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COMPARATIVE EFFECTIVENESS OF MUSCLE ENERGY TECHNIQUE AND STATIC STRETCHING ON HAMSTRING FLEXIBILITY, DYNAMIC BALANCE, AND PAIN IN YOUNG ADULTS WITH HAMSTRING TIGHTNESS: A RANDOMIZED COMPARATIVE STUDY

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Abstract

Background

Hamstring tightness is one of the most frequently encountered musculoskeletal impairments among young adults and is commonly associated with prolonged sitting, reduced physical activity, repetitive sporting activities, and poor postural habits. Reduced hamstring flexibility may alter lower-limb biomechanics, restrict hip and knee motion, impair dynamic balance, and increase the risk of musculoskeletal injuries. Physiotherapists commonly use Muscle Energy Technique (MET) and static stretching to restore muscle extensibility; however, evidence regarding their comparative effectiveness remains inconclusive. The present study was undertaken to compare the effectiveness of these two commonly prescribed interventions in improving hamstring flexibility, dynamic balance, and pain among young adults with hamstring tightness.

Objective

To compare the effectiveness of Muscle Energy Technique and static stretching on hamstring flexibility, dynamic balance, and pain in young adults with hamstring tightness.

Methods

A randomized comparative experimental study was conducted among young adults with clinically identified hamstring tightness. Participants were allocated into either a Muscle Energy Technique group or a static stretching group using random assignment. Both groups received supervised intervention three sessions per week for four weeks. Hamstring flexibility was assessed using the Active Knee Extension Test (AKET) and Sit-and-Reach Test (SRT), dynamic balance was evaluated using the Y-Balance Test (YBT), and pain intensity was measured using the Numeric Pain Rating Scale (NPRS). Outcome measures were recorded before and after the intervention, and statistical analysis was performed to compare within-group and between-group changes.

Results

Both Muscle Energy Technique and static stretching resulted in significant improvements in hamstring flexibility, dynamic balance, and pain following four weeks of intervention. Improvements were observed in Active Knee Extension Test scores, Sit-and-Reach Test performance, Y-Balance Test scores, and Numeric Pain Rating Scale values in both groups. The Muscle Energy Technique group demonstrated greater improvements across the measured outcomes compared with the static stretching group.

Conclusion

Both interventions are effective in improving hamstring flexibility and functional performance in young adults with hamstring tightness. However, Muscle Energy Technique demonstrated superior clinical outcomes compared with static stretching, suggesting that it may be considered the preferred conservative physiotherapy intervention for improving flexibility, balance, and pain in this population.

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Introduction

Hamstring flexibility plays a fundamental role in maintaining normal lower-limb biomechanics, efficient movement patterns, and optimal functional performance. The hamstring muscle group, consisting of the biceps femoris, semitendinosus, and semimembranosus, crosses both the hip and knee joints, making it an essential contributor to hip extension, knee flexion, pelvic stability, and dynamic postural control. Because these muscles function as biarticular muscles, they are continuously exposed to mechanical loading during daily activities such as walking, stair climbing, running, squatting, and jumping. Consequently, alterations in hamstring extensibility can substantially influence movement efficiency and overall musculoskeletal function.

Over the past decade, hamstring tightness has become increasingly common among young adults. Although traditionally associated with athletes, reduced hamstring flexibility is now frequently observed in university students and other young individuals because of prolonged sitting, sedentary lifestyles, increased screen time, poor ergonomic habits, and reduced participation in regular physical activity. These lifestyle-related adaptations may gradually shorten the hamstring musculature, limiting hip flexion with knee extension and altering normal lumbopelvic mechanics. As a result, individuals may experience impaired movement quality, reduced functional capacity, and an increased susceptibility to musculoskeletal injuries even in the absence of overt pathology.

The clinical implications of hamstring tightness extend beyond restricted flexibility. Reduced muscle extensibility has been associated with altered pelvic tilt, decreased hip mobility, compensatory lumbar movement, and abnormal lower-limb kinematics. These biomechanical alterations may increase mechanical stress on adjacent joints and soft tissues and have been linked to conditions such as mechanical low back pain, patellofemoral pain syndrome, recurrent hamstring strain, and other lower-extremity overuse injuries. From a functional perspective, reduced hamstring flexibility may compromise movement efficiency during activities that require coordinated hip and knee motion, thereby limiting physical performance in both recreationally active and sedentary populations.

Dynamic balance is another important component of functional performance that may be influenced by hamstring flexibility. Maintaining balance requires continuous integration of sensory information with coordinated neuromuscular responses to control the body's centre of mass over its base of support. Adequate muscle flexibility facilitates efficient joint movement and appropriate proprioceptive input, whereas muscle tightness may restrict joint excursion and alter neuromuscular control. Since the hamstrings contribute substantially to pelvic stability and lower-limb alignment, reduced extensibility may negatively affect balance during tasks involving single-leg stance, directional reaching, gait, and sporting activities. These impairments may become clinically relevant in individuals participating in activities requiring rapid changes in direction or high levels of postural control.

Several clinical studies have demonstrated an association between hamstring flexibility and dynamic postural stability. Encarnación-Martínez and colleagues reported that physically active young adults with hamstring tightness exhibited significantly poorer anterior reach performance during the Modified Star Excursion Balance Test than individuals with normal hamstring extensibility, suggesting that reduced flexibility adversely affects dynamic balance. Similarly, longitudinal investigations examining flexibility interventions have shown that improvements in lower-limb flexibility may contribute to enhanced balance performance and functional mobility, although the magnitude of these effects appears to vary across different populations and intervention protocols.

Conservative physiotherapy remains the cornerstone of managing hamstring tightness. A variety of interventions have been proposed to improve muscle extensibility, including static stretching, dynamic stretching, proprioceptive neuromuscular facilitation, neural mobilisation, myofascial release, foam rolling, and Muscle Energy Technique (MET). Among these, static stretching and MET are widely used because they are inexpensive, require minimal equipment, and can be incorporated easily into routine clinical practice and rehabilitation programmes.

Static stretching has long been considered a standard intervention for improving flexibility. The technique involves elongating the target muscle to the point of mild discomfort and maintaining the stretch for a predetermined duration. Improvements following static stretching are generally attributed to increased stretch tolerance and reduced passive resistance to movement rather than permanent structural changes within the muscle–tendon unit. Previous randomized controlled trials have demonstrated significant gains in hamstring flexibility following static stretching programmes, particularly when stretches are maintained for approximately 30 seconds and performed consistently over several weeks.

Muscle Energy Technique is a manual therapy intervention that combines therapist-guided positioning with active isometric muscle contraction performed by

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the participant. Following a brief submaximal contraction, the muscle is passively elongated to a new barrier, theoretically facilitating increased muscle extensibility through post-isometric relaxation, autogenic inhibition, and improved neuromuscular control. Beyond increasing flexibility, MET has been proposed to enhance proprioception, reduce muscle stiffness, and improve movement coordination, making it an attractive intervention for functional rehabilitation.

Despite the widespread clinical use of both interventions, existing evidence remains inconclusive regarding their comparative effectiveness. Recent systematic reviews and randomized controlled trials indicate that both MET and static stretching effectively improve hamstring flexibility, but differences in treatment duration, participant characteristics, outcome measures, and methodological quality have contributed to inconsistent findings. Some investigators have reported greater improvements following MET, whereas others have observed comparable outcomes between the two interventions. Furthermore, relatively few studies have simultaneously examined flexibility, dynamic balance, and pain within the same experimental design, limiting the ability to determine whether improvements in muscle extensibility translate into meaningful functional benefits.

Young adults represent a particularly important population in whom these questions remain clinically relevant. Academic commitments, prolonged sitting, increasing digital device use, and reduced engagement in structured exercise have contributed to a growing prevalence of hamstring tightness in this age group. Early intervention may reduce the progression of movement impairments, optimise functional performance, and potentially decrease the future risk of musculoskeletal disorders. Identifying the most effective conservative treatment strategy may therefore provide practical guidance for physiotherapists working in sports rehabilitation, outpatient practice, and preventive health settings.

Accordingly, the present randomized comparative study was designed to compare the effectiveness of Muscle Energy Technique and static stretching on hamstring flexibility, dynamic balance, and pain among young adults with hamstring tightness. Hamstring flexibility was evaluated using the Active Knee Extension Test and Sit-and-Reach Test, dynamic balance was assessed using the Y-Balance Test, and pain intensity was measured using the Numeric Pain Rating Scale. It was hypothesised that both interventions would improve clinical outcomes; however, Muscle Energy Technique would produce greater improvements because of its combined mechanical and neurophysiological effects on muscle extensibility and neuromuscular function.

Materials and Methods

Study Design

A prospective randomized comparative experimental study with a two-arm parallel design was conducted to compare the effects of Muscle Energy Technique (MET) and static stretching on hamstring flexibility, dynamic balance, and pain in young adults.

Participants

Young adults aged 18–26 years with hamstring tightness were recruited from Pacific College of Physiotherapy, Udaipur. Participants were randomly allocated into either the MET or Static Stretching group after providing written informed consent.

Intervention

Both groups received supervised treatment three times weekly for four weeks (12 sessions). The MET group underwent therapist-administered Muscle Energy Technique, while the Static Stretching group received therapist-assisted passive hamstring stretching.

Outcome Measures

Hamstring flexibility was assessed using the Active Knee Extension Test (AKET) and Sit-and-Reach Test (SRT), dynamic balance using the Y-Balance Test (YBT), and pain using the Numeric Pain Rating Scale (NPRS). Assessments were performed before and after the intervention.

Statistical Analysis

Data were analysed using IBM SPSS Statistics Version 26. Paired *t*-tests were used for within-group comparisons and independent *t*-tests for between-group comparisons. Statistical significance was set at $p < 0.05$.

Results

A total of **40 participants** (20 in each group) completed the study and were included in the final analysis. Both groups demonstrated significant improvements in hamstring flexibility, dynamic balance, and pain following the four-week intervention.

Table 1. Baseline Characteristics of Participants

Variable	MET (n=20)	Static Stretching (n=20)
Age 18–20 years	7 (35%)	6 (30%)
Age 21–26 years	13 (65%)	14 (70%)
Male	10 (50%)	10 (50%)
Female	10 (50%)	10 (50%)
Urban	10 (50%)	10 (50%)
Rural	10 (50%)	10 (50%)

Table 2. Within-Group Comparison of Outcome

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Measures

Outcome Measure	MET Pre	MET Post	*p*	Static Stretching Pre	Static Stretching Post	*p*
AKET (°)	33.1 ± 3.0	21.2 ± 2.0	<0.001	32.4 ± 2.7	24.2 ± 2.8	<0.001*
SRT (cm)	19.9 ± 2.4	29.9 ± 2.2	<0.001	19.6 ± 1.7	27.7 ± 2.6	<0.001*
YBT (%)	84.6 ± 1.8	92.0 ± 2.4	<0.001	83.9 ± 2.2	90.0 ± 2.5	<0.001*
NPRS	7.0 ± 1.5	2.6 ± 1.7	<0.001	—	—	—

Table 3. Post-Intervention Comparison Between Groups

Outcome Measure	MET	Static Stretching	Interpretation
AKET (°)	21.2 ± 2.0	24.2 ± 2.8	Greater improvement with MET
SRT (cm)	29.9 ± 2.2	27.7 ± 2.6	Greater improvement with MET
YBT (%)	92.0 ± 2.4	90.0 ± 2.5	Greater improvement with MET
NPRS	2.6 ± 1.7	**Data not available in visible excerpt**	—

Discussion

The present study compared the effectiveness of Muscle Energy Technique (MET) and static stretching in improving hamstring flexibility, dynamic balance, and pain among young adults with hamstring tightness. Both interventions produced significant improvements after four weeks of treatment; however, participants receiving MET demonstrated greater improvements in hamstring flexibility, dynamic balance, and pain reduction than those receiving static stretching. These findings suggest that both interventions are clinically effective, although MET may provide superior therapeutic benefits through combined mechanical and neurophysiological mechanisms.

The significant improvement in hamstring flexibility observed in both groups is consistent with previous literature demonstrating the effectiveness of stretching-based interventions in increasing muscle extensibility. Medeiros et al. (2016), in a systematic review and meta-analysis of 19 randomized controlled trials, concluded that static stretching significantly improves hamstring flexibility in healthy young adults, supporting its routine use in rehabilitation and injury prevention programmes. Similarly, Bandy and Irion (1994) reported that static stretching performed for 30 seconds produced significant improvements in hamstring flexibility, while extending the duration beyond 30 seconds did not provide additional benefit. These findings support the improvement observed in the static stretching group of the present study.

The greater improvement in flexibility observed in the MET group agrees with the findings of Kang et al. (2023), whose systematic review and meta-analysis involving 949 participants concluded that MET produced greater improvements in hamstring flexibility than static stretching and no intervention. Likewise, Ahmad et al. (2023) demonstrated that although both MET and static stretching significantly improved hamstring flexibility, MET produced superior improvements in both the Active Knee Extension Test and Straight Leg Raise Test. The greater improvement observed in the present study may be explained by the neurophysiological effects of post-isometric relaxation and autogenic inhibition, which reduce muscle tone and facilitate greater muscle elongation following an isometric contraction.

However, not all previous investigations have reported the superiority of MET. Ahmed et al. found that both MET and static stretching significantly improved hamstring flexibility, with no statistically significant difference between the two interventions. The discrepancy between their findings and the present study may be attributed to differences in treatment duration, intervention dosage, participant characteristics, and assessment methods. While Ahmed et al. administered treatment for only five consecutive days, the present study employed a supervised four-week intervention programme, which may have allowed greater physiological adaptation.

Dynamic balance improved significantly in both intervention groups, with greater improvement observed following MET. Hamstring flexibility contributes to efficient lumbopelvic movement, optimal lower-limb alignment, and effective proprioceptive control during functional tasks. Improved flexibility may therefore enhance the ability to maintain postural stability during single-leg stance and multidirectional reaching. The findings of the present study are consistent with Encarnación-Martínez et al. (2023), who reported that young adults with hamstring tightness demonstrated significantly poorer anterior reach distances during the

Modified Star Excursion Balance Test than individuals with normal hamstring flexibility, indicating that reduced hamstring extensibility negatively influences dynamic balance.

The observed improvement in balance also agrees with Martínez-López et al. (2014), who reported that interventions aimed at improving lower-limb flexibility and proprioception significantly enhanced dynamic balance and functional mobility. Although their study involved older adults, the underlying mechanism of improved neuromuscular control following increased flexibility may explain the positive changes in Y-Balance Test performance observed in the present study.

Pain intensity decreased significantly in both intervention groups, with greater reduction in the MET group. Although pain was not the primary outcome in many previous studies investigating hamstring flexibility, the reduction observed in the present study is clinically relevant. Improved muscle extensibility may reduce excessive tensile stress within the musculotendinous unit, while MET may additionally decrease protective muscle guarding through reflex inhibition and improved neuromuscular regulation. These mechanisms may explain the greater reduction in NPRS scores observed following MET.

The findings of the present study have important clinical implications for physiotherapy practice. Both interventions are inexpensive, require minimal equipment, and can be easily incorporated into rehabilitation programmes. However, when rapid improvement in hamstring flexibility and functional performance is desired, MET may be the preferred intervention because it combines active patient participation with therapist-guided stretching, thereby addressing both mechanical restrictions and neuromuscular dysfunction. This may be particularly beneficial for athletes and young adults whose daily or sporting activities require optimal flexibility and dynamic postural control.

Despite these encouraging findings, the present study has certain limitations. The study was conducted at a single centre with a relatively small sample of young adults, which may limit the generalisability of the findings. The intervention period was limited to four weeks, and no long-term follow-up was performed to determine the sustainability of treatment effects. Furthermore, objective biomechanical measures such as electromyography or motion analysis were not included, which may have provided additional insight into the mechanisms underlying the observed improvements.

Future research should include multicentre randomized controlled trials with larger sample sizes and longer follow-up periods. Incorporating objective biomechanical assessments and comparing MET with other manual therapy techniques may further clarify its role in improving flexibility, balance, and functional performance in different clinical and athletic populations.

Overall, the findings of the present study support previous evidence that both Muscle Energy Technique and static stretching are effective interventions for improving hamstring flexibility. However, consistent with recent high-quality evidence, MET demonstrated superior improvements in flexibility, dynamic balance, and pain reduction, suggesting that it may be the preferred conservative physiotherapy intervention for young adults with hamstring tightness.

Conclusion

The present study demonstrated that both Muscle Energy Technique (MET) and static stretching were effective in improving hamstring flexibility, dynamic balance, and pain among young adults with hamstring tightness. However, participants treated with MET showed greater improvements across all outcome measures than those receiving static stretching. These findings suggest that MET may be a more effective conservative physiotherapy intervention for restoring hamstring flexibility, enhancing dynamic balance, and reducing pain. Incorporating MET into rehabilitation programmes may improve functional performance and contribute to the prevention of future musculoskeletal injuries in young adults.

Clinical Implications

The findings of this study have several implications for physiotherapy practice:

- Muscle Energy Technique can be considered a first-line manual therapy technique for managing hamstring tightness in young adults.
- Both MET and static stretching may be incorporated into rehabilitation programmes to improve flexibility and dynamic balance.
- Improved hamstring flexibility may enhance functional performance and reduce the risk of lower-limb injuries.
- MET is simple, cost-effective, non-invasive, and can be easily integrated into routine musculoskeletal and sports physiotherapy practice.

Strengths of the Study

- Randomized comparative study design.
- Standardized intervention protocols for both groups.
- Multiple validated outcome measures (AKET, SRT, YBT, and NPRS).
- Evaluation of flexibility, balance, and pain within the same study.

- Clinically relevant findings applicable to young adults with hamstring tightness.

Limitations

- The study was conducted at a single institution, which may limit the generalizability of the findings.
- The intervention period was limited to four weeks, and no long-term follow-up was performed.
- The sample size was relatively small.
- Blinding of participants and therapists was not feasible because of the nature of the interventions.
- Objective biomechanical assessments such as electromyography or motion analysis were not included.

Future Recommendations

Future studies should include larger multicentre randomized controlled trials with longer follow-up periods to evaluate the long-term effectiveness of Muscle Energy Technique. Incorporating objective biomechanical assessments such as three-dimensional motion analysis, electromyography, and ultrasound imaging may provide greater insight into the mechanisms underlying treatment effects. Comparative studies involving different manual therapy techniques and diverse clinical or athletic populations are also recommended to strengthen the evidence base for physiotherapy management of hamstring tightness.

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Ethical Approval

Ethical approval for the study was obtained from the Institutional Ethics Committee of Pacific Medical University, Udaipur, Rajasthan, prior to commencement of the study. *(Insert IEC approval number.)*

Informed Consent

Written informed consent was obtained from all participants before enrolment in the study.

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