Ahmed *et al.*
Bulletin of Faculty of Physical Therapy (2024) 29:44
https://doi.org/10.1186/s43161-024-00211-9

Bulletin of Faculty of Physical Therapy

ORIGINAL RESEARCH ARTICLE — Open Access

The comparison of the effects of percussive massage therapy, foam rolling and hamstring stretching on flexibility, knee range of motion, and jumping performance in junior athlete: a randomized controlled trial

Sohel Ahmed[1,2*], G M Jakaria[3], Md. Shafiqul Islam[4], Md. Akhsaful Imam[5], Sudipto Kumar Ratul[6], Ruwaida Jahangir[7], Joy Saha[8], Jalal Uddin[9] and Mohammad Jahirul Islam[10]

Abstract

Background Before every sporting event, almost all athletes engage in a routine practice of warming up to prepare the body for peak performance. There has been a surge in popularity within the athletic world around the use of percussive massage therapy (PMT).

Objectives The objectives of this study were to see if using percussive massage therapy, foam rolling (FR), and hamstring stretching (HStr) as part of a warm-up routine had any acute effects on flexibility, jumping performance, and range of motion in junior athletes, and if so, whether there was a significant difference in the acute effects of these treatment methods.

Methods Thirty-nine junior athletes with at least 3 years of experience, male gender, age range above 17, seated flexion test < 40 cm, and a willingness to participate were all considered for admittance. Participants were randomly divided into three groups. Before and after the treatment, the seated flexion test, vertical jump test, active SLR, and active knee extension were measured.

Results The study found significant improvement in all three groups when comparing them within the groups in the sit and reach test (PMT $p < 0.001$, FR $p = 0.002$, and HStr $p = 0.001$), active SLR (PMT $p < 0.001$, FR $p < 0.001$, and HStr $p = 0.001$), active knee extension (PMT $p < 0.001$, FR $p = 0.002$, and HStr $p = 0.004$), and vertical jump test (PMT $p < 0.001$, FR $p = 0.011$, and HStr ($p < 0.001$). Comparisons between groups showed significant differences among PMT vs. FR ($p = 0.041$) in vertical jump height and PMT vs. HStr ($p = 0.034$) in active SLR.

Conclusion We detected a notable disparity in hamstring flexibility between the PMT and FR groups, as well as in vertical jump height between the PMT and HStr groups. However, there was no apparent alteration in active knee extension in all three groups.

Keywords Athletes, Hamstring flexibility, Percussive massage therapy, Sports

*Correspondence:
Sohel Ahmed
ptsohel@gmail.com
Full list of author information is available at the end of the article

Introduction

Preparing the body for peak performance through warming up is a typical practice followed by almost all athletes before every sporting event [1, 2]. It is often used to raise body and muscle temperature, enhance blood flow, reduce or prevent injury, and enhance performance [2, 3]. In recent years, the use of a non-vibrating foam roller [4] and a vibrating foam roller [5] as a tool for self-myofascial release has shown substantial growth in popularity. Individuals use their own body weight to apply pressure to certain soft tissues while using a foam roller, thereby producing friction. Numerous studies have been conducted to examine the immediate effects of foam rolling on enhancing joint range of motion [6], improving muscle flexibility [3], and decreasing muscular stiffness [7] without compromising future performance measures such as sprint time, jump height [4], and muscle strength [8]. Several studies have shown that foam rolling interventions provide rapid enhancements in athletic performance, including increases in strength and speed [9].

In recent years, there has been a surge in popularity within the athletic world around the use of percussive massage guns [10–14]. These devices possess the capacity to vibrate at different frequencies, with a maximum frequency of 53 Hz. The devices may be outfitted with a range of attachment heads designed to accommodate diverse tissue types, including soft and bony tissues [14]. Despite the growing use of percussive massage in amateur and professional sports, there is a dearth of scholarly research investigating its treatment outcomes and its immediate and long-term impact on athletic performance [15]. The use of PMT has been associated to many key benefits, including the reduction of pain and muscle spasms [13], an increase of blood and lymphatic circulation [16], the improvement of range of motion, and the acceleration of the recovery process [12, 17]. Using a variety of stretching techniques, postures, and durations, hamstring stretching has been shown to enhance the range of motion in the knee joint, according to a systematic literature review [18]. Another study found that a single hamstring stretch resulted in a minor, transient alteration in the dynamic ROM of the knee joint [19].

Numerous portable local vibrators have been employed in earlier research, including hand-held vibrating dumbbells [20], and strapped vibrators [21]. Utilizing local vibration devices during warm-up had an immediate influence on quadriceps function [22] and hamstring and quadriceps flexibility [23]. However, no research has been done on the use of PMT and its effect on warm-up regimens. A vibrating foam roller (VFR), which combines foam rolling methods with local vibration, has also been utilized in warm-up routines to enhance sports performance [24]. The immediate impact of PMT has been demonstrated in several studies to affect joint ROM [14], perceived joint stability [11], muscular strength, and dynamic balance [5]. These studies compared vibrating massage to non-vibrating massage [11, 24] as well as the stretching method [19]. Currently, no study has compared the acute effects of PMT, FR, and HStr methods on athletic performance during warm-up routines. Therefore, the primary goal of this study was to see if using PMT, FR, and HStr as part of a warm-up routine had any acute effects on flexibility, jumping performance, and range of motion in junior athletes, and if so, whether there was a significant difference in the acute effects of these treatment methods. It was hypothesized that both PMT and FR would immediately improve junior athletes' performance, and significant differences in the acute effects on performance between the three groups were also anticipated.

Materials and methods

Study design and sampling

This study was a double-blinded (participants and assessor) randomized controlled trial. Convenience sampling was used to choose participants. The whole process of developing the research topic, collecting the data, analyzing the data, and writing up the findings took place between July and December of 2023.

Ethical statement

This study was performed according to the latest version of the Declaration of Helsinki, and the experimental protocol was approved by the ethical review board of Mount Adora Hospital with the reference number MAH/ERB:0212. Written consent was obtained from each participant for the voluntary participation of this study. The protocol of this study has been registered under the Clinical Trial Registry of India with the reference number: CTRI/2023/07/055794. The research has been documented according to the guidelines outlined in the Consolidated Standards of Reporting Trials (CONSORT) 2017 guideline. The CONSORT flowchart, seen in Fig. 1, provides a clear visual representation of the trial's plan.

Participants

Thirty-nine junior athletes were recruited from Bangladesh Krira Shikkha Prothisthan, Zirani, Dhaka. Professional athletes with at least 3 years of experience, male gender, age above 17, seated flexion test < 40 cm, and a willingness to participate were all considered for admittance. Participants were not allowed to take part if they had a history of hamstring injury, such as a sprain (lasting less than 3 months), or if they were currently experiencing any of the following: cardiac, respiratory, or neurological disease;

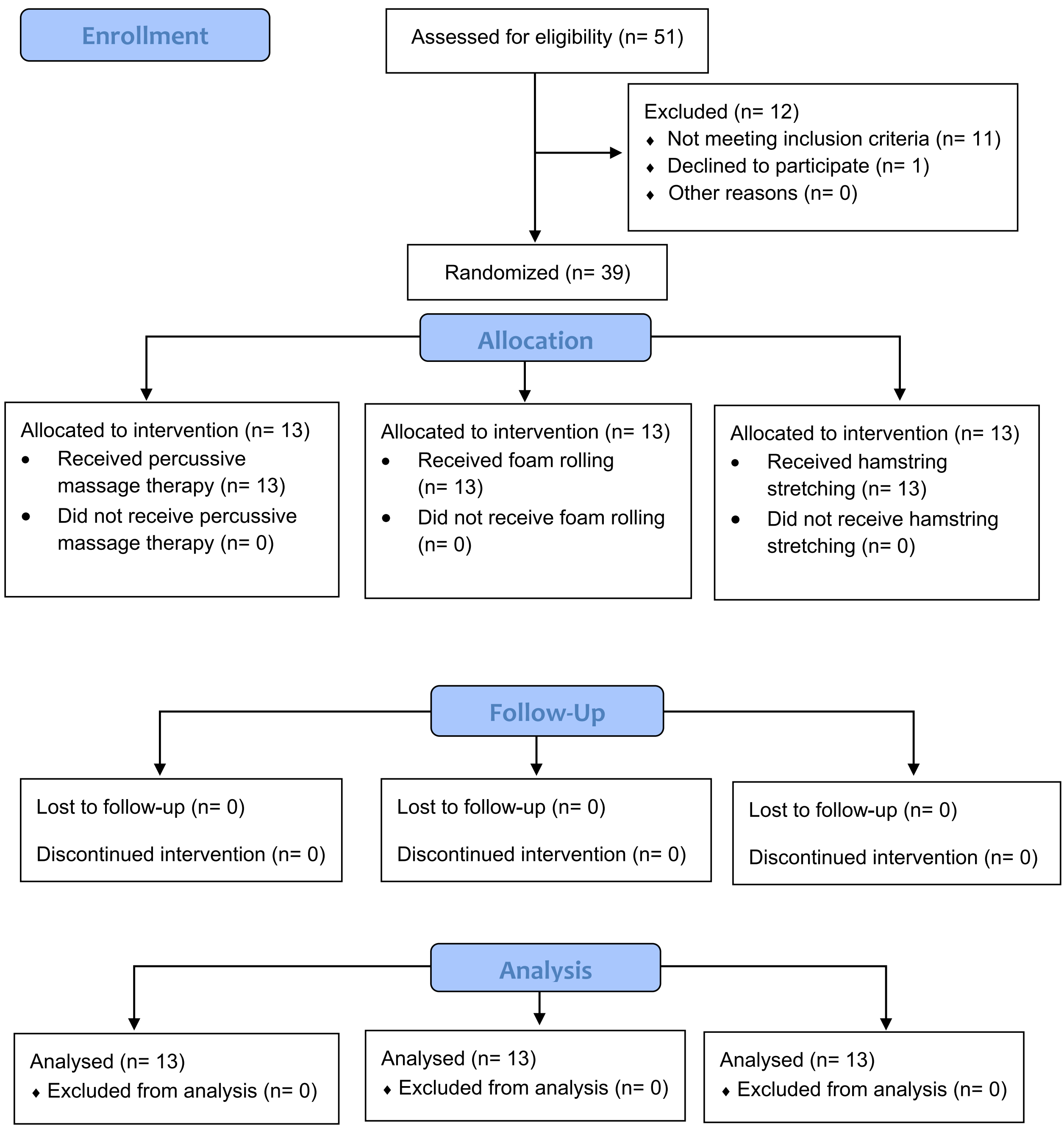

Fig. 1 CONSORT flow diagram of the trial

an open wound; a recent fracture of the lower extremity; or if they were currently taking muscle relaxants.

Sample size estimation

The sample size was calculated by the G* Power software, version 3.1.9.4 for Windows; test families: ANOVA, fixed effects, omnibus, and one-way were used. To calculate the sample size a priori: A computer-required sample size—given alpha, power, and effect size—was employed. We utilized a medium effect size of 0.60 [25], 90% power of the study, and an alpha value of 0.05. A total of 39 people were needed (13 for each of the three groups).

Participant allocation

The study employed a randomized block design. There were thirteen participants in each block: Block A (consisting of people ranked 1 to 13), Block B (consisting of participants ranked 14 to 26), and Block C (consisting of participants ranked 27 to 39). The blocks were subdivided into three groups at random, which were then randomly assigned to the PMT, FR, and HStr interventions.

Procedure

Participants were selected and enlisted based on pre-established criteria for inclusion and exclusion. The participants were provided with information on the purpose and goals of the research. Volunteerism was ensured by the acquisition of written consent to participate. Data on age, gender, body mass index (BMI), and height were collected for every participant. The subject's height and weight were measured using a calibrated digital weighing scale. The modified sit and reach test was used to evaluate hamstring flexibility, a universal Goniometer was used to evaluate hip and knee range of motion, and the vertical jump test was used to evaluate hamstring muscle strength. These were conducted in a randomized sequence, with a break of 5 min between each. Data was collected at baseline and 5 min after the intervention. In order to mitigate data collection errors, we conducted the same test twice and recorded the best outcome value. For convenience, the measurement of the range of motion (active straight leg raise and active knee extension) was solely conducted on the dominant limb.

Intervention

Experimental group 1 (PMT)

The hamstring muscle was worked on for 5 min at a frequency of 53 Hz using the "hardball" head of a percussive massage gun (China). The semitendinosus and semimembranosus muscles were massaged for a total of 2.5 min, followed by 2.5 min of focus on the biceps femoris muscle (Fig. 2a). Both hamstrings received the PMT for a total of 10 min (5 min on the right hamstring and 5 min on the left).

Experimental group 2 (FR)

The foam roller was applied to participants in a sitting position. The participant positioned their hands behind their torso, while placing their left leg on their knees. Maintain extension of the right lower limb while positioning the foam roller under the right hamstring muscle (Fig. 2b). Engage in a reciprocal motion of rolling back and forth for a duration of 1 min, then transitioning to the other side. The participants rolled one hamstring for 5 min. When one leg is done, they switch and do the same thing with the other.

Experimental group 3 (HStr)

The supine position was used for the purpose of static hamstring stretching (HStr). The patient assumes a supine position on a table, whereby the therapist proceeds to perform a passive hip flexion maneuver, bringing

Fig. 2 Intervention procedure of **a** percussive massage therapy, **b** foam rolling, and **c** hamstring stretching

the hip joint to a 90-degree angle. This action subsequently induces extension of the knee joint to a tolerable extent. The proposed protocol included doing a 30-s hamstring stretching exercise followed by a subsequent 30-s period of rest (Fig. 2c). A total of 5 min was spent on the exercise, with each of the five sets preceded by a 30-s static stretch and a 30-s rest period for both legs.

Outcome measurement

Modified sit and reach test

The participant was positioned on the floor, leaning against a wall, and it was required to remove their shoes. Ensure that both knees are in contact with the ground and that the legs are aligned straight in front. The box should be positioned horizontally against the feet by another individual. Instruct the participants to stretch their arms out towards the box while maintaining their backs and heads against the wall (Fig. 3a). Instruct the participants to put their hands side by side and gently lean forward as far as they can (your head and shoulders can drift away from the wall), maintaining their legs flat and their fingertips level with each other. To extend your reach, avoid jerking or bouncing. Take 2 s to maintain the full-reach position before recording the score. Vega et al. found that sit and reach tests demonstrated a moderate level of criterion-related validity in evaluating hamstring extensibility in a meta-analysis [26].

Active SLR

The test measured the angle of maximum flexion of the hip joint in a supine position when the leg was raised straightly. The lateral condyle of the femur was attached to a double-arm universal goniometer (Baseline Stainless Steel Goniometer; Fabrication Enterprises Inc., Elmsford, NY, USA), and the participant was asked to actively flex their hip to full flexion. The movement's final point angle was noted (Fig. 3b). The test demonstrated exceptional interrater reliability in assessing hamstring flexibility [27].

Active knee extension

The subject was instructed to lie supine on the bed with the hip flex maximally supported with both hands and the contralateral hip and knee fully extended. The lateral condyle of the femur was attached to a double-arm universal goniometer (Baseline Stainless Steel Goniometer; Fabrication Enterprises Inc., Elmsford, NY, USA), and the participant was asked to actively extend their knee to full extension (Fig. 3c). The movement's final point angle was noted. The test demonstrated exceptional interrater reliability in assessing hamstring flexibility [27].

Vertical jump test

The vertical jump test was used to measure the vertical jump height. It is a widely used test to measure lower body power. First, the standing reach was recorded by keeping the feet flat on the ground. The athletes stand

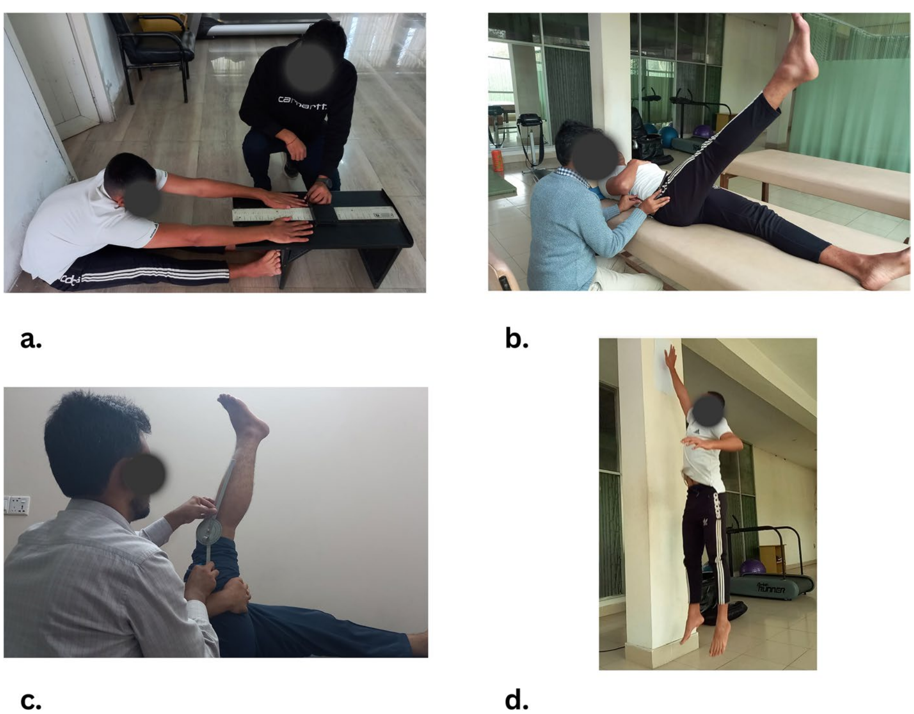

Fig. 3 Outcome assessment of **a** sit and reach test, **b** active SLR, **c** active knee extension, and **d** vertical jump

next to a wall and reach up with the hand closest to the wall, and the point of the fingertips was marked. The person then stands away from the wall and jumps vertically as high as possible, using both arms and legs to assist in projecting the body upwards. Attempt to touch the wall at the highest point of the jump (Fig. 3d). The difference in distance between the standing reach height and the jump height is the score. The best of two attempts was recorded. The vertical jump is widely regarded as a fundamental motor skill in several team sports. Test results have demonstrated significant intraclass correlation values ranging from 0.969 to 0.995 [28].

Statistical analysis

The program SPSS 25 (IBM Co., Armonk, NY, USA) was used for data analysis. Shapiro–Wilk test was used to determine the data's normality ($P > 0.05$). Data are given as mean and standard deviation since the distribution of the data was normal. Baseline and post-intervention differences between the independent variables within the various groups were analyzed using a paired t test. The difference between the scores obtained from the PMT, FR, and HStr groups baseline and post-intervention was analyzed using one-way analysis of variance (ANOVA). To determine the clinical significance of the statistical difference seen between the independent variables, post hoc analysis was done. The significance threshold was set at 0.05.

Results

Baseline demographics

In this present study, a total of 39 male participants took part. The mean age of the participants was 20.87 ± 2.53 years. The participants' mean weight, height, and BMI were 64.92 ± 8.62 kg, 173.05 ± 8.84 cm, and 21.73 ± 2.78 kg/m^2, respectively. This study found no statistically significant difference in baseline characteristics among the three groups which are presented in Table 1.

Results from within-group analysis

The study found significant improvement in the sit and reach test in all three groups when comparing them within the groups (PMT $p < 0.001$, FR $p = 0.002$, and HStr $p = 0.001$). Additionally, active SLR of the PMT ($p < 0.001$), FR ($p < 0.001$), and HStr ($p = 0.001$) groups showed significant improvement according to the study. Following the intervention, the active knee extension and vertical jump test scores also showed statistically significant improvement in all three groups which are presented in Table 2.

Results from between-group analysis

Multiple comparisons between groups showed significant differences among PMT vs FR in vertical jump height and PMT vs HStr in active SLR. There was no significant difference between PMT vs HStr and HStr vs FR in vertical jump height and PMT vs FR and HStr vs FR in active SLR. The study also found no significant differences in sit and reach test and active knee extension in all three groups. Details are presented in Table 3.

Discussion

The objective of this research was to examine if the inclusion of PMT, FR, and HStr in a warm-up routine had any immediate impact on flexibility, jumping performance, and range of motion in junior athletes. Consistent with our expectation, we observed a significant difference in the immediate impacts of different treatment methods when compared them within the group which is in favor of our null hypothesis. Statistical analysis revealed significant differences in vertical jump height between the

Table 1 Baseline demographics of the participants

Variables	PMT		FR		HStr		*P* value
	Mean	SD	Mean	SD	Mean	SD	
Age	20.77	± 2.86	21.08	± 2.90	20.77	± 1.92	0.001*
Weight	63.54	± 7.63	64.77	± 8.40	66.46	± 10.10	0.207
Height	175.47	± 7.65	173.50	± 7.21	170.57	± 11.20	0.095
BMI	20.78	± 2.56	21.52	± 2.62	22.89	± 2.93	0.336
Active SLR	84.31	± 3.94	82.62	± 6.72	85.08	± 5.31	0.054
Active knee extension	47.92	± 5.07	45.00	± 6.28	45.31	± 5.37	0.096
Sit and reach test	34.19	± 3.90	33.20	± 2.53	34.03	± 2.49	0.346
Vertical jump test	21.07	± 2.11	22.29	± 1.69	22.24	± 1.47	0.062

PMT percussive massage therapy, *FR* foam rolling, *HStr* hamstring stretching, *BMI* body mass index, *SLR* straight leg raising, *SD* standard deviation

[*] Significant

Table 2 Baseline and post-intervention scores of PMT, FR, and HStr groups among the participants

Baseline to post-test									
Variables	**PMT**			**FR**			**HStr**		
	Mean	**SD**	***P***	**Mean**	**SD**	***P***	**Mean**	**SD**	***P***
Sit and reach test									
Baseline	34.19	3.90	**< 0.001***	33.20	2.53	**0.002***	34.03	2.49	**0.001***
Post	35.73	4.09		34.24	2.77		35.19	2.92	
Active SLR									
Baseline	84.31	3.94	**< 0.001***	82.62	6.72	**< 0.001***	85.08	5.31	**0.001***
Post	89.31	4.59		86.23	5.64		87.92	4.89	
Active knee extension									
Baseline	47.92	5.07	**< 0.001***	45.00	6.28	**0.002***	45.31	5.37	**0.004***
Post	43.92	5.80		41.92	7.50		42.69	6.52	
Vertical jump test									
Baseline	21.07	2.11	**< 0.001***	22.29	1.69	**0.011***	22.24	1.47	**< 0.001***
Post	21.93	2.07		22.76	1.88		22.83	1.34	

PMT percussive massage therapy, *FR* foam rolling, *HStr* hamstring stretching, *SLR* straight leg raising, *SD* standard deviation

[*] Significant at < 0.05

Table 3 Multiple comparisons between groups by one-way MANOVA in post-test (post hoc Tukey analysis)

Variables	Group		MD	Std. error	95% CI	*p*
Sit and reach test	PMT	FR	0.507	0.340	− 0.182–1.198	0.144
		HStr	0.384	0.340	− 0.305–1.075	0.266
	FR	PMT	− 0.507	0.340	− 1.198–0.182	0.144
		HStr	− 0.123	0.340	− 0.813–0.567	0.720
	HStr	PMT	− 0.384	0.340	− 1.075—0.305	0.266
		FR	− 0.123	0.340	− 0.567—0.813	0.720
Vertical jump	PMT	FR	0.392	0.184	0.017 – 0.767	0.041*
		HStr	0.269	0.184	− 0.105 – 0.644	0.154
	FR	PMT	− 0.392	0.184	− 0.767 to − 0.017	0.041*
		HStr	− 0.123	0.184	− 0.498–0.252	0.510
	HStr	PMT	− 0.269	0.184	− 0.644–0.105	0.154
		FR	− 0.123	0.184	− 0.252–0.498	0.510
Active SLR	PMT	FR	1.384	0.980	− 0.603–3.372	0.166
		HStr	2.153	0.980	0.166–4.141	0.034*
	FR	PMT	− 1.384	0.980	− 3.372–0.603	0.166
		HStr	0.769	0.980	− 1.218–2.756	0.438
	HStr	PMT	− 2.153	0.980	− 4.141 to − 0.166	0.034*
		FR	− 0.769	0.980	− 2.756–1.218	0.438
Active knee extension	PMT	FR	0.923	1.025	− 1.156–3.002	0.374
		HStr	1.384	1.025	− 0.694–3.464	0.185
	FR	PMT	− 0.923	1.025	− 1.617–0.254	0.374
		HStr	0.461	1.025	− 3.464–0.694	0.655
	HStr	PMT	− 1.384	1.025	− 3.002–1.156	0.185
		FR	− 0.461	1.025	− 3.464–0.694	0.655

PMT percussive massage therapy, *FR* foam rolling, *HStr* hamstring stretching, *MD* mean difference, *Std. error* standard error, *SD* standard deviation

[*] Significant at < 0.05

PMT and Fr groups, as well as between the PMT and HStr groups in active SLR. Additionally, there was no notable disparity seen in any of the metrics across the other groups.

Previous research found that the dorsiflexion and plantarflexion ranges of motion of the ankle joint were significantly improved by the immediate effects of percussive massage therapy [14, 24, 29]. Percussive massage treatment helps improve acute muscle strength, improve flexibility, and reduce experiences of musculoskeletal pain reported in a systematic review [13]. Percussion massage devices have been shown to improve joint range of motion, but not to affect jumping or agility performance [12]. According to Weerapong et al. (2005), biomechanical changes—that is, a decrease in muscle compliance—as well as physiological, neurological, and psychological changes—that is, an increase in blood flow, a decrease in pain perception, and an increase in relaxation—are the mechanisms underlying the increase in range of motion after a massage [30]. Additionally, the increase in range of motion after the percussive massage therapy, foam rolling [31], and stretching [32] may also be explained by thixotropic effects. Pressure and friction are applied to the affected muscle, skin, and fascia during the percussive massage therapy and foam rolling. This could affect the viscosity of the fluid, resulting in decreased resistance to movement [31]. Regarding vibration treatment, a reduction in pain perception mostly accounts for the improvement in range of motion [33]. Therefore, it stands to reason that a reduction in muscular stiffness and improved flexibility would account for the ROM alterations that occurred after the percussive massage therapy, stretching, and foam rolling.

In this present study, there was a significant improvement in jumping performance following the intervention in all three groups. This study showed a significant difference between Physiogun and foam roller when comparing them in within group. Similar to our study findings, Wang F. et al. reported implementing vibrating foam roller may have an instantaneous beneficial impact on power, reactive strength, and change of direction capabilities which could lead to an immediate enhancement in reactive strength performance [25]. In contrast to the findings of Kujala et al., who observed no alterations in vertical jump performance after a 5-min percussive massage intervention targeting the muscles of the lower leg [10]. In contrast to the current study, Kujala et al. (2019) administered a massage that targeted the gluteal, quadriceps, calves, and hamstring muscles of both legs however our study focused on percussive massage only for the hamstring muscle. The current study's findings on muscle performance align with those of a traditional massage [34], but diverge from the results of vibration treatment [29, 33], which have demonstrated an improvement in strength. One potential explanation for these findings is that vibration therapy may activate a greater number of muscle receptors across all three kinds, resulting in enhanced recruitment of motor fibers [29, 35].

Limitation and future recommendation

Initially, the individuals involved in our study were junior athletes. The outcomes could have varied if the experiments had been carried out with athletes of a higher level. Furthermore, the repeated administration of multiple tests may have resulted in a diminished impact of the interventions in later tests. Moreover, manual timing in certain tests can be imprecise. This study focused on examining the immediate effects of percussive massage therapy. However, further research is necessary to investigate the long-term impacts of this therapy on a diverse population.

Conclusion

Handheld percussive massage therapy is an innovative method utilized by therapists and athletes. This study was the inaugural investigation to assess the impact of a percussive massage therapy on the hamstring muscle on the flexibility of the hamstring, range of motion, and jumping performance of junior athletes. We detected a notable disparity in hamstring flexibility between the PMT and FR groups, as well as in vertical jump height between the PMT and HStr groups. However, there was no apparent alteration in active knee extension in all three groups. Hence, we recommend incorporating a percussive massage therapy into an athlete's warm-up routine to enhance their level of flexibility.

Acknowledgements

We appreciate Bangladesh Kria Sikkha Prothistan's permission to collect data. We sincerely thank all the study participants.

Patient and public involvement

Patients and/or the public were not involved in the design, conduct, reporting, or dissemination plans of this research.

Authors' contributions

Conceptualization: Sohel Ahmed, G M Jakaria, and Mohammad Jahirul Islam. Data curation: Sohel Ahmed, Ruwaida Jahangir, Joy Saha, Md Shafiqul Islam, and Sudipto Kumar Ratul. Formal analysis: Sohel Ahmed and G M Jakaria. Investigation: Sohel Ahmed, Md Shafiqul Islam, and Mohammad Jahirul Islam. Methodology: Sohel Ahmed, Md. Akshaful Imam, G M Jakaria, Jalal Uddin, and Mohammad Jahirul Islam. Project administration: Sohel Ahmed, Md. Akshaful Imam, G M Jakaria, Md Shafiqul Islam, and Mohammad Jahirul Islam. Resources: Sohel Ahmed, Md. Akshaful Imam, Ruwaida Jahangir, Joy Saha, and Sudipto Kumar Ratul. Software: Sohel Ahmed. Supervision: Sohel Ahmed. Validation: Sohel Ahmed. Visualization: Sohel Ahmed. Writing—original draft: Sohel Ahmed. Writing—review and editing: Sohel Ahmed, Mohammad Jahirul Islam and Jalal Uddin.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or non-profit sectors.

Availability of data and materials
Data will be made available on request.

Declarations

Ethics approval and consent to participate
Approved by the ethical review board of Mount Adora Hospital with the reference number MAH/ERB:0212.

Consent for publication
Informed consent was taken from the participants prior to participating in this study.

Competing interests
The authors declare that they have no competing interests.

Author details
[1]Ahmed Physiotherapy & Research Center, Dhaka 1205, Bangladesh. [2]Physiotherapy Research Foundation, Dhaka 1205, Bangladesh. [3]Lincoln University College, Petaling Jaya, Selangor, Darul Ehsan 47310, Malaysia. [4]Chittagong Medical College Hospital, Chittagong 3483, Bangladesh. [5]Remede Clinic Bournemouth Limited, Bournemouth BH2 5RH, UK. [6]Faculty of Sports Science and Recreation, University Teknologi Mara, Shah Alam, Selangor 40450, Malaysia. [7]Gonoshasthay Nagar Hospital, Dhaka 1205, Bangladesh. [8]Bangladesh Krira Shikkha Prothisthan, Zirani, Dhaka, Bangladesh. [9]University of Nevada Las Vegas, Maryland Parkway, Las Vegas, NV 98154, USA. [10]MAG Osmani Medical College Hospital, Sylhet 3100, Bangladesh.

Received: 5 March 2024 Accepted: 5 June 2024
Published online: 02 October 2024

References

1. McGowan CJ, Pyne DB, Thompson KG, Rattray B. Warm-up strategies for sport and exercise: mechanisms and applications. Sports Med. 2015;45(11):1523–46.
2. Cochrane D. The sports performance application of vibration exercise for warm-up, flexibility and sprint speed. Eur J Sport Sci. 2013;13(3):256–71.
3. Lim JH, Park CB. The immediate effects of foam roller with vibration on hamstring flexibility and jump performance in healthy adults. J Exerc Rehabil. 2019;15(1):50–4.
4. Wilke J, Müller AL, Giesche F, Power G, Ahmedi H, Behm DG. Acute effects of foam rolling on range of motion in healthy adults: a systematic review with multilevel meta-analysis. Sports Med. 2020;50(2):387–402.
5. Lee CL, Chu IH, Lyu BJ, Chang WD, Chang NJ. Comparison of vibration rolling, nonvibration rolling, and static stretching as a warm-up exercise on flexibility, joint proprioception, muscle strength, and balance in young adults. J Sports Sci. 2018;36(22):2575–82.
6. Godwin M, Stanhope E, Bateman J, Mills H. An acute bout of self-myofascial release does not affect drop jump performance despite an increase in ankle range of motion. Sport (Basel, Switzerland). 2020;8(3):37.
7. Hendricks S, Hill H, den Hollander S, Lombard W, Parker R. Effects of foam rolling on performance and recovery: a systematic review of the literature to guide practitioners on the use of foam rolling. J Bodyw Mov Ther. 2020;24(2):151–74.
8. MacDonald GZ, Penney MDH, Mullaley ME, Cuconato AL, Drake CDJ, Behm DG, et al. An acute bout of self-myofascial release increases range of motion without a subsequent decrease in muscle activation or force. J strength Cond Res. 2013;27(3):812–21.
9. Peacock CA, Krein DD, Silver TA, Sanders GJ, Von Carlowitz KPA. An acute bout of self-myofascial release in the form of foam rolling improves performance testing. Int J Exerc Sci. 2014;7(3):202–11.
10. Kujala R, Davis C, Young L. The effect of handheld percussion treatment on vertical jump height. Int J Exerc Sci Conf Proc. 2019;8(7). Article 75. Available at: https://digitalcommons.wku.edu/ijesab/vol8/iss7/75.
11. de Benito AM, Valldecabres R, Ceca D, Richards J, BarrachinaIgual J, Pablos A. Effect of vibration vs non-vibration foam rolling techniques on flexibility, dynamic balance and perceived joint stability after fatigue. PeerJ. 2019;7:e8000.
12. Canbulut A, Kıyak G, Ercan S, Çetin C. Acute effect of percussion massage applied on quadriceps with Hypervolt device on range of motion and performance. Turkish J Sport Med. 2023;58(2):55–60.
13. Sams L, Langdown BL, Simons J, Vseteckova J. The effect of percussive therapy on musculoskeletal performance and experiences of pain: a systematic literature review. Int J Sports Phys Ther. 2023;18(2):309–27.
14. Konrad A, Glashüttner C, Reiner MM, Bernsteiner D, Tilp M. The acute effects of a percussive massage treatment with a hypervolt device on plantar flexor muscles' range of motion and performance. J Sports Sci Med. 2020;19(4):690–4.
15. Behm DG, Peach A, Maddigan M, Aboodarda SJ, DiSanto MC, Button DC, et al. Massage and stretching reduce spinal reflex excitability without affecting twitch contractile properties. J Electromyogr Kinesiol Off J Int Soc Electrophysiol Kinesiol. 2013;23(5):1215–21.
16. Kablan N, Alaca N, Tatar Y. Comparison of the immediate effect of petrissage massage and manual lymph drainage following exercise on biomechanical and viscoelastic properties of the rectus femoris muscle in women. J Sport Rehabil. 2021;30(5):725–30.
17. Alvarado F, Valenzuela KA, Finn A, Avila EL, Crussemeyer JA, Nakajima M. The biomechanical effects of percussive therapy treatment on jump performance. Int J Exerc Sci. 2022;15(1):994–1006.
18. Decoster LC, Cleland J, Altieri C, Russell P. The effects of hamstring stretching on range of motion: a systematic literature review. J Orthop Sports Phys Ther. 2005;35(6):377–87.
19. Cronin J, Nash M, Whatman C. The acute effects of hamstring stretching and vibration on dynamic knee joint range of motion and jump performance. Phys Ther Sport Off J Assoc Chart Physiother Sport Med. 2008;9(2):89–96.
20. Cochrane DJ. Vibration exercise: the potential benefits. Int J Sports Med. 2011;32(2):75–99.
21. Lapole T, Pérot C. Effects of repeated Achilles tendon vibration on triceps surae force production. J Electromyogr Kinesiol Off J Int Soc Electrophysiol Kinesiol. 2010;20(4):648–54.
22. Pamukoff DN, Pietrosimone B, Lewek MD, Ryan ED, Weinhold PS, Lee DR, et al. Whole-body and local muscle vibration immediately improve quadriceps function in individuals with anterior cruciate ligament reconstruction. Arch Phys Med Rehabil. 2016;97(7):1121–9.
23. Jemni M, Mkaouer B, Marina M, Asllani A, Sands WA. Acute static vibration-induced stretching enhanced muscle viscoelasticity but did not affect maximal voluntary contractions in footballers. J Strength Cond Res. 2014;28(11):3105–14.
24. Romero-Moraleda B, González-García J, Cuéllar-Rayo Á, Balsalobre-Fernández C, Muñoz-García D, Morencos E. Effects of vibration and non-vibration foam rolling on recovery after exercise with induced muscle damage. J Sports Sci Med. 2019;18(1):172–80.
25. Wang F, Zhang Z, Li C, Zhu D, Hu Y, Fu H, et al. Acute effects of vibration foam rolling and local vibration during warm-up on athletic performance in tennis players. PLoS One. 2022;17(5 May):1–14. http://dx.doi.org/10.1371/journal.pone.0268515.
26. Mayorga-Vega D, Merino-Marban R, Viciana J. Criterion-related validity of sit-and-reach tests for estimating hamstring and lumbar extensibility: a meta-analysis. J Sports Sci Med. 2014;13(1):1–14.
27. Neto T, Jacobsohn L, Carita AI, Oliveira R. Reliability of the active-knee-extension and straight-leg-raise tests in subjects with flexibility deficits. J Sport Rehabil. 2015;24(4):2014–0220.
28. Rodríguez-Rosell D, Mora-Custodio R, Franco-Márquez F, Yáñez-García JM, González-Badillo JJ. Traditional vs. sport-specific vertical jump tests: reliability, validity, and relationship with the legs strength and sprint performance in adult and teen soccer and basketball players. J Strength Cond Res. 2017;31(1). Available from: https://journals.lww.com/nsca-jscr/fulltext/2017/01000/traditional_vs__sport_specific_vertical_jump.22.aspx.
29. Germann D, El Bouse A, Shnier J, Abdelkader N, Kazemi M. Effects of local vibration therapy on various performance parameters: a narrative literature review. J Can Chiropr Assoc. 2018;62(3):170–81.
30. Weerapong P, Hume PA, Kolt GS. The mechanisms of massage and effects on performance, muscle recovery and injury prevention. Sports Med. 2005;35(3):235–56.
31. Behm DG, Wilke J. Do self-myofascial release devices release myofascia? rolling mechanisms: a narrative review. Sports Med. 2019;49(8):1173–81.

32. Behm DG. The Science and Physiology of Flexibility and Stretching. 2018. Chapter 2 page 14–7.
33. Cheatham SW, Stull KR, Kolber MJ. Comparison of a vibration roller and a nonvibration roller intervention on knee range of motion and pressure pain threshold: a randomized controlled trial. J Sport Rehabil. 2019;28(1):39–45.
34 Davis HL, Alabed S, Chico TJA. Effect of sports massage on performance and recovery: a systematic review and meta-analysis. BMJ Open Sport Exerc Med. 2020;6:e000614. England.
35. Fallon JB, Macefield VG. Vibration sensitivity of human muscle spindles and Golgi tendon organs. Muscle Nerve. 2007;36(1):21–9.

Publisher's Note