hypothesis number 2 wasn't confirmed. None of the interventions shows significant improvement in jump height, whereas TF showed significant improvement for brakingRFD when compared pre and post max value. On the other hand FR showed significant decrease in jump height when compared pre and post mac measurements. Both of the interventions show significant improvement in AROM, however no significant difference between tissue flossing and foam rolling was revealed (F(1,58) = 0.154; p = 0.696; η2 = 0.003). In addition, ANOVA analysis revealed no significant differences between the interventions in any of the measurements of viscoelastic properties. Nonetheless, there was a main effect of time on muscle tone and stiffness of measurements indicating significant differences between pre and post for all of the muscle and legs. For dynamic stability TF yielded significant improvement in composite score for right leg and left when compared pre and post max value whereas FR only for left leg. However no significant differences between conditions were observed.

Alternative hypothesis 3: Both the foam rolling and tissue flossing conditionings will demonstrate significant improvements when compared to the control conditioning.

Alternative hypothesis 2 was not supported by the data. None of the interventions demonstrated significant improvements compared to the control condition.

Discussion

Tissue flossing

Tissue flossing is a technique that involves wrapping a flexible band or floss around a specific joint or muscle group and performing various movements to create compression and shear forces. It is regarded as an innovative warm-up technique that has the potential to enhance joint flexibility without diminishing muscular strength and power (18). Our aim was to examine the effect of tissue flossing on hamstring AROM, jump performance, viscoelastic properties of Vastus Lateralis, Rectus Femoris and Biceps Femoris Caput Longum and dynamic stabilization with wrapping the thigh on both legs. Results shows that there is statistically significant improvement in AROM measurements for both legs which agrees with the results obtained by (3) where TF significantly enhanced straight leg raise test when compared to dynamic stretching and Cheatham (19) where TF significantly improved knee flexion. Tissue flossing also seems to positively impact ROM when applied on other part of body, in example Driller and Stevenson applied TF on ankle where it improved ankle ROM (20, 21), similarly application on calf positively affects ankle ROM (3, 7, 22). However, not all of the studies received positive feedback, Vogrin (4) when was evaluating effect of different application pressure didn’t obtain any significant improvement in ROM, neither Mills (23) after applying TF on ankle didn’t observe significant improvement. In the study conducted by Kaneda (24) comparing static stretching and tissue flossing, the static stretching group demonstrated a reduction in muscle stiffness with no significant change in stretch tolerance and no change in fascial length. Conversely, the tissue flossing group did not exhibit any changes in muscle stiffness and no change in fascial length was observed but received improve in ROM and passive torque at the end range of dorsiflexion. Similarly, our own findings indicated a significant improvement in AROM, but no changes in Biceps Femoris stiffness. Therefore an explanation for the observed increase in range of motion after a single application of tissue flossing is likely associated with an improvement in stretch tolerance (3), rather than alterations in the stiffness of the myotendinous tissue (24, 25). However, physiological mechanisms involved in changes in ROM remains unknown. Various authors have compared the effects of tissue flossing on ROM to those achieved through the application of pressure on muscles and fascia using a foam roller. While the exact physiological mechanisms underlying the effects of foam rolling are not yet fully understood, they can be categorized into two groups: neurophysiological and mechanical mechanisms focusing on fascial adjustment. According to Schleip (26), neurophysiological mechanisms may contribute to the effects of foam rolling. Additionally, Schleip and Müller (27) emphasize the mechanical mechanisms involved in fascial adjustments. In light of this, (3) suggest that the pressure exerted by tissue flossing on the skin, muscles, and fascia may impact fluid viscosity, resulting in reduced resistance to movement. Similar to the effects of pressure on the skin, muscle, or fascia, tissue flossing also induces vascular occlusion, which can be likened to ischemic preconditioning. Both tissue flossing and ischemic preconditioning techniques involve vascular occlusion, leading to a reduced supply of oxygen to the wrapped body part. A recent study conducted by Pavlů et al. (28) demonstrated that a two-minute application of tissue flossing resulted in a significant decrease in blood flow to the affected area. Ischemic conditioning can result in enhanced exercise performance (29), therefore it can be assumed that tissue flossing impact on performance enhancement may have a comparable underlying mechanism as blood flow restriction training. While our study did not show any jump height improvements, increase in braking RFD was shown when compared pre and maximum post measurements similarly as in study made by Kaneda (160). Several other studies have reported enhancements in jump (7, 30), sprint performance (7) after applying tissue flossing to the ankle or gastrocnemius muscle. These findings align with the results reported by Baumgart (31), who found a decrease in muscle stiffness following a single foam rolling session in the rectus femoris muscle but not in the gastrocnemius muscle. Therefore, it is possible that the outcomes of floss band treatment on different muscles may vary in terms of range of motion or their underlying mechanisms, such as changes in muscle stiffness. Interestingly, several studies were observed improvement in maximal voluntary contraction for knee extensors (3, 4) but in Konrad study it didn't align with improvement in CMJ (32). One possible explanation is that performance in activities such as jumps and explosive movements is predominantly influenced by the rapid development of force, known as rate of force development (RFD), and to a lesser extent by maximal strength (33). While the flossing intervention may have positively affected maximum isometric torque production, it may have had a limited impact on the rate of force development.

To date, no studies have assessed dynamic balance evaluation specifically after applying tissue flossing to the thigh. Only two studies have investigated the effects of tissue flossing on dynamic stabilization, with one study applying the band to the ankle (34) and the other to the knee (35). Both studies reported significant improvements in composite scores where after ankle application there was significant improvement in ANT direction and knee application in all directions. These findings agree with our own results, where we did observe significant improvement in dynamic balance in both legs when compared pre and post max value. Kinematic predictors of performance in the reach directions of the YBT indicate that hip flexion is significantly correlated with reach distances in all three directions. Additionally, knee flexion and contralateral torso rotation were found to increase the predictive capability of the model, but significantly correlated only with the anterior (ANT) direction (36). According to the study by Nakagawa and Petersen (37), the ANT direction in the Y Balance Test-Lower Quarter (YBT-LQ) demonstrated that dorsiflexion is a kinematic predictor. The study found that an increase in the ANT score can only occur if there is an increase in dorsiflexion. Based on these findings, it appears that the impact of tissue flossing on dynamic balance may vary depending on the specific application site and the directions of movement being evaluated.

This study reveals that TF has significantly increase muscle tone only immediately after application in Rectus Femoris on left leg whereas on right leg there was significant decline from pre to post1 and pre to post2 measurements. From post1 to post2 was already significant drop in muscle tone. For VL, RF on right side TF significantly decrease muscle tone and muscle stiffness. Our study aligns with the findings reported by Klich et al. (7), where a decrease in muscle stiffness was observed in the intermuscular septum between the medial and lateral heads of the gastrocnemius, as well as in Achilles tendon stiffness in general. This reduction in soft tissue stiffness following tissue flossing is thought to be a result of increased arterial blood flow and an automatic release of soft tissues and ankle structures, including capsules. However, it should be noted that the results of our study differ from the findings reported by Kaneda et al. (24) and Vogrin et al. (25). These studies did not observe any decrease in muscle stiffness after tissue flossing application on the calf, which contrasts with our and Klich results. These discrepancies may be attributed to variations in study design, and application pressure. It was observed that higher pressure applied with tissue flossing decrease its positive effect (4, 7, 38). The observed effects can be explained by the fact that neuromuscular fatigue and muscle activation are sensitive to pressure and can vary based on the degree of vascular occlusion (39). In our study, we employed a Kikuhime pressure sensor to monitor the applied pressure during tissue flossing. The pressure sensor provided real-time feedback to ensure that the pressure applied did not exceed 150 mmHg and was similar in both legs. This measurement limitation was put in place to maintain a safe and controlled pressure level during the tissue flossing intervention. In Kaneda (24) average applied pressure was 160 ± 3 mmHg which could affect the results.

Foam rolling

Results shows for FR significant improvement in ROM from pre to post1 for both left and right leg ($p < 0.001$, $p = 0.02$ respectively) and from pre to post2 for right leg ($p = 0.036$). Similar to our findings Junker (1) and Su (40) reported improved flexibility after FR. The increase in flexibility observed after foam rolling may be attributed to changes in the thixotropic properties of the fascia surrounding the muscle. Thixotropy refers to the ability of certain materials, including fascia, to become less viscous and more fluid-like when subjected to mechanical stress (41). During foam rolling, the technique involves applying direct and sweeping pressure on the soft tissue by rolling back and forth over a dense foam roller. This pressure and friction generated between the soft tissues and the foam roller can warm the fascia, promoting it to take on a more fluid-like state. As a result, the fascia becomes more pliable and elastic, leading to an improvement in soft tissue extensibility and greater flexibility (42, 43). Furthermore, the vigorous pressure applied during foam rolling may contribute to increased flexibility. This intense pressure can potentially overload the cutaneous receptors, which are responsible for sensory feedback. By overwhelming these receptors, the sensation of reaching the stretch endpoint may be dulled, resulting in increased stretch tolerance. This increased tolerance allows for further stretching and improved flexibility over time (42). It is worth noting that the mechanisms underlying the effects of foam rolling on fascia and flexibility are still being investigated.

Our study findings align with the results observed by Mayer (44), which demonstrated a significant decrease in connective tissue stiffness in experienced athletes. Similarly, in our study, we observed a significant decrease in muscle tone and muscle stiffness in the VL, RF, and BF muscles on both sides. The fact that our participants were experienced handball players could have influenced these results. Regular and intense physical activity, as experienced by athletes, can have an impact on muscle tone and stiffness (45). The repeated engagement in sport-specific movements and training may contribute to improved muscle flexibility and a reduction in muscle tone and stiffness. In our study we observed a significant decrease in viscoelastic properties of muscles, and this resulted in a significant decline in jump performance. These findings indicate that the changes in muscle tone and stiffness may have a direct impact on jump performance in the context of our study, which corresponds to Gervasi study (46). Fama and Bueti (47) proposed that the compressive force from foam rolling likely stimulates Golgi receptors through ischemic compression. Their research showed that using foam rolling as a warm-up negatively impacted jump performance, particularly in the countermovement jump, when compared to a dynamic warm-up. On the other hand, our findings, contrast with the results observed by Behara (15), where an improvement in vertical jump was reported, however muscle stiffness wasn't monitored. However, in his study longer FR application was applied with additional gluteus maximus, and gastrocnemius muscles added for conditioning. Based on these contrasting findings, it can be concluded that focusing solely on foam rolling the front and back part of the thigh may not be sufficient to enhance jump performance. The gluteus maximus and gastrocnemius muscles play significant roles in jump performance, and targeting these muscles in addition to the thigh muscles may be necessary for optimal improvements in jump performance. Another possible mechanism why decreases in jump height occurred in our study is that it could be caused by fatigue which occurred after FR (48, 49). It is important to consider that the effects of foam rolling can vary based on the specific muscles targeted, the duration of application, and individual variations among participants.

Interestingly foam rolling demonstrated a significant improvement in dynamic balance for the non-dominant limb while standing on the dominant side. One possible explanation for this observation could be related to the changes in AROM between the legs. It is possible that there was a nonsignificant decrease in active ROM for the left leg, while the right leg maintained its ROM after foam rolling. This difference in ROM between the legs may have influenced the dynamic balance performance when standing on the dominant side. Another potential explanation is that reducing voluntary muscle activation, which can occur due to factors such as swelling or stiffness, may contribute to a reduction in muscular function. Foam rolling has been suggested to help alleviate swelling and reduce stiffness in the muscles, potentially leading to improved muscle activation and function. By promoting a more optimal level of voluntary muscle activation, foam rolling could enhance the dynamic balance performance for the non-dominant limb on the dominant side (50). It is important to consider that these explanations are speculative and would require further investigation to confirm their validity. Factors such as individual variability, specific muscle imbalances, and other underlying physiological processes may also play a role in the observed effects. Further research is needed to elucidate the mechanisms underlying the observed improvements in dynamic balance after foam rolling and to determine the broader implications for muscular function and performance.

Conclusions

Our findings indicate that tissue flossing did not demonstrate superior improvements in range of motion, dynamic stabilization, muscle tone and stiffness, or jump performance compared to foam rolling. However, both tissue flossing and foam rolling showed significant improvements in hamstring flexibility. Considering that FR had a negative impact on jump height performance, but both were effective in improving hamstring flexibility, it is reasonable to suggest that method which is going to be as a part of a warm-up routine should be carefully selected based on our exercise objective. Athletes and individuals can choose either tissue flossing, or foam rolling based on personal preference, accessibility, or specific goals. It is important to note that individual responses to these techniques may vary, and some individuals may find one method more effective or suitable for their needs. Therefore, it is recommended for individuals to experiment and determine which method works best for them in terms of warm-up, flexibility, and overall performance enhancement.

The outcomes of the study may be influenced by the specific exercises carried out while the floss band was applied. For some participants, these exercises were relatively easy, while for others, they caused significant discomfort and pain during the floss band application. To mitigate such variability, it would be beneficial to measure participants' perceived exertion levels. Classifying participants based on their perceived difficulty in performing the exercises could offer a more nuanced understanding of the results.

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