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ORIGINAL ARTICLE

Effect of Static Stretching and Eccentric Exercise on Improving Hamstring Flexibility in University Students.

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Abstract

Hamstring tightness is prevalent among sedentary young adults and is associated with altered pelvic alignment, reduced lumbar lordosis, and increased risk of musculoskeletal injury. While static stretching and eccentric exercise are frequently used to improve hamstring flexibility, evidence comparing their effectiveness in non-athletic student populations is limited. This study aimed to evaluate and compare the effects of a four-week static stretching and eccentric exercise programme on hamstring flexibility. An experimental study was conducted with 36 university students (aged 18 to 25 years) not involved in structured exercise programmes. Participants were randomly allocated to a static stretching group (n=18) or an eccentric exercise group (n=18). Interventions were performed three times per week for four weeks. Hamstring flexibility was assessed using the Active Knee Extension Test (AKET) and hip flexion active range of motion (AROM) pre- and post-intervention. Data were analysed using paired and independent t-tests, with significance set at $p<0.05$. Both groups demonstrated significant improvements in AKET and hip flexion AROM following the intervention ($p=0.001$). However, no significant difference was found between the two groups in post-intervention outcomes ($p>0.05$). In conclusion, static stretching and eccentric exercise are comparably effective in improving hamstring flexibility among sedentary university students. These findings support the use of either modality for enhancing flexibility in this population.

Keywords: *Active knee extension test, eccentric exercise, hamstring flexibility, static stretching.*

Introduction

The hamstrings are key muscles responsible for hip and knee joint mobility and pelvic and spine alignment [1]. These muscles are prone to shortening, yet are functionally vital during walking, running, jogging, and other daily activities [2]. Tight hamstrings can contribute to lower back pain by inducing a posterior tilt and reducing lumbar lordosis [3].

Muscle flexibility refers to a muscle's ability to absorb stretch while reducing stress on its myofibrils. Insufficient hamstring flexibility is linked to alterations in lower extremity kinematics [4]. The hamstring consists of three muscles located at the back of the thigh: the biceps femoris, semitendinosus, and semimembranosus. It is one of the most frequently damaged muscles, typically during very intense and fast-paced activities [5].

Another study showed that prolonged sitting can be a contributory factor for hamstring tightness, with a prevalence of 82% as measured by the straight leg raise test. As a result, hamstring tightness is a fairly common ailment among students, particularly those who sit for long periods, and the majority of the population suffers from it [6].

Hamstring flexibility is influenced by age, gender, race, tissue temperature, strength training, stiffness, undesirable posture, and a shorter warm-up period during activity [7]. Genetic and hormonal differences may account for these discrepancies. Additionally, variations in fat deposition across genders may play a part [8]. Frequent stretching is necessary to maintain appropriate muscle length in order to prevent muscular stiffness, lower the risk of musculoskeletal injuries, and enhance physical performance [9].

In physical therapy, stretching exercises are used to improve joint range of motion (ROM) and hamstring flexibility [4]. By stimulating proprioceptors, stretching may enhance neuromuscular functions. It can assist in relieving pressure on the spinal cord's neurons by improving muscle mobility and flexibility, particularly in the hip flexors and piriformis. This is due to the fact that multifidus pain can be greatly reduced by stretching the muscles in these regions [10].

One exercise that can be used to increase hamstring flexibility is stretching. According to earlier studies, eccentric exercise and static stretching can improve hamstring flexibility and lessen muscular strain. However, some shortcomings in the earlier study have been revealed, such as the fact that it was primarily concerned with athletics. Fewer studies have examined the impact of exercise on sedentary people. Moreover, some studies were restricted to men. It is unclear if females respond similarly to eccentric exercise and static stretching. Therefore, the purpose of this study is to examine how university students' hamstring flexibility can be improved through static stretching and eccentric training.

Muscle extensibility is described as a muscle's capacity to expand to a predefined length [11]. During the maneuver, variations in the perceived stretch load seem to be associated with stretch tolerance, or the capacity to withstand stretching to a greater passive joint moment [12].

Both physiological and anatomical factors contribute to muscle extensibility. Anatomical causes include muscle shortening and stiffness. Muscular shortness is the term used to describe a muscle's reduced ability to expand due to a decrease of sarcomere units or connective tissue flexibility [13].

Muscle stiffness may be described as a change in pressure divided by the corresponding alteration in length, where the length change is generated by an external force or a shift in the outside load on the muscle [14]. Alpha motor neuron activity is the physiological cause of decreased muscular extensibility since it raises the force needed for muscle elongation, as evidenced by muscle stiffness in people with upper motor neuron injuries [13].

Limited hamstring flexibility is the inability to extend the knee by more than 160 degrees while maintaining 90 degrees of hip flexion [15].

This study was designed to investigate the effects of static stretching and eccentric exercise on hamstring flexibility in university students. It also aimed to examine the changes in hamstring flexibility following a four-week intervention of static stretching and eccentric exercise, as measured by the Active Knee Extension Test (AKET) and hip flexion active range of motion (AROM)To compare the effectiveness of static stretching versus eccentric exercise in improving hamstring flexibility among university students.

Methodology

Research setting and design

This study used an experimental study design and took place at the physiotherapy gymnasium of Universiti Kuala Lumpur Royal College of Medicine Perak (UniKL RCMP) to investigate the effects of static stretching and eccentric exercise in improving hamstring flexibility in university students. Thirty-six university students were enrolled in this study. For subject recruitment, convenience sampling method was applied. The subjects randomly chose one of two sealed envelopes that contained group divisions, which were the static stretching group and the eccentric exercise group. All the groups were assessed using AKET and hip flexion AROM before the session began. The subjects underwent the intervention 3 times per week for 4 weeks. After the interventions were completed, both groups were reassessed using the AKET and hip flexion AROM. This study was conducted during August 2023.

Sample size

Sample size estimation was performed using G*Power (version 3.1). The calculation was done based on a one-tailed independent samples *t*-test with an assumed effect size (Cohen's *d*) of 1.22, a type I error rate (α) of 0.05, and a desired statistical power of 95% ($1-\beta = 0.95$). The allocation ratio between the two groups was set at 1:1 [16]. The analysis indicated that a minimum of 16 participants per group was required, resulting in a total sample size of 32 participants, with an achieved power of 0.958. To account for a possible dropout rate of 10%, the total sample size was increased to 36 participants.

Inclusion and exclusion criteria

Participants aged between 18 and 25 years of both genders who were not involved in any structured fitness or exercise program were included in the study. Individuals were excluded if they had a history of musculoskeletal injury or surgery, including hamstring injuries; diagnosed cardiovascular disorders such as unstable angina; systemic diseases such as hypertension; or if they refused or were unwilling to participate in the study.

Procedure

All participants who met the inclusion criteria were separated into two groups: static stretching and eccentric exercise groups. Each group was assigned 18 participants. All groups were assessed before the session began by using the active knee extension test (AKET) and hip flexion active range of motion (AROM) to investigate the effect of static stretching and eccentric exercise in improving hamstring flexibility among university students.

The subjects underwent the intervention based on their specific group. For the static stretching group, they performed static stretching and the standing one-legged hamstring stretch. In the standing one-legged hamstring stretch, subjects stretched their dominant leg and placed it at knee height on a surface. Subjects were asked to maintain their backs erect and not bend forward until they noticed minor hamstring discomfort [17]. The position was maintained for 30 seconds [18] (Figure 2). The eccentric exercise group, they performed eccentric exercise. In a supine posture, the subject put the blue TheraBand around the heel and held the end with both hands. In its original posture, the knee joint was completely extended. The hip joint was flexed while the TheraBand provided eccentric resistance to the hamstring muscles as the limb was moved through its full range of motion (Figure 3). The subjects were encouraged to feel a strong contraction of their hamstring muscles during the movement. To complete the full range of hip flexion in approximately five seconds, the participants were instructed to exert sufficient effort to control and overcome the eccentric resistance applied to the hamstrings [5].

The procedure was repeated six times without interruptions for a total of 30 seconds of stretching at the end of the range [19]. The subjects underwent the interventions 3 times per week for 4 weeks. Once the interventions were completed, both groups were reassessed by the active knee extension test (AKET) and hip flexion active range of motion (AROM).

Statistical analysis

All data were analyzed using SPSS software (version 27.0). An independent-samples t-test was employed for normally distributed data, using a significance level of $p < 0.05$.

Results

Demographic data of subjects

Table 1 shows the gender proportion of this study and in table 2, the individuals' demographic variables (age, height weight and BMI) are illustrated. Table 3 results reported that the active knee extension test demonstrated a significant difference between pre- and post-intervention, p=0.001 in the static stretching group. Furthermore, there was a significant improvement in the hip flexion active range of motion in the static stretching group compared to pre-intervention. Table 4 results showed that the t-value of the active knee extension test for pre-intervention is -0.45 and the p-value is 0.66 for both groups. Next, the t-value of the active knee extension test for post-intervention is -0.51, and the p-value is 0.62 for both groups.

Discussion

This study investigated the effects of static stretching and eccentric exercise on improving hamstring flexibility in university students. Both interventions were shown to be effective in improving flexibility. After four weeks of static hamstring stretching and eccentric exercise, both groups showed considerable hamstring flexibility gains.

The results showed that both interventions produced statistically significant improvements ($p < 0.05$). The active knee extension test accurately assesses hamstring flexibility by stabilizing the pelvis and minimizing the influence of trunk flexors [9]. Another study showed that the active static stretching group had an 11.99° increase, and the eccentric exercise group had a 7.46° increase using the active knee extension test [5]. Moreover, in another study, physiotherapy students were divided into two groups- a static stretching group and an eccentric exercise group to examine the alteration of hamstring flexibility [19]. This study found that physiotherapy students had significant improvements in hamstring flexibility.

It is unknown how eccentric hamstring activity leads to greater flexibility over the entire range of motion. Examining the neuronal mechanisms associated with stretching may provide an explanation. Static stretching can lengthen muscles, allowing the muscle spindle to adjust [20].

The demographic characteristics of participants in both groups were comparable at baseline in terms of age, height, weight, body mass index, and gender distribution. This similarity indicates that the two groups were well matched before the intervention. Therefore, the observed changes in flexibility and AROM can be attributed primarily to the interventions rather than to underlying demographic differences [21].

Within-group analyses showed that static stretching significantly increased AKET values from 143.89° to 146.83°. Eccentric exercise also produced a significant improvement, with AKET values increasing from 145.06° to 148.28°. These results are consistent with previous research. Earlier studies have demonstrated that static stretching enhances muscle extensibility through viscoelastic adaptations and increased stretch tolerance [22,23].

Significant improvements in hip flexion AROM were observed in both groups. In the static stretching group, hip flexion AROM increased from 83.39° to 87.89°. In the eccentric exercise group, it increased from 82.94° to 86.83°. These findings suggested that reducing passive resistance in the hamstring muscles facilitated greater hip mobility [24,25].

Our findings aligned with previous research showing that both static stretching and eccentric training improved hamstring flexibility. Static stretching has been widely documented to increase muscle extensibility and joint mobility [23]. Concurrently, eccentric training has been shown to elicit adaptations that improve flexibility and strength [26]. The comparable effectiveness observed in this study suggest that multiple exercise modalities can be used to address hamstring tightness effectively.

Although both interventions were effective, no statistically significant between-group differences were found for AKET or hip flexion AROM ($p > 0.05$). This result revealed that for participants with hamstring tightness, static stretching and eccentric exercise were equally effective in increasing flexibility and joint range of motion. The absence of a significant difference between the two interventions suggests that both interventions may be similarly effective in reducing hamstring stiffness and enhancing lower limb mobility. These results were consistent with a previous study, which reported that comparable effects of stretching and eccentric-based interventions on hamstring flexibility [27].

Overall, both static stretching and eccentric exercises significantly improved hamstring flexibility and hip flexion AROM in young adults with hamstring tightness. No significant differences were observed between the two interventions. These findings suggest that either modality could be effectively integrated into physiotherapy and rehabilitation programs aimed at improving flexibility and joint mobility. Selection of the intervention may be guided by clinical goals, individual needs, and program context.

Conclusion

In conclusion, both static stretching and eccentric exercises significantly improved hamstring flexibility and hip flexion AROM in young adults with hamstring tightness, with no significant differences between the interventions. Sarcomerogenesis likely plays a central role in the efficacy of eccentric exercise, while static stretching primarily enhances flexibility through viscoelastic and neuromuscular adaptations. These findings support the use of either intervention in clinical and rehabilitation settings, with the choice of modality guided by therapeutic goals, patient preferences, and available resources.

Limitation

A key limitation of this study was the absence of a control group, which precludes definitive conclusions regarding whether the observed improvements were solely attributable to the interventions rather than to natural variation or to a learning effect on the AKET. The short intervention duration of four weeks represents another limitation, as this may not fully capture the potential long-term adaptations or retention of flexibility gains. Furthermore, blinding of the outcome assessor was not implemented, introducing the possibility of measurement bias. Future studies should address these limitations by including a control group, extending the duration of interventions, and employing blinded assessors to strengthen the internal validity and generalizability of the findings.

Recommendation
Future research is therefore recommended to involve larger sample sizes, include participants from a broader range of age groups to determine whether similar improvements in range of motion can be achieved, and implement longer-duration exercise programmes to enhance the reliability and validity of the intervention outcomes.

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Authors' contribution
NAR- Main researcher; responsible for study conception, data collection, conducting the research, and drafting the original manuscript. VSM- Co-researcher; responsible for reviewing, editing, and finalizing the manuscript.

Ethics
Ethical approval was obtained from the UniKL Medical Research Ethics Committee.

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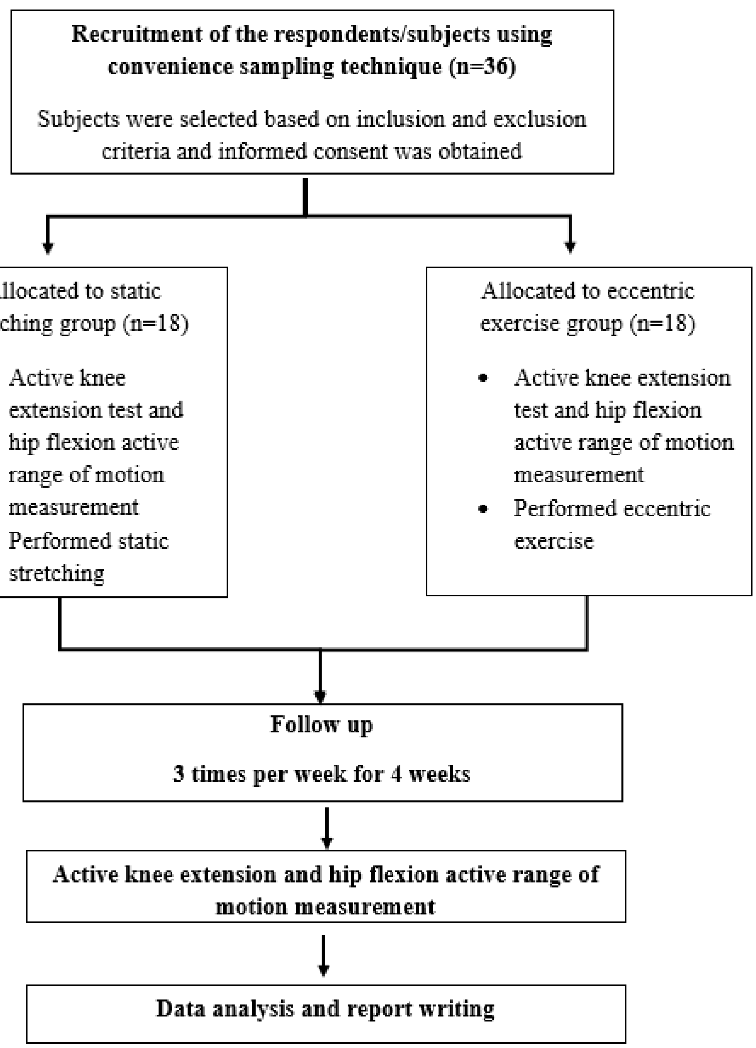

Figure 1. Flowchart of the study

Figure 2. Eccentric exercise

Table 1. The frequency and percentage of genders (n,%)

		Static stretching group	Eccentric exercise group	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Male	9	50	9	50
Female	9	50	9	50

Table 2. General characteristics of the subjects (Mean ± SD)

Characteristics	Static stretching group	Eccentric exercise group
Age (years)	21.17±1.47	20.83±1.20
Height (cm)	164.00±8.94	164.22±8.66
Weight (kg)	69.94±14.70	69.83±19.18
BMI (kg/m^2)	25.81±3.86	25.14±5.13

Note: Mean±standard deviation, BMI; body mass index

Table 3. Comparison of AKET and hip flexion AROM pre- and post-intervention

	Static stretching group			Eccentric exercise group		
	Pre	Post	*p*	Pre	Post	*P*
AKET (Degree)	143.89±7.15	146.83±8.62	0.001	145.06±8.32	148.28±8.44	0.001
Hip flexion AROM (Degree)	83.39±4.91	87.89±6.81	0.001	82.94±6.41	86.83±6.60	0.001

Note: Mean±standard deviation, AKET; active knee extension test, hip flexion AROM; hip flexion active range of motion

Table 4. Comparison of AKET and hip AROM between groups

		Static stretching group	Eccentric exercise group	t	*p*
AKET (Degree)	Pre	143.89±7.15	145.06±8.32	-0.45	0.66
	Post	146.83±8.62	148.28±8.44	-0.51	0.62
Hip Flexion AROM (Degree)	Pre	83.39±4.91	82.94±6.41	0.23	0.82
	Post	87.89±6.81	86.83±6.60	0.47	0.64

Note: Mean±standard deviation, AKET; active knee extension test, hip flexion AROM; hip flexion active range of motion

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