

Immediate and Short-term Effects of Neurodynamic Sliding Technique on Hamstring Flexibility and Balance in Community-dwelling Older Adults: An Interventional Study

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ABSTRACT

Introduction: Age-related reduction in motor strength, the processing of the neural signals, and sensory function has an effect on postural control and mobility. Hamstring tightness is a commonly observed musculoskeletal impairment in the elderly, which plays a crucial role in maintaining stability, smooth movement, and balance. Hence, it is thought that the interventions that target Flexibility and neuromuscular function may improve balance and reduce the risk of falls. Neural Mobilisation (NM) has been reported to increase hamstring flexibility by reducing neural mechanosensitivity and also by restoring ideal physiological functions of the musculoskeletal system.

Aim: To determine the short-term effects of neurodynamic sliding techniques on hamstring flexibility and balance in elderly individuals.

Materials and Methods: An interventional study was conducted at the Department of Neurophysiotherapy, Karnataka Lingayat Education Society (KLE) College of Physiotherapy, Hubballi, Karnataka, India, from November 2025 to March 2026. A total of 104 community-dwelling participants of the age group 60-75 years were enrolled using convenient sampling. Inclusion criteria included physically independent individuals with bilateral

hamstring tightness, defined as a passive straight-leg raise of less than 70 degrees. Outcome measures were passive SLR for assessing hamstring flexibility and the Functional Reach Test for balance assessment. Readings were taken before and immediately after intervention. After two days, follow-up, post-intervention assessments were conducted. Data was not normally distributed for all the outcome measures, so, non parametric tests were applied for within-group analysis. Friedman's test was used for analysis of the intervention group for pre, post and after 2 days test. Data was analysed at 5% level of significance with a Confidence Interval (CI) at 95%.

Results: The mean age of the study participants was 66.6±3.6 years. The findings showed that neurodynamic sliding techniques have a statistical significant improvement on both hamstring flexibility and balance. Also, these effects were sustained at a follow-up after two days.

Conclusion: Neurodynamic sliding techniques seem to be an effective intervention for short term improvement of flexibility and balance in the elderly and may be recommended as a treatment approach to reduce fall risk and enhance functional mobility in elderly.

Keywords: Elderly, Flexibility, Neural sliding technique, Postural stability

INTRODUCTION

There is an increase in the ageing population globally, with the number of individuals of 60 years and above expected to increase from 688 million in 2006 to nearly 2 billion by 2050, representing almost 22% of the total global population [1]. This ageing is accompanied by significant physiological changes, including reduced muscle mass, strength, mobility, and balance, which increase the risk of falls. Amongst these changes, poor postural balance is a strong predictor of falls, which cause fatal and non fatal injuries in older adults [1].

Balance and gait are essential for the health of the elderly. Around 13% to 46% of older adults experience balance issues, with the incidence increasing with age [2]. Gait disorders are prevalent in about 35% of adults aged 70 and above [3]. The decline in strength, neural processing speed, and sensory receptor function contributes to impaired postural control and reflexive motion. Both intrinsic factors (such as aging, muscle strength, and vision) and extrinsic factors (such as environmental risks) play a role in falls [4]. While some of these factors are unmodifiable, interventions like balance and strength training can improve stability and reduce fall risks [4-6].

Muscle tightness, mainly in the hamstrings, is common with ageing. The hamstrings play a critical role in balance and posture by stabilising the trunk and supporting movement [7]. Tight hamstrings can reduce flexibility, limit range of motion, and impair balance due to altered neurodynamics. Flexibility, which involves the ability to move joints through pain-free ranges, is essential for functional movement and injury prevention [8]. Reduced flexibility of the hamstrings can result from restricted mobility of the sciatic and tibial nerves, adding to poor postural control [9].

Balance requires both voluntary movement and reflexive muscle reactions. Musculoskeletal flexibility and proper posture are key to maintaining stability. With age, the visual, somatosensory, and vestibular systems undergo changes that diminish the body's capacity to provide balance, escalating the risk of falls [10]. Several stretching techniques, including static, dynamic, and Proprioceptive Neuromuscular Facilitation (PNF), are used to improve flexibility, but older muscles are more prone to injury and slower to recover [11]. Thus, it is important to modify the interventions to the elderly's specific needs.

One promising approach is Neural Mobilisation (NM), or nerve glide stretches, which aim to improve hamstring flexibility by reducing neural mechanosensitivity and restoring optimal physiological

function [12]. NM involves actively stretching neural tissues, which helps maintain a balance between neural and surrounding mechanical interfaces. This technique has shown potential benefits in improving flexibility, pain relief, and muscle strength in older adults [13].

In clinical settings, balance is often assessed using tools like the Timed "Functional Reach Test" (FRT) [14] and goniometers to measure flexibility [15,16]. While neurodynamic interventions have been shown to improve flexibility and strength, fewer studies have assessed their impact on balance. Therefore, the present study aimed to evaluate the short-term effects of neural sliding techniques on hamstring flexibility and balance in the elderly, using passive knee extension and the Functional Reach Test to assess outcomes.

MATERIALS AND METHODS

An interventional study was conducted at the Department of Neurophysiotherapy, KLE College of Physiotherapy, Hubballi, Karnataka, India, from November 2025 to March 2026. Ethical clearance was granted by the Ethics Committee of Jagadguru Gangadhar Mahaswamigalu Moorusavirmath Medical College (JGMMMC) (Ref No: JGMMMC/IEC/136/2025).

Sample size calculation: A total of 104 community-dwelling individuals aged between 60 to 75 years were recruited based on sample size estimation using G*Power software version 3.1.9.4. The sample size was calculated with reference to a previous study by Park J et al., [14] which reported pre-test Range of Motion (ROM) values of 79.00 ± 4.50 and post-test values of 91.67 ± 6.74 , with $\alpha=0.05$ and $\beta=0.2$ to achieve 95% confidence and 80% power.

Inclusion criteria: Males and females aged 60-75 years, physically independent and demonstrated bilateral hamstring tightness, defined as a passive Straight-Leg Raise (SLR) of less than 70 degrees. Participants were required to follow commands and be willing to participate.

Exclusion criteria: Any neurological condition, recent lower limb or spinal surgery (within six months), orthopaedic disorders such as low back pain or severe osteoarthritis with deformity or fracture (within one year), individuals undergoing balance training, and those requiring assistive devices.

Study Procedure

Demographic parameters considered were age and Body Mass Index (BMI). BMI was classified as per the World Health Organisation (WHO) classification [17]. Following informed consent, participants were screened and assessed as per the inclusion and exclusion criteria. Baseline measurements for hamstring flexibility and balance were recorded using a universal goniometer and yardstick, among other tools. Participants then received a standardised neurodynamic sliding intervention comprising two distal sliders for each leg, performed in supine lying with hip flexion and ankle dorsiflexion. The technique involved 15 repetitions per set across three sets with 10-second rest intervals. Readings were taken before and immediately after intervention. After two days, follow-up, post-intervention assessments were conducted using the same tools and procedures to evaluate changes in hamstring flexibility and balance.

Two primary outcome measures were used to assess the intervention's effectiveness: the Passive Straight Leg Raise (SLR) Test and the Functional Reach Test (FRT). The Passive SLR Test evaluated hamstring flexibility by measuring hip joint flexion ROM with a universal goniometer. Participants lay supine with the pelvis and trunk stabilised on the plinth, and the dominant leg aligned along the bed's edge. The goniometer axis was positioned at the greater trochanter, with one arm parallel to the bed and the other aligned along the fibular head to the lateral malleolus. The hip was passively flexed with the knee and ankle extended, stopping at the point of first posterior thigh pain without hip rotation. This test demonstrated

high reliability, with Intraclass Correlation Coefficients (ICCs) ranging from 0.95 to 0.98 [18].

The Functional Reach Test (FRT) was used to assess dynamic balance²⁰. Participants stood close to a wall, raised one arm to 90° shoulder flexion with a closed fist, and were asked to "reach as far as you can forward without taking a step." The distance between the starting and ending positions of the 3rd metacarpal head was measured using a yardstick. After two practice trials, three test trials were conducted, and the average of the three was recorded. The test duration was approximately five minutes and demonstrated excellent reliability (ICC=0.99) [19]. The test was stopped if the participant's feet lifted or balance was lost, with a therapist guarding from the front for safety.

STATISTICAL ANALYSIS

The information was entered into an Excel spreadsheet, and the analysis was performed using Statistical Package for Social Sciences (SPSS) version 20.0. Descriptive statistics were computed, including the average age and BMI. All the outcome measures were analysed at baseline, at the end of the intervention and 2 days after the intervention using appropriate statistical tests. Data was not normally distributed for all the outcome measures, so, non parametric tests were applied for within-group analysis. Friedman's two way analysis was used for analysis of intervention group for pre, post and after 2 days test. Data was analysed at 5% level of significance with a Confidence Interval (CI) at 95%.

RESULTS

The mean and standard deviation of age and BMI of 104 subjects enrolled in the study is shown in [Table/Fig-1]. Out of the total 104 participants, 46 (44.2%) were males and 58 (55.8%) were females.

Variables	No. of subjects	Mean±SD
Age	104	66.6±3.6 (67-Median)
BMI	104	31.16±4.01

[Table/Fig-1]: Baseline data

SD: Standard Deviation; BMI: Body Mass Index

The above table shows the median and interquartile range of Right ROM (RT ROM). The RT ROM pre, post, follow-up has a median value of 63.5, 70 and 70. And RT ROM pre, post, follow-up has a IQR value of 7, 6, 8 [Table/Fig-2].

Variables	Number	Median	Interquartile range
RT ROM (degree) pre	104	63.5	7
RT ROM (degree) post	104	70.0	6
RT ROM (degree) follow-up	104	70.0	8

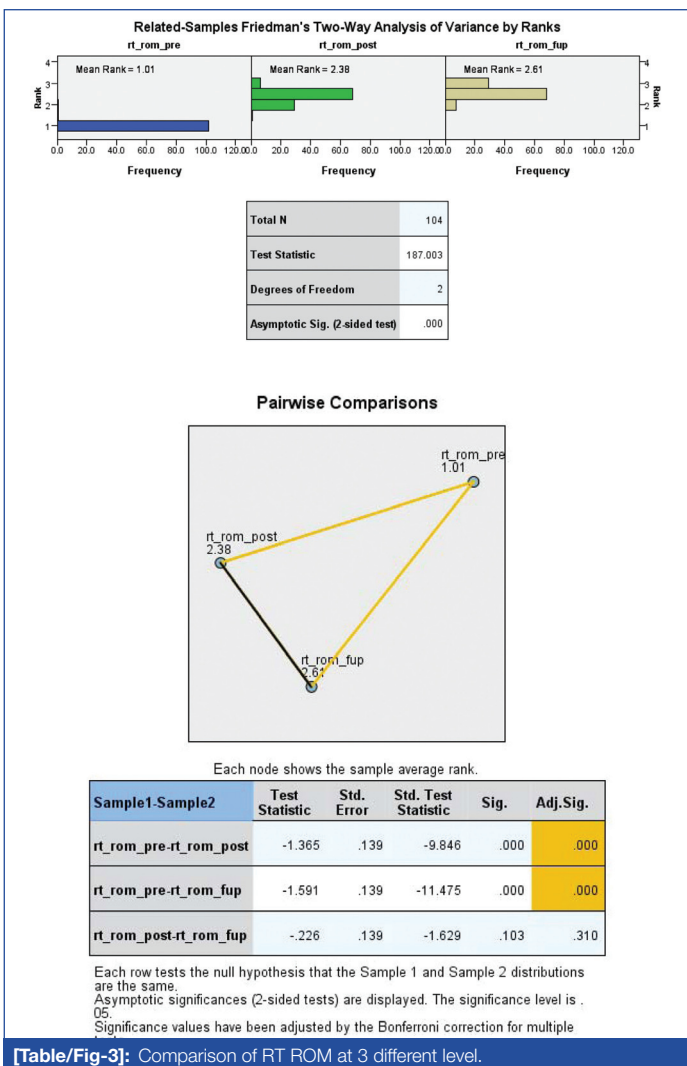
[Table/Fig-2]: Median and interquartile range of right ROM.

ROM- range of motion RT- right

The variables RT ROM - pre, post, and follow-up were tested using non parametric test called Friedman's test as these quantitative variables were not normally distributed and they were matched. The results show that significant differences were found between pre - post as the p-value was <0.001 and pre - follow-up as the p-value was <0.001; whereas the difference between post and follow-up was not significant (p-value=0.310) [Table/Fig-3].

The above table depicts the median and interquartile range of Left (LT) ROM. The LT ROM pre, post, follow-up has a median value of 65, 70 and 70. And LT ROM pre, post, follow-up has a IQR value of 5, 5, 5 [Table/Fig-4].

The variables LT ROM - pre, post, and follow-up were tested using non parametric test called Friedman's test as these quantitative variables were not normally distributed and they were matched. The results show that significant differences were found between pre - post as the p-value was <0.001 and pre - follow-up as the p-value was <0.001; whereas the difference



[Table/Fig-3]: Comparison of RT ROM at 3 different level.

Variables	Number	Median	Interquartile range
LT ROM (degree) pre	104	65.0	5
LT ROM (degree) post	104	70.0	5
LT ROM (degree) follow-up	104	70.0	5

[Table/Fig-4]: Median and interquartile range of LT ROM.
LT: Left ROM: Range of motion

between post and follow-up was not significant (p-value=0.944) [Table/Fig-5].

The above table shows the median and interquartile range of FRT. The FRT pre, post, follow-up has a median value of 23, 29 and 29. And FRT pre, post, follow-up has a interquartile range value of 4, 5, 5 [Table/Fig-6].

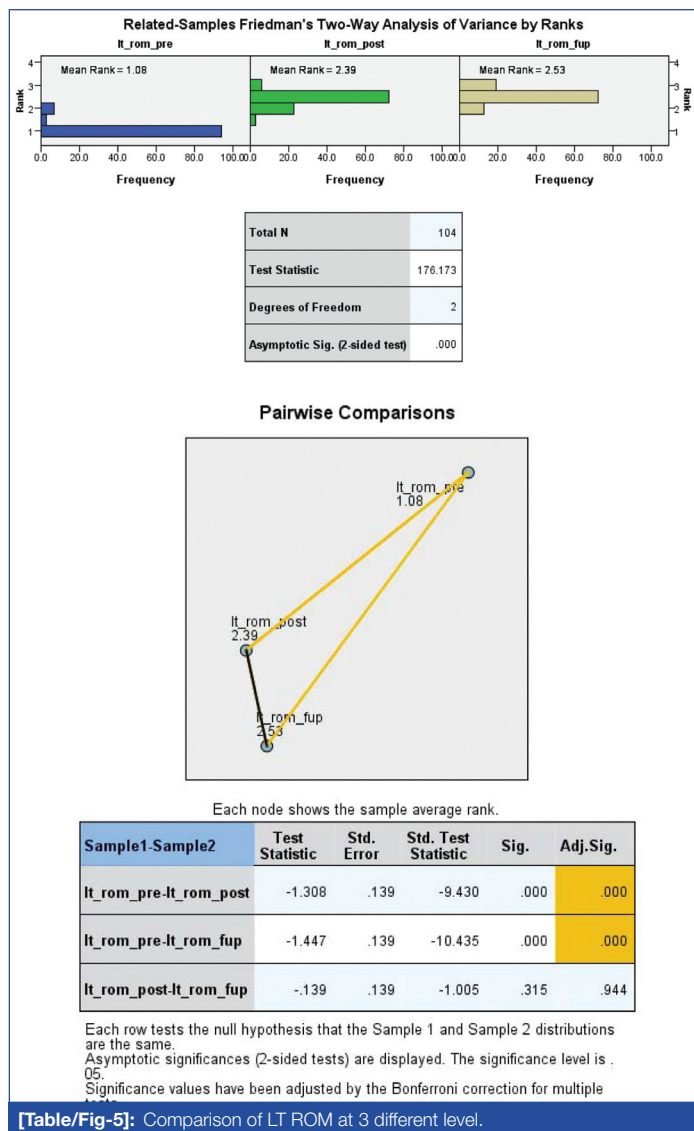
The variables FRT - pre, post, and follow-up were tested using non parametric test called Friedman's test as these quantitative variables were not normally distributed and they were matched. The results show that significant differences were found between pre - post as the p-value was <0.001 and pre- follow-up as the p-value was <0.001; whereas the difference between post and follow-up was not significant (p-value=0.061) [Table/Fig-7].

DISCUSSION

The present study was conducted to evaluate the effect of the neurodynamic sliding technique on hamstring flexibility and balance in the elderly. A total of 104 subjects were included in the study.

Outcome measures used in the present study were the passive SLR test and the Functional reach test.

The first objective of the present study was to study the effect of the neurodynamic sliding technique on hamstring flexibility by the passive SLR test in the elderly.



[Table/Fig-5]: Comparison of LT ROM at 3 different level.

Variables	Number	Median	Interquartile range
FRT pre	104	23.0	4
FRT post	104	29.0	5
FRT follow-up	104	29.0	5

[Table/Fig-6]: Median and interquartile range of FRT.

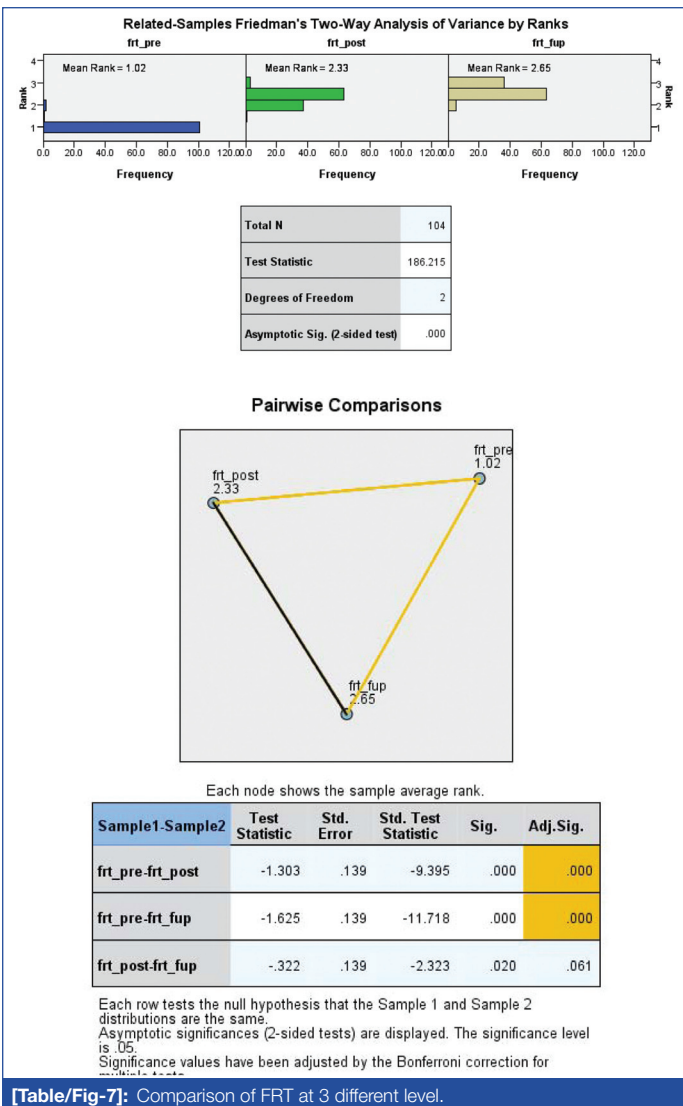
The present study has used passive straight leg rise test (with goniometer) to evaluate the hamstring flexibility in elderly. The reliability of this test is ICCs to be 0.95-0.98.

The mean baseline value for SLR with RT ROM was 62.57±5.05 and after neurodynamic sliding the mean value of RT ROM among participants was 68.605±4.805 and after 2 days the mean value is 69.09±4.90. The present study shows mean of RT ROM (p-value<0.05) was highly significant between pre, post and follow-up after 2 day.

The mean baseline value for SLR with LT ROM was 62.85±4.08 and after neurodynamic sliding the mean value of LT ROM among participants was 68.77±4.57 and after 2 days the mean value is 69.105±4.59. The present study shows mean of LT ROM (p-value<0.05) was highly significant between pre, post and follow-up after 2 day.

Neurodynamic mobilisation decreases the neural mechanosensitivity and may be a helpful technique in the management of hamstring flexibility [17,18].

Existing studies indicate that the neurodynamic sliding technique helps restore nervous system movement and elasticity by re-establishing axoplasmic flow and nerve tissue homeostasis [18]. Lower extremity neurodynamics which involve the integrated



biomechanical, physiological, and morphological functions of the nervous system affect resting muscle length and increase mechanosensitivity [20]. Therefore, in this study, the neurodynamic sliding technique may effectively enhance muscle flexibility.

Muragod AR et al., in 2017 conducted a study Effects of static stretching and neurodynamic mobilisation on hamstring flexibility in elderly population concluded that both the interventions were equally effective in elderly and that neural mobilisation can be recommended to elderly population as a home programme as it's easily performed and is comfortable than static stretching which includes holding limb in one position for a prescribed time [2].

Yolanda Castellote et al., conducted a study in 2014, immediate effects of neurodynamic sliding versus muscle stretching on hamstring flexibility in elderly has shown that neurodynamic sliding intervention improved hamstring flexibility as assessed by the passive SLR to a greater degree as compared to hamstring stretching in elderly [15].

The subsequent objective of the present study was to determine the effect of neurodynamic sliding technique on balance by functional reach test in elderly.

The present study has used Functional reach test to assess the balance in elderly. The reliability of this test is (ICC= 0.99) [21].

The mean baseline value for SLR with FRT was 23.03 ± 3.41 and after neurodynamic sliding the mean value of FRT among participants was 27.40 ± 3.42 and after 2 days the mean value is 27.83 ± 3.57 . The present study shows mean of FRT (p-value<0.05) was highly significant between pre, post and follow-up after 2 day.

Neural mobilisation may have a positive influence on older adults' pain, postural control, and flexibility (21). Therefore, to the authors

best available understanding, the neurodynamic sliding technique can be effective in enhancing balance ability in elderly.

Mateus A et al., in 2019 investigated the effects of a multimodal exercise program plus neural gliding on postural control, pain, and flexibility of Institutionalised older adults and found that neurodynamic sliding technique have a positive impact on pain intensity, balance and gait velocity [20]. Thus from this in present study, the authors can infer that balance improvement is a result of neurodynamic gliding.

Yogeshwar D and Sahoo T. conducted a randomised controlled trial in 2023 to investigate the immediate effects of sciatic neurodynamic slider and tensioner techniques on hamstring flexibility and postural balance in healthy adults. The study demonstrated that both neurodynamic slider and tensioner techniques significantly improved hamstring flexibility and postural balance immediately after the intervention [21].

In both clinical and general applications, the selection of treatment is influenced by aspects such as practical application, availability, and effectiveness. Neurodynamic sliding technique is safe and efficient for improving balance and hamstring flexibility in elderly people.

Limitation(s)

The study poses some limitations that may affect the validity and generalisability of its findings. Firstly, there was no long-term follow-up conducted after the cessation of the intervention, making it difficult to assess the lasting effects of the treatment. Secondly, the potential placebo effects experienced by the patients were not considered, which could have influenced the outcomes. Thirdly, the present study used a simple pre-post design, where each participant was compared to their own baseline to understand the short-term effects of the intervention. However, since there was no control group, it is difficult to confirm a direct cause-and-effect relationship. Future randomised controlled trials are required to strengthen and validate these findings.

CONCLUSION(S)

The present study shows that neurodynamic sliding technique shows short-term improvement in hamstring flexibility and balance in the elderly. Effects on flexibility and balance are sustained at the follow-up of 2 days. Hence, this treatment can be further recommended to treat hamstring flexibility and balance in the elderly.

Editorial disclosure: Prospective trial registration was not completed before participant enrolment. The journal recognize the unique clinical value of this data. Henceforth publication is permitted as an exception with transparent disclosure.

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