Research Article

Modified Hold-Relax Stretching Technique Combined with Moist Heat Therapy to Improve Neuromuscular Properties in College Students with Hamstring Tightness

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ABSTRACT

Introduction: This study aims to evaluate the effect of modified hold-relax stretching combined with moist heat therapy on hamstring muscle flexibility, EMG activity and strength in college students with hamstring tightness.

Materials and Methods: Thirty-eight college students with hamstring tightness were recruited and were divided into two groups. Group 1 received modified hold-relax stretching plus moist heat therapy and Group 2 received moist heat therapy alone, three days a week for four weeks. The knee range of motion (ROM), muscle strength and Electromyography (EMG) activity before and after the treatment protocol were measured.

Results: There was no significant difference between the two groups in demographic characteristics. The knee ROM was significantly different between groups in terms of time (P=0.001) and group (P=0.005) effects, but the strength and EMG activity were not significantly different.

Conclusion: The modified hold-relax technique combined with moist heat therapy is effective in increasing hamstring flexibility, but has no significant effect on the muscle EMG activity and strength.

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1. Introduction

Muscle strength and flexibility are important components of the musculoskeletal system in human body. The normal functioning of the musculoskeletal system is necessary for optimal physical functioning [1]. Reduced muscular flexibility can affect the range of motion (ROM) of a joint, which in turn may affect body mechanics. Hamstring muscle flexibility has been associated with a number of musculoskeletal problems related to low back pain and lower extremity dysfunction [2-4]. Different stretching techniques are used to improve the length and flexibility of this muscle. The passive stretching focuses primarily on the viscoelastic properties of the muscle, while the proprioceptive neuromuscular facilitation (PNF) stretching depends on the principle of reciprocal inhibition. Hold-relax technique uses isometric contraction of the muscle [5]. The technique was used in a study with no rotation component and its effectiveness in improving the flexibility of hamstring muscle was reported [6]. The hold-relax PNF stretching utilizes an isometric contraction instead of isotonic contraction. The post isometric relaxation following an isometric contraction may lead to further reduction in reflex activity of muscle and improving its flexibility [7].The isometric contraction may be useful to improve muscle function and flexibility, when the isotonic contraction is not possible due to pain or loss of strength in the muscle. Various studies have reported differing reports on muscle activity following PNF stretching [8-10]. There is not much information on muscle activity following PNF stretching with isometric contraction. Positive effects of modified hold-relax technique on knee ROM has previously been reported. The single and multiple sessions of modified hold-relax techniques have shown to increase the flexibility of hamstring muscle [11-13].

The application of heat is regularly used as a method to enhance the efficacy of stretching. The heat can improve the effectiveness of stretching by increasing tissue temperature and blood flow or by reducing muscle activity [14]. The deep heating modalities are therapeutic ultrasound, shortwave diathermy, and microwave diathermy. Among the superficial heating modalities, moist heat is more common. The deep heating modalities achieve deeper tissue heating and more effectiveness in increasing the muscle flexibility. The advantages of moist heat are availability and affordability. Combination of moist heat and stretching have reported better results in comparison with moist heat or stretching alone for muscle flexibility [15, 16]. There is scant research on the effect of modified hold-relax technique on strength and activity of hamstring muscle. Therefore, this study aims to examine the effect of modified hold-relax technique on ROM, strength and Electromyography (EMG) activity of hamstring muscle after 4 weeks of treatment.

2. Materials and Methods

Study design and participants

This was a repeated measures randomized clinical trial. Participants were 38 subjects with hamstring tightness who were recruited from a department of physiotherapy in New Delhi, India using a convenience sampling method. The study was approved by the institutional ethics committee of Jamia Millia Islamia, New Delhi. GPower v. 3.15 software was used to calculate the sample size. To detect an 11-degree change in knee extension with an alpha level of 0.05 and a test power of 0.80, sample size was obtained 34. Considering a 10% of dropout, it was increased to 38. The inclusion criteria were being a college students, age 18-25 years with impaired hamstring flexibility if knee extension angle was <160 degree based on an active knee extension test (in supine position) [12], and no history of injury in the trunk and lower extremities in the past 6 months. Exclusion criteria were history of any inflammatory conditions, open wounds/ulcers on the bottom of the feet, inability to walk independently, and recently healed fracture in the lower extremity. Participants were explained about the study purpose, methodology and possible risk. Then, they signed an informed consent form. Their information were kept confidential by assigning a number to each subject. Medical examination and fitness certificate was obtained from qualified medical practitioner. They were randomly allocated into two groups of hold-relax stretching+moist heat (Group 1) and moist heat (Group 2) using a random number generator application. The flowchart of allocation and sampling is shown in Figure 1.

Procedure

The demographic characteristics of subjects as well as their baseline assessments were conducted on the day of recruitment. Weighing machine, stadiometer, PowerLab EMG system and LabChart Pro software (AD instrument, Australia), handheld dynamometer, and goniometer were used for assessments. The process of assessment and recording was completed in 40 minutes on average. The treatment was started from the next day. Subjects in group 1 received modified hold-relax

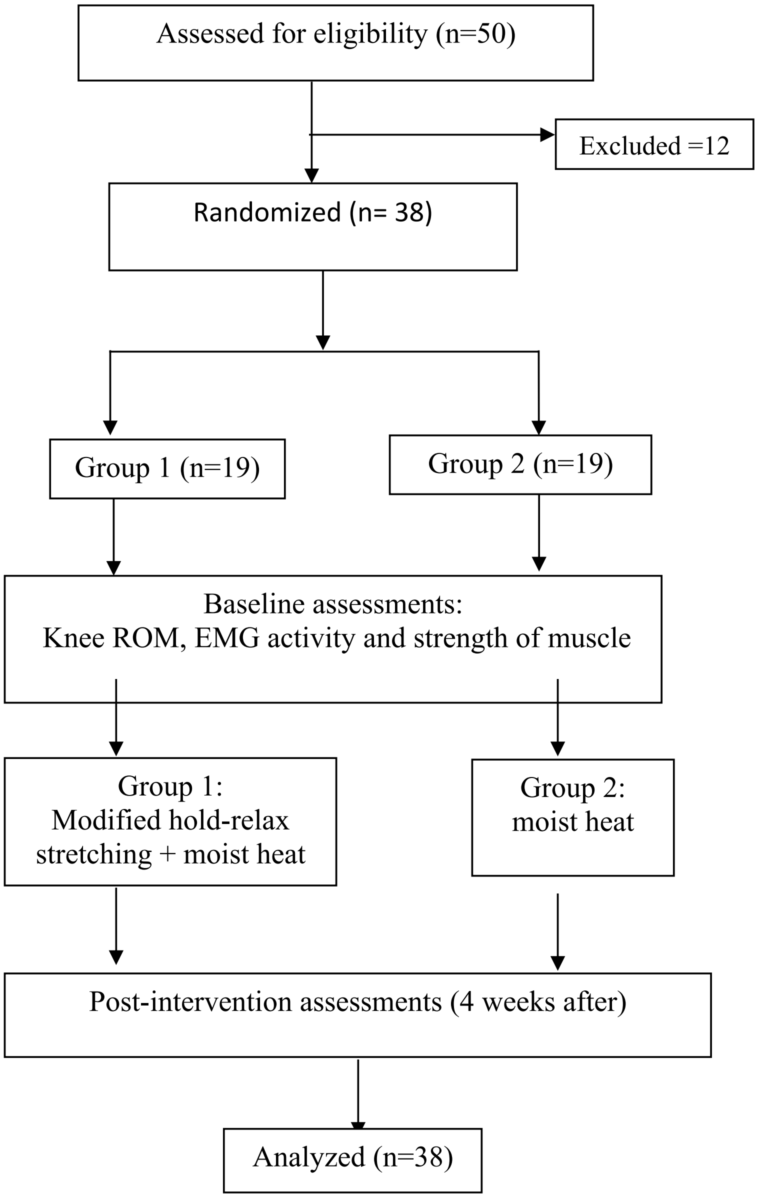

Figure 1. The flowchart diagram of allocation and sampling

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stretching combined with moist heat while those in group 2 received moist heat therapy only. Each treatment session lasted for 40-45 minutes. Both groups received treatment for four weeks, 3 days a week. After completion of the treatment protocol, subjects were reassessed and outcome measures were recorded on the next day. The assessment and treatment were done by two different therapists who had no information about the study protocol. This was done to avoid their influence on assessment and intervention.

Intervention

The modified hold-relax stretching was done in supine position with 90 degrees of hip flexion. The opposite side hip and knee joint were stabilized in neutral position fixed to the bed using a Velcro strap. Hamstring muscle on the treated side was stretched passively until a mild stretch was felt by the subject. The end position was held for 10 seconds. The subject was then asked to push the leg back down to the bed and the therapist applied resistance against the subject's effort at lower part of the leg. This was the isometric contraction and the subject was told to hold the position for 10 seconds (Figure 2). The subject was asked to rest for 5 seconds and the same procedure was repeated 6 times. The stretching was done three days per week for 4 weeks [6, 17]. The hip rotation was not used in the modified hold-relax stretching. It was adopted from the modified hold-relax stretching protocol reported by Spernoga et al [6].

Figure 2. The hamstring muscle hold-relax stretching

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The moist heat therapy was administered by a terry cloth hot moist pack cover (160.8° F) on each subject's hamstring muscle group in prone position for 20 minutes. Hot packs were secured with an elastic wrap, to the posterior thigh. The covered area was approximately 10×20 inches covering the central portion of the hamstring muscle group [18]. Moist heat therapy was followed by modified hold-relax stretching in group 1.

Outcome measures

Changes in hamstring flexibility was assessed using passive knee extension test. The test was done in supine position with the hip flexed to 90 degrees and contralateral limb remained flat on the bed. The axis of a goniometer was placed at the lateral epicondyle of femur, while the moving arm pointed towards the lateral malleolus and stationary arm pointed towards the major trochanter. This method to measure knee ROM is a reliable and valid technique [19]. The therapist extended the knee until the maximal tolerable stretching of hamstring muscle was reached and the knee angle was measured by a goniometer. The passive knee extension test has inter-rater reliability of 0.99 and is a reliable test for hamstring length testing [20].

The strength of the hamstring muscle was tested in sitting position. Knee joint on the tested side was flexed to 60° and feet was kept off the ground. A handheld dynamometer was placed on the posterior aspect of the lower leg, just above the malleoli. An inelastic strap was attached the tested leg to the waist of the examiner sitting in front of the subject. The strap was used to maintain the position of the handheld dynamometer and the knee angle during the test. Subjects were then asked to flex their knee as strong as possible by pushing the leg into the hand-held dynamometer. The subject was instructed to continue exerting force for 4 seconds. There was a 20-sec rest interval. The test was conducted three times and the average value was used for final analysis. The average force in Newton (N) was normalized across the three trials to body mass (N/kg) [21, 22].

The surface EMG was used to find out the muscle activity of hamstring muscle before and after the treatment protocol using AD instrument PowerLab system. To reduce impedance, skin was prepared by shaving hair and cleaning the skin using alcohol swabs prior to EMG recording. Ag/AgCl bipolar EMG electrodes were placed on the hamstring muscle belly in the direction of muscle fibers to record its maximal voluntary isometric contraction (MVIC). The ischial tuberosity was identified first, and then the common hamstring insertion tendon was palpated proximal to distal. Subject were then asked to perform a maximal contraction to locate the largest area of muscle mass with the knee flexion of approximately 60 degrees. All electrodes were aligned parallel to the underlying muscle fibers in prone position. The distance between the electrodes were 20 mm to reduce cross-talk. Elastic wraps were applied over the electrodes to prevent slippage during the procedure [23]. Reference electrode was placed on the fibular head. The MVIC of hamstring was recorded in prone position, using velcro straps to stabilize pelvis and contralateral limb. The knee was bent at 30 degrees and subject was asked to push the knee towards the resistance with maximum force for 5 seconds followed by a 20 seconds of rest. The procedure was repeated three times and the average value was recorded. The root mean square (RMS) values were calculated from the 3 seconds in the middle of each 5-sec contraction. The muscle activity of MVIC was expressed as average RMS value of three muscle contractions. Then, the hamstring muscle activity was measured using active knee flexion test. The normalisation of EMG was done by calculating percentage of muscle activity. It was determined as: % MVIC=Muscle activity during knee flexion×100/MVIC [24]. LabChart Pro software was used for EMG signal processing. The raw EMG data sampling was done at 2 KHz using bandpass filter with a 500 Hz low-pass cutoff frequency and 10 Hz high-pass cutoff frequency

Data analysis

Data were analyzed in SPSS software. The descriptive statistics (mean and standard deviation) was used for presenting pre- and post-intervention scores and participants' characteristics. Independent t-test was used to analyze difference between the participant's characteristics, and two-way ANOVA (group as between-subject factor and time as within-subject factor) was used to analyze difference between the groups in terms of outcome measures. Significance level was set at 0.05.

3. Results

The descriptive statistics of participant's characteristics and outcome measures are presented in Tables 1 and 2, respectively. In group 1, there were 7 males and 12 females. In group 2, there were 6 males and 13 females. There was no significant difference between the subjects in terms of demographic characteristics. Figures 3, 4 & 5 show the difference between groups in terms of knee ROM and muscle EMG activity and strength. The knee ROM showed a significant difference in terms of time (P= 0.001) and group (P=0.005). The muscle strength and EMG activity were not significantly different and there were no time effect, group effect or group-time interaction effect (Table 3).

4. Discussion

The objective of the present study was to determine the effect of modified hold-relax stretching plus moist heat on knee ROM, and EMG activity and strength of hamstring muscle in college students. The result of the study showed that combined technique had sig-

Table 1. Characteristics of the participants

Variables	Mean±SD		t	P
	Group 1 (n=19)	Group 2 (n=19)		
Age (y)	22.29±1.79	21.88±1.93	0.644	0.52
Height (cm)	159.29±6.78	162.35±7.68	-1.23	0.22
Weight (kg)	52.82±7.46	55.06±8.67	-0.80	0.42
Body Mass Index (BMI) (kg/m²)	20.72±1.72	20.82±3.14	-0.11	0.91

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Table 2. Descriptive statistics of the outcome measures

Variables	Mean±SD			
	Group 1		Group 2	
	Pre-test	Post-test	Pre-test	Post-test
ROM	148.24±8.09	161.27±8.79	145.29±9.91	149.21±10.29
EMG activity	0.20±0.05	0.25±0.06	0.20±0.08	0.21±0.07
Strength (N)	87.01±12.5	92.22±17.02	87.25±19.12	91. 53±16.71

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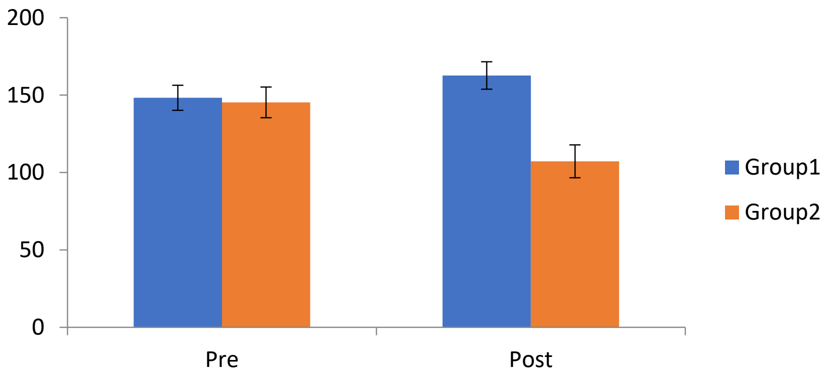

Figure 3. Changes in knee ROM before and after intervention in two groups

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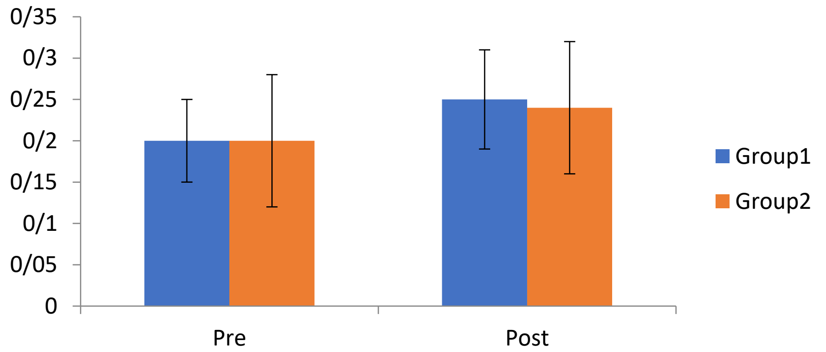

Figure 4. Changes in muscle EMG activity before and after intervention in two groups

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nificant effect on knee ROM, but not on EMG activity and strength of hamstring muscle. The findings are in accordance with the previous studies [11, 25, 26] in which it was observed that modified hold-relax technique improved the ROM of the hamstring muscle. There are reports which suggests that PNF stretching helps to improve the flexibility of muscle but there is still debate about which stretching techniques are the best [8]. Changes in knee ROM following modified hold-relax stretching plus moist heat could be due to its effect on the viscoelasticity, thixotropic properties and neural components of the muscle [6]. The neuromuscular properties of the muscles can be assumed to be influenced by the stretching exercises. Therefore, these stretching techniques can be an effective tool to improve muscle flexibility which need less equipment and cost. Modified hold-relax technique is based on the principle of autogenic inhibition in which the muscle is made to contract isometrically to maximum level activating the golgi tendon followed by inhibition of the

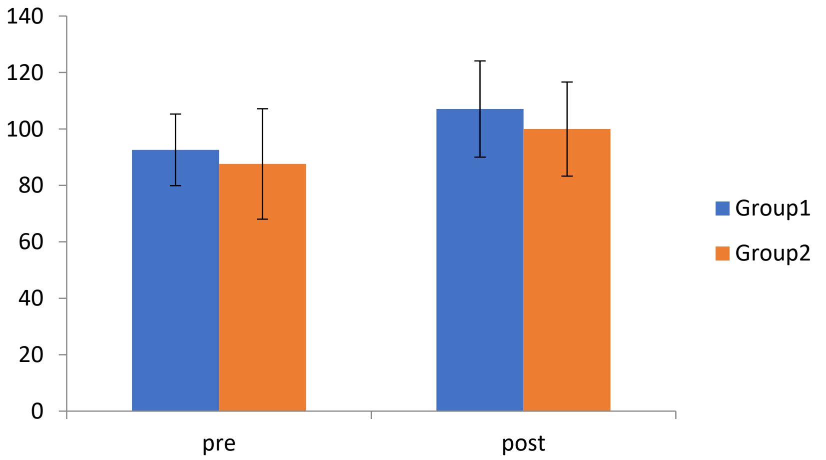

Figure 5. Changes in muscle strength before and after intervention in two groups

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Table 3. Summary of ANOVA results

Variables	Group		Time		Group×Time	
	P	η^2	P	η^2	P	η^2
ROM	0.05	0.08	0.001	0.72	0.43	0.72
EMG activity	0.70	0.005	0.73	0.004	0.78	0.004
Strength	0.34	0.02	0.72	0.04	0.96	0.001

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muscle [26]. In recent studies, presynaptic inhibition of the muscle spindle sensory signal has been suggested as one of the reasons for the decrease in amplitude of H- and stretch reflex response following contraction of stretched muscle [27, 28]. Even though the PNF stretching techniques increases muscle flexibility, its effect on muscle activity and strength has not been reported in detail.

In this study, the results are consistent with the results of previous studies reporting no effect on muscle activity following PNF stretching [29-31]. In contrast to our findings, Carter et al. reported reduced muscle activity after reflex desensitization [32]. The flexibility and strength of the muscle are important factors in physical performance. Therefore the current study explored whether increased muscle flexibility can have an effect on muscle strength, but we found no change in strength following the intervention. This is against the previous studies in which a reduction in muscle strength was observed following stretching [33, 34]. The discrepancy in results can be attributed to the fact that earlier studies primarily checked the acute effects but our intervention was for longer duration i.e. four weeks. Future studies are recommended for longer duration with follow-up. The stretching techniques may be used in combination with other techniques to evaluate its effect on neuromuscular properties of the muscle. Low sample size was a major limitation of the study. Studies using larger sample size is recommended to increase the generalizability of the findings.

Conclusion

The modified hold-relax technique combined with moist heat is effective in increasing hamstring muscle flexibility but has no effect on muscle activity and strength.

Ethical Considerations

Compliance with ethical guidelines

The study was approved by the institute ethical committee of Jamia Millia Islamia, New Delhi (ID: 16/9/131/IEC/2017).

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declare no conflict of interest.

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