Original Article

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Immediate Effect of Hamstring Stretching on Q Angle, Flexibility, and Balance in Individuals with Hamstring Tightness

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Abstract:

Objective: Hamstring tightness is a common problem that can affect the quadriceps angle, flexibility of knee extension, and balance. The purpose of this study was to investigate the immediate effects of passive static hamstring stretching on the quadriceps angle, knee joint range of motion (ROM), and static and dynamic balance in people with hamstring tightness.

Material and Methods: A total of 52 male participants were randomly divided into two groups: a stretching group and a control group. All participants underwent a physical therapy examination before the experiment (Pre-test), including an Active Knee Extension Test, quadriceps angle (Q angle) measurement, and static balance and dynamic balance assessments. After that, the stretching group received passive static hamstring muscle stretching, while the control group received knowledge about the tightness of the hamstring muscle. After the experiment, all participants underwent a physical therapy examination using the same testing method.

Results: The study found that passive static hamstring muscle stretching increased the knee extension ROM by 5.54±3.78 degrees (p-value<0.01) and decreased the Q angle by -1.85±1.46 degrees (p-value<0.01) compared to the control group. However, there were no significant differences between the groups for the balance outcomes.

Conclusion: This study found that passive static hamstring muscle stretching improved knee extension and decreased the Q angle. These findings can confirm the positive effects of exercise for increasing flexibility among individuals with tight hamstrings and abnormal Q angle.

Keywords: balance, hamstring muscles, quadriceps angle, range of motion, static stretching

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Introduction

Muscle tightness is a common problem in people of all ages, even athletes, and it can occur from injury, scarring, immobilization, or following abnormal or imbalanced muscle activity, causing movement restriction and leading to clinical problems[1].

One multi-joint muscle that is often injured by tightness is the hamstring. Adults often experience hamstring tightness as a result of leading more sedentary lives. College students often sit for long periods of time which can reduce soft tissue elasticity, particularly in the muscles that support two joints. Constantly shortened postures from extended sitting cause tightness in the hamstring muscles[2]. Additionally, a study by Youdas et al.[3] found that gender impacted hamstring length, with males having tighter hamstrings than females. Several factors can cause this tightness, such as an imbalance in the strength of the front and back thigh muscles, repetitive injury, immobility of the lower limbs, and tissue scars[4,5]. Hamstring tightness may result in various problems such as patellofemoral pain syndrome, abnormal positioning of the pelvic bones, decreased lumbar spinal curve when sitting, deficits in movement, balance, and weight-bearing during walking, and physiological changes[6,7].

Hamstring tightness causes the Q angle to change, which is used to indicate pathology in the patellofemoral joint[8]. Minoonejad et al.[9] found that futsal players with hamstring tightness had an increased Q angle that decreased performance. An increase in the Q angle puts pressure on the joint surface, causing a lateral shift of the patella, and increased pressure at the lateral tibiofemoral joint leading to knee pain in the patient[10]. Hamstring tightness also affects balance because the tightness load anomaly changes the lower limb muscle and joint position sense[11].

Adequate flexibility reduces muscle tension, improves range of motion (ROM), and prevents injury to soft tissue and muscles. Stretching increases the flexibility of muscles and tendons, improves efficiency in movement or playing sports, and can prevent sports-related injuries[12]. Static stretching is commonly used to increase flexibility. Previous studies found that static stretching of the hamstring muscles was effective for increasing knee extension ROM and hamstring flexibility[13,14].

A previous review found that hamstring tightness may affect the Q angle, flexibility, and balance. Lim et al.[15] found that stretching hamstrings can improve knee extension range, and Ciftci and Kurtoğlu[16] found that hamstring muscle length is associated with Q angle. However, the association between hamstring tightness and balance has not been clarified. Therefore, this study was conducted to investigate the immediate effects of passive static hamstring stretching on Q angle, ROM of the knee, and balance in people with hamstring tightness.

Material and Methods

Study design

The study was a randomized controlled trial (RCT) design. The study was approved by the Mae Fah Luang University Ethics Committee on Human Research, Mae Fah Luang University, Thailand (COA 193/2020, Protocol No: EC 20187-25). A convenience sampling method was used for participant selection. The sample size was calculated using G* Power software version 3.1.9.4 (Heinrich Heine University, Germany) with a power of 80%, an alpha error of 0.05, and an effect size of 0.73[17]. The study required 52 participants, who were divided into two groups with 26 persons per group. The study followed the CONSORT guidelines as shown in Figure 1.

Participants

This study was conducted at the Physical Therapy Department, School of Integrative Medicine, Mae Fah Luang University. A total of 52 healthy young adult males were

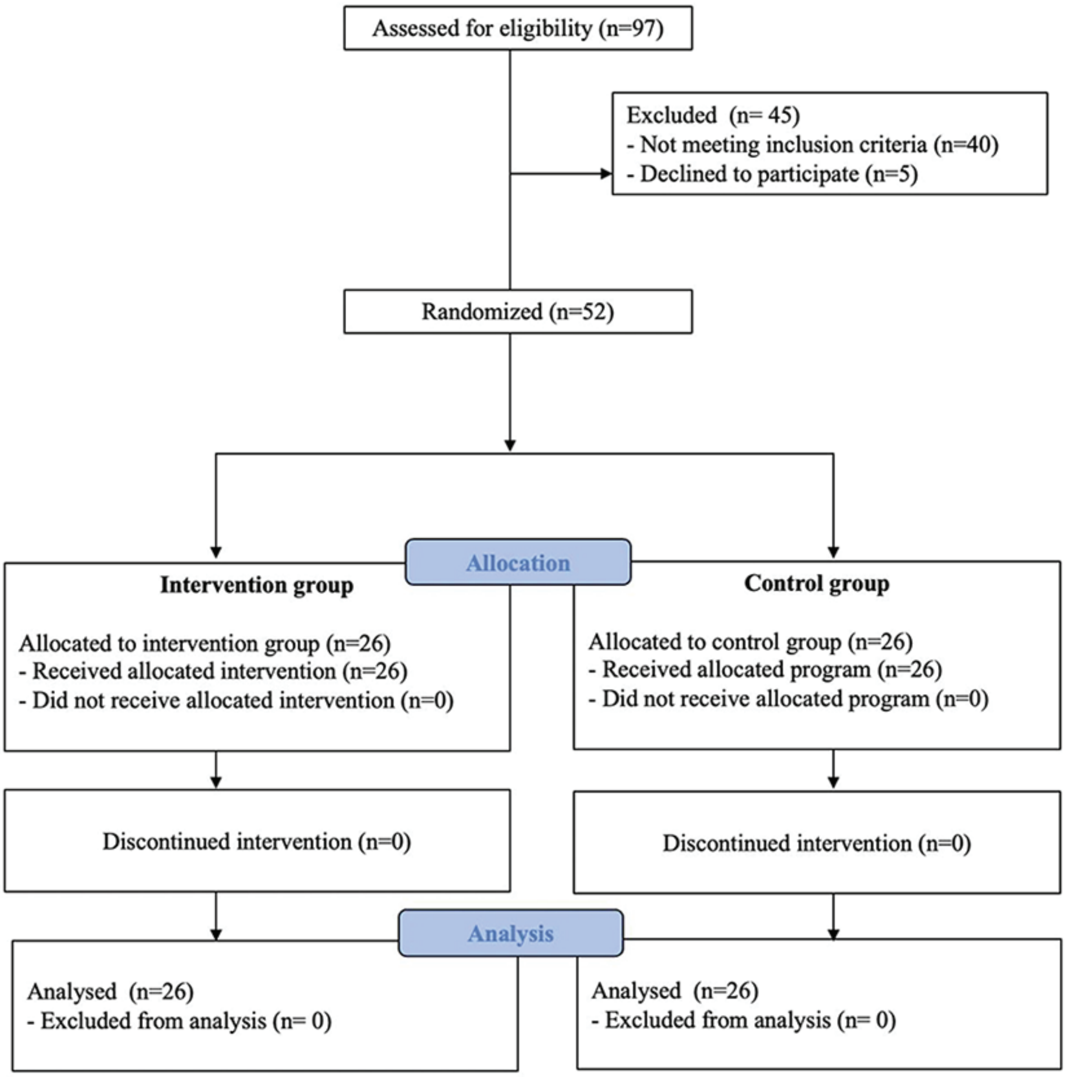

Figure 1 CONSORT diagram

recruited based on the following criteria: healthy male aged between 18 and 35 years, having knee extension deficit (KED) with Active Knee Extension Test (AKE) score ≤60 degrees[18] on the dominant leg, and a Q angle ≥15 degrees[19]. The exclusion criteria were having a hamstring injury in the past 6 months, hip surgery or broken leg bone in the past year, congenital anomaly of the spine, rheumatoid arthritis, gouty arthritis, infection of the spine or discs, meniscus tears, or inner ear or vestibular disorders.

Procedure

Before the trial commenced, individuals who satisfied the inclusion requirements were screened if their Q angle was ≥15 degrees and their AKE score was ≤60 degrees. Following this, each participant was placed randomly in either the stretching or control group. Then, all participants' physical performance was evaluated using the AKE test, Q angle measurement, Single Leg Stance Test (SLS), and Y-balance test (YBT) to determine their pre-experimental score. All physical performance tests were measured on the dominant leg. The participant's preferred leg when kicking a ball was used to determine the dominant leg.

The stretching group received a passive static hamstring stretching intervention of 15-second hold durations repeated three times with a 15-second rest between each repetition[20]. During the stretching procedure, the participant lay supine on the treatment table in a straight posture. Next, velcro straps were used to fasten the thighs that were in opposition to the lower limb that was going to be stretched. The dominant leg was flexed at the hip and knee at 90° in the supine position. The therapist passively extended the knee with external force until the hamstring muscles were stretched with mild and tolerable pain (Figure 2). Participants in the control group received knowledge about the tightness of the hamstring muscles during resting in a chair for 3 minutes, the approximate time required to complete the stretching intervention. The same physical performance assessments were administered to both groups of participants again after the passive static stretching or control sessions.

Outcome measurements

AKE[21]

All participants received a description of the AKE testing process. They were asked to extend their knee joint as much as possible while lying supine with their hip and knee at 90° flexion, using straps and PVC tubes to restrict leg and pelvic motion (Figure 3). Each participant was measured twice, with a 15-second rest between each test, and the analyses were performed using the mean angle of the AKE test. A previous study's test-retest reliability reported a range of ICC values between 0.78 and 0.97[21].

Q angle measurement[22]

The Q angle is the angle between an imaginary line drawn from the center of the patella to the middle of the anterior tibial tuberosity and from the anterior superior iliac spine to the patella's center. Using the goniometric method, the testee stands with their knees extended and their quadriceps relaxed (Figure 4). All participants were tested twice, and the analyses were performed using the

Figure 2 Passive static hamstring stretching

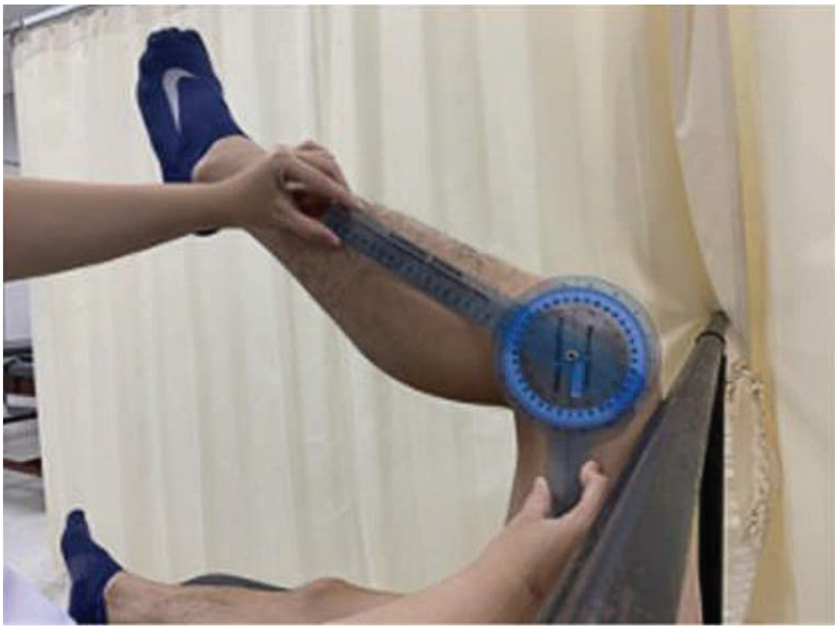

Figure 3 Active Knee Extension test (AKE)

Figure 4 Q-angle measurement

mean angle. The intra-rater reliability reported the ICC value in an earlier study of this test was 0.88[23].

SLS[24]

Participants were instructed to stand barefoot on an even stable surface on their dominant leg, with the other limb raised but not touching the tested leg. For the duration of the eyes open test, each participant was instructed to fix theirs attention on a spot at eye level on the wall in front of them. The participant's arms were crossed over their chest before the limb was raised. The participant's ability to stand on one leg was timed by the investigator using a stopwatch. Time started as soon as the participant lifted their non-tested foot off the ground. The timer ended when the participant uncrossed their arms or used his raised foot to maintain balance by moving it toward or away from the standing limb or touching the floor. A previous study reported an ICC reliability of 0.99[24].

YBT[25]

The YBT used in the study was the shortened version modified from the Star Excursion Balance Test (SEBT). To reduce the impact of a learning effect, each participant completed two practice trials after watching an investigator-produced YBT instructional video. The participant stands in the center while reaching the contralateral limb as far as possible along the line. Scoring for the YBT involves measuring the farthest reach in each of the three reach directions (anterior, posteromedial, and posterolateral). The test-retest reliability was reported as an ICC value of 0.80 to 0.85[26].

Before data collection, ten participants' physical performance tests were evaluated for test-retest reliability. Each participant underwent two examinations for the physical performance test, separated by a 30-minute break. The test-retest reliability results demonstrated fair (0.70) to excellent (0.97) reliability for the AKE (0.97), Q angle (0.89), SLS (0.78), and YBT (0.70).

Statistical analysis

For the reliability study, intraclass correlation coefficients (ICC) were calculated for continuous data. The ICC (3,2) was calculated for the physical performance outcomes. According to the interpretation of the ICC values, >0.75 indicated excellent quality, 0.40–0.75 was fair to good, and <0.40 indicates poor quality[27].

All data were recorded and entered into the Statistical Package for Social Sciences (SPSS Version 20.0, IL, Chicago, USA). The Shapiro-Wilk test was used to assess the normality of the data. Demographic characteristics were described using descriptive statistics with mean and standard deviation (S.D.). The Mann-Whitney U test was used for AKE, Q angle, SLS, and YBT to compare the groups' similarities. All outcomes had non-normal distributions at baseline with Shapiro-Wilk p-values ≤0.05, except for the YBT. As a result of some baseline differences, mean differences were used to compare the groups. The Mann-Whitney U test was used to compare between-group effects of the AKE, Q angle, SLS, and YBT tests. Pre- and post-intervention measurements were compared using the Wilcoxon signed-rank test for the AKE, Q angle, and SLS, while the YBT used the paired t-test to analyze within-effects. The level of statistical significance was set at p-value<0.05 for all analyses.

Results

A total of 52 participants were randomly assigned to either a stretching (n=26) or control (n=26) group, with mean ages of 21.31±1.67 years and 21.69±1.87 years, respectively. Table 1 presents the baseline characteristics of the study population. At baseline, there were significant differences in the AKE and Q angle results between the groups (p-value<0.05). As a result, group differences were evaluated as the group's mean differences.

The findings demonstrated that, in comparison to the control group, passive static hamstring stretching considerably increased the knee ROM and decreased the Q angle (p-value<0.05) (Table 2). On the other hand, balance outcomes for both the SLS and YBT tests did not significantly differ between the groups (p-value>0.05). The study found a significant increase in knee ROM from 31.27±8.39 to 36.81±8.57 degrees (p-value<0.01) and a decrease in Q angle from 20.23±2.79 to 18.23±2.69 degrees (p-value<0.01) when comparing the changes within the stretching group (Table 3). Furthermore, YBT was found to have significantly improved in both groups.

Table 1 Characteristics of the study population (n=52)

Variables	Stretching group (n=26) (mean±S.D.)	Control group (n=26) (mean ± S.D.)	p-value
Age (years)	21.31±1.67	21.69±1.87	0.24
Weight (kg)	70.11±13.18	73.70±15.94	0.39
Height (cm)	174.08±6.45	172.81±6.66	0.48
AKE (degrees)	31.27±8.39	37.71±8.89	0.02*
Q angle (degrees)	20.23±2.79	18.31±2.75	<0.01*
SLS (sec)	44.18±3.73	41.75±7.70	0.12
YBT (%)	86.62±11.59	86.20±13.00	0.90

*There were significant differences between groups
n=number, S.D.=standard deviation, kg=kilograms, cm=centimeters, AKE=active knee extension test, SLS=single leg stance test, YBT=Y-balance test

Table 2 Comparison of outcomes (mean differences) between the study stretching and control groups (n=26 per group)

Outcomes	Stretching group (mean±S.D.)	Control group (mean±S.D.)	p-value
AKE (degrees)	5.54±3.78	0.62±0.68	<0.01*
Q angle (degrees)	-1.85±1.46	-0.08±0.39	<0.01*
SLS (sec)	0.49±2.11	1.29±3.89	0.93
YBT (%)	6.79±4.56	4.48±6.08	0.13

*The Mann-Whitney U test showed significant differences between groups
n=number, S.D.=standard deviation, AKE=active knee extension test, SLS=single leg stance test, YBT=Y-balance test

Table 3 Comparison of outcomes between pre- and post-interventions (n=26 per group)

Outcomes	Group	Pre-intervention (mean±S.D.)	Post-intervention (mean±S.D.)	p-value
AKE (degrees)	Stretching group	31.27±8.39#	36.81±8.57 #	<0.01#
	Control group	37.71±8.89	38.32±9.28	0.38
Q angle (degrees)	Stretching group	20.23±2.79 #	18.23±2.69 #	<0.01#
	Control group	18.31±2.75	18.23±2.75	0.34
SLS (sec)	Stretching group	44.18±3.73	44.68±1.65	0.18
	Control group	41.75±7.71	42.91±6.59	0.24
YBT (%)	Stretching group	86.62±11.60	93.41±11.17	<0.01†
	Control group	86.20±13.00	90.68±13.40	<0.01†

#There were significant differences between pre-and post-interventions with the Wilcoxon Signed Rank test
†There were significant differences between pre-and post-interventions with the paired t-test
n=number, S.D.=standard deviation, AKE=active knee extension test, SLS=single leg stance test, YBT=Y-balance test

Discussion

The objective of this study was to compare the immediate effects of passive static hamstring stretching with a control group in terms of AKE, Q angle, SLS, and YBT outcomes. The study found that passive static hamstring stretching significantly increased the AKE and decreased the Q angle in the intervention group compared to the control group. Furthermore, in both pre-and post-interventions, increased AKE and decreased Q angle were observed in the intervention group. Additionally, it was found that YBT improved in both groups. On the other hand, there were no statistically significant differences in SLS both within and between groups.

The study's findings revealed an increase in AKE when stretching the muscles with constant force for an appropriate period. Static stretching has been found to be a secure and efficient way to lengthen the hamstring muscles[13]. In a previous study[28], static stretching was found to be effective in increasing ROM. The greatest change in ROM with a static stretch occurs between 15 and 30 seconds, which is sufficient for increasing flexibility. However, rather than extensibility (increased muscle length), the majority of static stretching training studies demonstrate an increase in ROM due to an increase in stretch tolerance. The results of our current study were consistent with previous research[29], indicating that static stretching is a practical and effective technique for hamstring muscles lengthening, which in turn increases the knee ROM. Lim et al.[15] found that both static stretching and PNF stretching led to significant increases in knee extension. In a study of normal adults with unrestricted joint ROM by Cramer et al.[30], both groups significantly reduced muscle activity following stretching. This was explained by the muscle relaxation effect activating the self-inhibition mechanism after stretching. In addition, Decoster et al.[31] found that stretching the hamstrings while lying down or standing increased the ROM of the knee. However, the supine stretch has more benefits than the standing stretch, as it can encourage relaxation and be safer and more comfortable for those who have previously suffered from low back pain.

The post-intervention Q angle in the stretching group was not only significantly reduced compared to pre-intervention but was also statistically significantly reduced compared to the control group. In a related study, the average Q angle was 14 degrees for males and 17 degrees for females; patellofemoral pain and knee extensor dysfunction are usually thought to be exacerbated by high Q angle values in excess of 15-20 degrees[32]. In one study, the Q angle and tibial torsion of futsal players with short hamstrings were found to be significantly higher than those of normal futsal players (without short hamstrings)[9]. Moreover, weakness in the lower limb muscles, followed by the internal rotation of the femur and external rotation of the tibia, shifts the gravitational pull to the outside of the knee. Bahadori et al.[33] suggested that strengthening exercises via TheraBand training significantly decreased the Q angle and improved the genu valgum position. Since one of the causes of knee pain and injuries is muscle imbalance, we can deduce, as reported in one study, that such malalignments (increased Q angle) can be caused by tightness in the hamstrings against the quadriceps[9]. Since muscle imbalance is one reason for knee injuries and pain, Minoonejad et al.[9] concluded that tightness in the hamstrings against the quadriceps resulted in an increased Q angle; therefore, static hamstring stretching might decrease the Q angle.

For the balance outcomes, this study found that the YBT improved in both the stretching and control groups. Since balance is a skill that can be improved via repetition and experience, it is learned through sensory input, the environment, and visual information. A study by Valodwala and Desai[34] found that visual feedback in conjunction with balance training could aid in readjusting perception impairments and correcting body imbalances.

Among the most popular and significant physiotherapy interventions used in inpatient rehabilitation centers is balancing practice[35]. Muehlbauer et al.[36] found that children, adolescents, and young adults who practiced a balancing task significantly improved their performance on the task. This confirms that practicing and relearning skills during multiple assessments may improve YBT. However, the SLS showed no significant change in either group, as its initial value closely approximated the normative value, suggesting it may represent the maximum achievable score for the SLS test[24].

The present study showed significant improvements in AKE and Q angles both within and between groups. However, there were some limitations to the study. First, due to the focus of the study on a single population (males), it is not possible to draw firm conclusions, and the results should be interpreted with caution when considering other groups of the population. Second, this study did not examine the knee and hip conditions of the participants, which may have affected the test results. Further research is required to determine the long-term effects of stretching and to examine knee and hip conditions as well as other groups of people.

Conclusion

Passive static hamstring stretching had an immediate benefit on knee ROM and quadriceps angle in hamstring tightness among young males. However, the study did not the effect of static hamstring stretching on static and dynamic balance.

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Conflict of interest

The authors declare that there were no conflicts of interest in this study.

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