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RESEARCH ARTICLE

ACUTE EFFECT OF STATIC STRETCHING, PNF AND MOTOR IMAGERY ON HAMSTRING FLEXIBILITY

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ABSTRACT

Introduction: The aim of the present study is to investigate the effects of a single session of static and proprioceptive neuromuscular facilitation (PNF) stretching and motor imagery (MI) techniques on hamstring flexibility.
Material and Methods: Sixty-one volunteers were included in the study. Individuals were randomly assigned as static stretching (SS), PNF and MI groups. SS and PNF stretching exercises were applied 15 times to the SS and PNF groups for both legs, respectively. MI group was asked to imagine a standard hamstring stretching exercise program with the commands of the physiotherapist, without any movement. Before and after the stretching session, hamstring flexibility was evaluated with the right and left leg active straight leg raise test (ASLRT) and sit-reach test (SRT).
Results: The statistically significant differences were found in the pre-and post-session right and left ASLRT and SRT scores of SS, PNF and MI groups ($p<0.01$). In addition, no statistically significant difference was found between the SS, PNF and MI groups in terms of right, left ASLRT and SRT scores ($p>0.05$).
Conclusion: The study presented that a single session application of SS, PNF, and MI have shown positive effects on hamstring flexibility and none of them were superior to each other. Considering clinical implications of current results, MI application may be recommended as a home exercise program or when SS and PNF stretching cannot be performed instead of these techniques. Further studies that compare the long-term effects of these techniques are needed in the literature.

Key Words: Motor imagery, static stretching, PNF, hamstring flexibility.

INTRODUCTION

The hamstring muscle is the primary flexor of the knee and flexibility is an essential issue for normal functions. Insufficient hamstring flexibility may cause numerous risks in lower extremity injuries, misalignment of pelvis and spine, hip immobility, and pain (1). Lack of hamstring flexibility is frequently associated with the prevalence of poor posture, physical inactivity, and bad exercise habits which are very common in recent years (2-4). Therefore, the appropriate extensibility of this muscle group is an important matter for both training and rehabilitation protocols.

The stretching exercise is the most common technique to improve hamstring flexibility. The underlying mechanism of stretching on flexibility is not clear, but there are some theories such as reduction in muscle-tendon unit stiffness and viscosity of tendon, alterations on connective tissues, and enhancement in the toleration of muscle length (5). Static stretching (SS), ballistic and dynamic stretching, Mulligan stretching, and proprioceptive neuromuscular facilitation (PNF) are among the common stretching stretching types (6,7). Additionally, instrument-assisted soft tissue mobilization, dry needling, and motor imagery (MI) are alternative methods to promote hamstring flexibility (8-10). There is a considerable amount of evidence that showed the effectiveness of SS and PNF on hamstring flexibility for both acutely and chronically (2, 3, 6, 7, 11-13). The results of previous studies that have compared SS and PNF are controversial. Many studies reported that PNF techniques increase hamstring length more than SS (7), but there are also studies showing similar effects of SS and PNF on hamstring flexibility (14, 15). These inconclusive results are also valid for both acute and chronic practice of techniques (6, 10, 14).

MI practice is generally used to focus on facilitating motor performance, motor learning, and relearning in physiotherapy. The studies about MI on hamstring flexibility which are a very limited number, have generally performed MI as an additional practice to real stretching techniques. Almost all of these studies showed improvement via MI practice on hamstring flexibility, but the effect of MI on is unclear when it is performed alone (8, 16, 17). Thus, the aim of this study is to compare the acute effect of SS, PNF, and MI practices on hamstring flexibility.

MATERIAL AND METHODS

Sixty-one participants who are without a history of any neurological or acute musculoskeletal injury were recruited to the study and randomly assigned to SS (n=20), PNF (n=20), and MI (n=21) groups using an electronic random sequence generator (www.random.org). The volunteers were numbered one by one All participants were right dominant leg. The participants who have acute or chronic pain, have any history of immobilization, and are diagnosed with any chronic diseases, including strengthening programs in the last 12 months were excluded. Written informed consent was obtained from all subjects. The experimental procedure was approved by Istanbul Atlas University Human Research Ethics Committee, and the experiments were performed in accordance with the Declaration of Helsinki (Approval date: 16.06.2021; Approval number: E-22686390-050.01.04-4786).

All participants have performed the Active Straight Leg Test (ASLRT) and Sit and Reach Test (SRT) before and after the stretching session by the same physiotherapist. While participants were asked to raise their leg with a knee extension as possible as much in the supine position for ASLRT, the physiotherapist measured hip flexion range of motion using a standard goniometer. ASLRT was assessed for right and left leg and the test is repeated if a knee flexion movement in the tested side or a movement in the other leg was determined. Higher values are shown better hamstring flexibility (18). SRT was performed in a sitting position with their feet approximately hip-wide against the testing box. We asked the participant to keep their knees extended and slowly reach forward as far as possible by sliding their hands along the testing box. The maximum point in which participants can stay in 6 seconds was accepted as SRT score. The test score was recorded as a negative value if the participant cannot reach the box, thus higher values are indicated better hamstring flexibility (19). ASLRT and SRT were performed three times and the highest score was recorded as the final test score of the participant. A one-minute resting period was given between each trial to prevent fatigue.

All stretching practices were done by the same physiotherapist 5 minutes after test session. Participants lied in the supine position and one leg was secured using a Velcro belt in the SS group. The physiotherapist stretched both legs by turns in the maximum, tolerable flexion position of the hip with knee extension for 15 seconds, and 15 repetitions (20). The participants had a rest for 15 seconds between each stretching. The hold-relax technique was performed in the same position with the SS group for participants in the PNF group. The physiotherapist applied resistance at the end of the hip flexion range against the optimal isometric contraction of the participant during 8-10 seconds, followed by a voluntary relaxation, the last position was kept for 5-8 seconds. PNF technique was also applied on both legs for 15 repetitions and given a rest for 15 seconds between each stretching (21). Participants lied in a comfortable supine and eyes closed position in the MI group. Following a breathing control exercise, basic hamstring stretching exercises were performed as kinesthetic imagined movements without a real movement according to instructions of the physiotherapist. This exercise program included straight leg raised, sit and reach forward in neutral and abduction of leg, standing forward fold exercises. The instructions contained the same verbal clues. MI session was completed approximately in 13-15 minutes.

Statistical Analysis

The statistical analysis was performed using SPSS program (Statistical Package for the Social Sciences, version 17,0, SPSS Inc, Chicago). Normality of all variables was tested using Shapiro-Wilk's test. The differences in demographic and clinical characteristics of groups were analyzed using one-way ANOVA or Kruskal-Wallis test according to the normality of data. The Chi-square test was used to compare gender distributions between groups. In groups differences between pre-and post-session were examined using the Paired-Sample T test or Wilcoxon test. A mixed ANOVA was used to determine the difference of pre-and post-session ASLRT and SRT scores between the three groups. A p-value of less than 0.05 was considered statistically significant.

The sample size estimation was calculated using "GPower- 3.1.9.2". It was calculated that minimum of 60 participants are need for the study to have 80% power and 95% confidence level (6). Therefore, 61 participants were included in the study.

RESULTS

The mean age and body mass index values of the participants were 21.4±1.7 years and 21.7±2.3 kg/m2 in the SS group, 21.0±1.9 years and 20.9±2.9 kg/m2 in the PNF group, and 21.2±1.3 years and 21.0±2.1 kg/m2 in the MI group, respectively (p>0.05). In addition, there was no difference in gender distribution among SS, PNF, and MI groups (p>0.05) (Table 1).

There are no statistically significant differences in baseline scores of right and left ASLRT, and SRT among the groups (F= 0.746, p=0.480; F=2.131, p=0.130; F=0.082, p=0.922; respectively). Pre- and post-session scores of right, left ASLRT and SRT showed statistically significant improvement in the groups (p<0.01). No statistically significant interaction was determined between stretching practices and time in right, left ASLRT and SRT scores (p>0.05) (Table 2).

DISCUSSION

The present study aimed to determine the acute effect of SS, PNF, and MI on hamstring flexibility. The study revealed that SS, PNF, and MI improved hamstring flexibility after a session. Furthermore, there is no superiority among these techniques with respect to the effectiveness of hamstring flexibility.

The proper, fluent range of motion in the joint complexes during body movements is a desirable characteristic for the comfortable completion of daily life activities. Flexibility is associated with not only the mechanics of the body but is also affected by neurophysiological systems (4). Therefore, techniques that are used for flexibility improvement focus to alter these systems. SS and PNF are the most commonly used techniques for enhancing hamstring flexibility. In line with the results of the present study, there are lots of reviews and studies to reveal the acute effectiveness of SS and PNF on hamstring flexibility (2, 3, 6, 7, 11-13). According to literature, it is claimed that the acute effect of stretching may happen as a result of a decrease in muscle-tendon unit stiffness and the increase in stretch tolerance on which PNF is more effective than SS (22, 23). However, both the present study and the current meta-analysis study results have shown that PNF and SS have similar acute and long-term effects on hamstring flexibility (11, 14). It is argued that PNF is presented as a more effective method than other stretching techniques because, the duration of PNF practice has been applied longer than the other techniques in some comparative studies (14, 24). In the present study, PNF and SS have practiced similar

Table 1. Demographic characteristic of the groups

	SS Group (n=20)	PNF Group (n=20)	MI Group (n=21)	p
Sex (F/M)	14/6	13/7	14/7	0.423
Age (year)	21.4±1.7	21.0±1.9	21.2±1.3	0.784
Height (m)	1.6±0.1	1.6±0.4	1.6±0.6	0.985
Weight (kg)	61.5±9.6	62.3±8.9	61.9±7.6	0.411
Body mass index (kg/m^2)	21.7±2.3	20.9±2.9	21.0±2.1	0.327

SS: Static Stretching. PNF: Proprioceptive Neuromuscular Facilitation. MI: Motor Imagery

Table 2. Pre- and Post-session Scores of ASLRT and SRT in the Groups

	SS Group (n=20) X±SD			PNF Group (n=20) X±SD			MI Group (n=21) X±SD			Between-groups difference	
	Pre-session	**Post-session**	**p**	**Pre-session**	**Post-session**	**p**	**Pre-session**	**Post-session**	**p**	**F**	**p**
Right ASLRT	70.0±11.7	75.4±7.9	**0.004**	73.4±11.3	79.7±8.3	**0.002**	68.5±12.7	71.5±20.6	**0.004**	0.396	0.675
Left ASLRT	72.0±9.2	78.0±8.0	**<0.001**	74.3±9.5	82.0±6.2	**<0.001**	67.3±11.6	76.1±10.2	**<0.001**	0.906	0.411
SRT	1.7±8.5	3.9±8.8	**0.009**	0.93±9.2	4.6±8.4	**0.002**	-0.2±19.3	-0.09±6.5	**0.003**	0.271	0.764

SS: Static Stretching. PNF: Proprioceptive Neuromuscular Facilitation. MI: Motor Imagery
ASLRT: Active Straight Leg Raised Test. SRT: Sit and Reach Test

time durations and their effects on hamstring flexibility were also found similar.

The evidence about the acute effect of MI on hamstring flexibility is limited. In MI, two types of imagery are performed: internal and external imagery. Internal imagery is also known as kinesthetic imagination in which the first person's visual, experienced from within, and is more effective as motor performance facilitation than is external imagery (25). Previous studies about flexibility have used either internal or external imagery techniques but some of them performed internal and external imagery techniques together in MI sessions (8, 16). Significant augmentation on hamstring flexibility was determined in the MI group in which the participants only performed imagination without stretching in this study. Unlike with the present study, MI has been applied as an additional method to a real stretching exercise in the other studies (8, 16, 17, 26). Kanthack et al revealed that one session MI with the sit and reach exercise is more effective than only performing the sit and reach exercise on hamstring flexibility via changing neuronal activation and motor system programing (8). Furthermore, there is some evidence about the effectiveness of MI on flexibility via physiological changes, general relaxation, focusing on motor skills (attentional control theory), changes in muscle activity, and neuromuscular activation (16, 26). Similarly, Frenkel et al applied MI for 3 weeks without movement and with a brace that was used to immobilize the wrist. MI group presented less limitation on range of motion than control group (27). According to literature and the results of this study revealed that MI may practice without any other application for flexibility.

While the acute effects of stretching generally are associated with mechanical alterations, the lack of real stretching or external force to the muscles in MI does not indicate that mechanical changes do not exist. It was shown that MI may alter tendon structures via changing spinal reflex pathways (28). In addition, Abraham et al presented that MI can increase the viscoelastic property of fascia via the autonomic nervous system (29). Physiological effects of MI such as regulation of muscle collagen synthesis and alteration of blood flow may be also attributed to improvement in flexibility (16). Williams et al compared the effect of additional MI to PNF and PNF alone on hip range of motion for 15 sessions and more progression was determined in the MI group than PNF (17). Another study also found more effective additional MI to SS than SS alone on hamstring flexibility (8). In the present study, MI was applied without combining with any stretching method and showed similar effects on hamstring flexibility compared to PNF and SS.

The lack of assessment of imagination ability might be accepted as the limitations of the study. Additionally, it has to be considered to all participants were healthy, thus present results of this study were not suggested to generalize on people with diseases in physiotherapy management.

CONCLUSION

In conclusion, this study showed that a single session application of SS, PNF, and MI have shown positive effects on hamstring flexibility and the improvements were not different among the three groups. According to these results, it is seen that in conditions where SS and PNF cannot be performed, or as a home program, MI may be recommended instead of SS and PNF which are generally used. Furthermore, SS, PNF, and MI can be practiced for stretching before antagonist muscle strengthening or aerobic exercise because of their similar effects on flexibility, but further studies are needed to compare the long-term effects and their influence on performance after stretching.

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