

## ORIGINAL RESEARCH

## REHABILITATION CARE

# Comparative effects of instrument assisted soft tissue mobilization and neurodynamic technique on lower extremity spasticity, range of motion, balance, and gait in chronic stroke patients

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## ABSTRACT

**Background & Objective:** Stroke is a medically characterized illness of sudden, focused neurological dysfunction caused by blood vessel derangement (e.g., infarction, hemorrhage) of the central nervous system. Various physical therapy modalities have been in use to mitigate the effects of stroke. This study was conducted to determine the comparative effects of instrument-assisted soft tissue mobilization (IASTM) and neurodynamic technique (NDT) on lower extremity spasticity, range of motion, balance, and gait in chronic stroke patients.

**Methodology:** A randomized clinical trial was done in the physiotherapy department of Allied Hospital, Faisalabad, in which 36 stroke patients, of both genders aged 45 to 60 years were included. Patients who had any other neuro-musculoskeletal disease were excluded. Patients were randomly divided into two groups; Group A received instrument-assisted, soft tissue mobilization and conventional physical therapy, while Group B received neurodynamic technique and conventional physiotherapy. Non-probability sampling technique was used. Data was collected on the baseline, at 4th week, and then at 8th week. Berg-Balance Scale (BBS), Modified Ashworth Scale (MAS), and goniometer tools were used for the assessment. The data were analyzed using SPSS version 25. The Mann-Whitney U test was used for between-group studies, and the Friedman test was used for within-group studies. A p-value less than or equal to 0.05 was considered significant.

**Results:** Both Instrumental-assisted soft tissue mobilization and neurodynamic technique have significant efficacy in improving lower extremity spasticity, range of motion, balance, and gait challenges in chronic stroke patients. Particularly, Soft Tissue Mobilization demonstrated a significantly increased therapeutic benefit, highlighting its potential as the primary treatment modality in this setting.

**Conclusion:** It is concluded that both techniques are effective but instrumental assisted soft tissue mobilization along with physiotherapy is more effective for spasticity, range of motion, balance, and gait in chronic stroke patients.

**Abbreviations:** BBS: Berg-Balance Scale, EMG: electromyogram, IASTM: instrument-assisted soft tissue mobilization, MAS: Modified Ashworth Scale, NDT: neurodynamic technique

**Keywords:** Balance; Gait; Instrument Assisted Soft Tissue Mobilization; Neurodynamic Technique; Stroke

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## 1. INTRODUCTION

Stroke has been described by the World Health Organization (WHO) as "rapidly experiencing clinical manifestations of confined or broad problems to neurological function."<sup>1</sup> A stroke is medically characterized illness of sudden, focused neurological dysfunction caused by blood vessel damage (infarction, hemorrhage) of the central nervous system, and in current clinical practice, neurological imaging is becoming more commonly used to identify the specific pattern of damage to the tissue.<sup>2</sup> Every year, more than fifteen million individuals worldwide suffer from stroke, in accordance to the WHO. Approximately five million of those individuals die and an additional five million are irreversibly crippled.<sup>3</sup> A stroke that is ischemic is triggered by insufficient oxygen and blood vessel delivery to the brain, whereas a stroke with hemorrhaging is triggered by hemorrhage or leaking vessels in the brain.<sup>4</sup>

Genetic factors influence both controllable and non-modifiable indicators of risk for stroke. Although hereditary incidence is proportionate to age, gender, and ethnicity, a variety of genetic processes can raise the possibility of stroke.<sup>5</sup> Major controllable risk variables for stroke include diabetes, high blood pressure, an absence of regular exercise, using drugs or alcohol, high cholesterol levels, food management, and heredity. These factors are critical since prompt and adequate medical care can lower the possibility of strokes in vulnerable patients.<sup>6</sup> Physiotherapists ought to become included earlier on and determine the amount of time they can devote to a patient. Even when accounting for the possible conflicting impact of illness severity, quick mobilization is linked with improved results. A randomized controlled trial of balance training with electromyogram-triggered functional electric stimulation (EMG-triggered FES) to enhance static balance, dynamic balance, and plantar muscle activation in individuals with stroke found promising outcomes.<sup>7</sup>

Instrumental aided soft tissue mobilization (IASTM) is a skillful myofascial technique used for soft-tissue therapy. It depends on the ideas of James Cyrix cross-friction massaging. IASTM is defined as "a skilled approach which entails the use of specialized tools for manipulating the layers of the skin, myofascial, muscles, and tendons through various straight pressure stroke strategies."<sup>8</sup> Research investigations additionally demonstrated that IASTM improves range of motion, muscle power, and sensation of pain after intervention.<sup>9</sup>

The term neurodynamic pertains to the interaction between different sections of the neurological system as well as how it has a link to the musculoskeletal system. The mobilisation of the neural system as an approach to physical pain therapy is referred to as neurodynamic in the sense intended here. The therapy and/or assessment is based on changing pain physiology by mechanical treatment of neural tissues and non-neural regions surrounding the nervous system's functions. This mobilization causes a variety of mechanical and biological responses in the nervous system. Neural sliding, pressurization, elongation, tension, and alterations in intraneural blood flow, axonal transport, and neural impulse motions are examples of such phenomena.<sup>10</sup> The goal of these therapy approaches is to bring back the neural system's disturbed homeostasis. Whenever it comes to ways for mobilizing the nervous system, there is a mechanical contrast between 'tensioning procedures' and 'sliding techniques.' Each attempt to mobilize the neurological system, but pulling approaches are linked with substantial rises in nerve strain, whilst sliding techniques can mobilize the nervous system despite significant increase in strain.<sup>11</sup>

This study addressed the critical need to optimize rehabilitation for chronic stroke patients by comparing the efficacy of Instrument Assisted Soft Tissue Mobilization and Neuro Dynamic Technique. By assessing their effects on spasticity, range of motion, balance, and gait, the research aims to provide evidence-based guidance for clinicians, leading to tailored interventions that enhance functional recovery and overall well-being. This could significantly contribute to improved rehabilitation strategies and quality of life for individuals grappling with post-stroke challenges.

## 2. METHODOLOGY

This randomized clinical trial was conducted with a sample size of 36 stroke patients, adding 20% dropouts, 18 in each group, with a 95% level of significance diagnosed by physicians through medical investigations.<sup>12</sup> Computer generated random number sampling method was used for randomization by using random numbers. The single-blind protocol was ensured by masking patients unaware of the treatment protocol being given to another treatment group. Subjects were selected from the Allied Hospital Faisalabad. This study was approved by the Medical Ethics Committee of the University of Lahore, which agreed to waive the requirement for informed consent. This study includes both genders with the age

between 45 to 65 years, onset period of 6 or greater months after being diagnosed as hemiplegic due to stroke as well as can stand on their own self for > 5 min by using Time up and go test.<sup>11,13</sup> Exclusion criteria were any co-morbidity such as malignancy, inflammatory rheumatologic disease, rheumatoid arthritis, etc. any kind of bruises or open wound on the lower limb, severe cognitive impairment, any cardiac issue as also spasticity within the last 1 month. The Berg balance scale, Modified Ashworth scale (MAS), and Goniometer were used.<sup>14</sup>

## 2.1. Intervention

Both groups received routine physical therapy as a baseline treatment, consisting of sessions held five times a week, each lasting 30 min. The routine physical therapy regimen included range of motion (ROM) exercises, stretching exercises, and strengthening exercises for the lower extremities. Additionally, all subjects underwent gait and balance training, which involved the use of a physio ball and walking in parallel bars.

### 2.1.1. Experimental Group A

Instrument-assisted soft tissue mobilization (IASTM) and conventional physical therapy were administered. The IASTM group received treatment five times a week for 15 min per session. IASTM was applied to the hamstring muscles and gastrocnemius muscles.<sup>15</sup>

### 2.1.2. Experimental Group B

Neurodynamic technique and conventional physical therapy were provided. The NDYT group received treatment five times a week for 15 min per session. Sciatic nerve dynamic technique and femoral nerve dynamic technique were applied.<sup>16</sup>

## 2.2. Statistical analysis

The data were analyzed using SPSS version 25. Quantitative variables were presented as mean  $\pm$  standard deviation, while qualitative variables were presented as frequency and percentage. After checking the normality of the data, which did not meet normal distribution criteria, the authors applied non-parametric tests. The Mann-Whitney U test was used for between-group studies, and the Friedman test was used for within-group studies. A p-value less than or equal to 0.05 was considered significant.

## 3. RESULTS

Table 1 shows demographic variables like age, height, weight, gender and affected side for both groups. The mean and standard deviation of age was  $50.94 \pm 12.47$  years for group A and  $54.44 \pm 5.46$  years for group B. The percentage of male gender in group A was 44.4% and in group B, it was 61.1%, while the percentage of female gender in group A was 55.6% and in group B it was 38.9%. In Group A; 72.2% were having right side

**Table 1: Descriptive statistics of demographic variables in both groups**

Variables	Group A	Group B	P-value
Age (years)	50.94 $\pm$ 12.47	54.44 $\pm$ 5.46	0.046
Height (feet)	5.53 $\pm$ 0.33	5.42 $\pm$ 0.31	0.051
Weight (kg)	71.83 $\pm$ 13.27	69.83 $\pm$ 14.02	0.063
Gender	Male	8 (44.4)	11 (61.1)
	Female	10 (55.6)	7 (38.9)
Affected Side	Right	13 (72.2)	9 (50.0)
	Left	5 (27.8)	9 (50.0)

*Data presented as mean  $\pm$  SD or n (%); P < 0.05 considered significant*

as affected side whereas in Group B; equal number of participants had each side affected.

After checking normality of study variables; it was found out that data was not normally distributed therefore; non-parametric statistical tests were used. Table 2 presented that 10 min walk test, MAS, berg balance scale, range of motion including hip flexion, extension, knee flexion, extension, ankle dorsi and planter flexion were checked for between group analyses through Mann Whitney U test. Result showed that there were no statistical differences at baseline between both groups ( $P > 0.05$ ) while after 4 weeks all variables showed significant differences among both groups ( $P < 0.05$ ) except MAS ( $> 0.05$ ) and all showed statistically significant differences after 8 weeks as  $P < 0.05$ .

Table 3 presented Friedman test analysis that was opted to assess within group analysis. Significant variations in variables over time within each group were indicated by  $P < 0.001$ . In order to compare the effectiveness of the intervention, mean ranks for each variable at each measurement period are provided in Table 3; for both Group A and Group B. Significant changes in variables were observed in both groups between the baseline and the fourth and eighth weeks, demonstrating that the interventions had improved the measured outcomes over time.

## 4. DISCUSSION

IASTM is a manual therapy technique using specialized tools to enhance soft tissue mobility and circulation. It helps break adhesions, improve flexibility, and facilitate muscle recovery.

**Table 2: Mann Whitney U test for all variables (between group analysis)**

Variables	Measurement time	Group A	Group B	P-value
<b>10 min walk test (m)</b>	Baseline	78.27 ± 6.54	77.83 ± 4.64	0.96
	4th weeks	76.67 ± 6.52	68.55 ± 3.77	0.00
	8th weeks	74.11 ± 6.62	59.88 ± 2.24	0.00
<b>Modified Ashworth scale</b>	Baseline	5.33 ± 0.48	5.33 ± 0.76	0.79
	4th weeks	4.77 ± 0.54	4.44 ± 0.98	0.37
	8th weeks	3.88 ± 0.67	2.22 ± 0.80	0.00
<b>Berg balance scale</b>	Baseline	21.50 ± 4.71	21.38 ± 4.79	0.96
	4th weeks	26.33 ± 4.48	36.38 ± 6.01	0.00
	8th weeks	21.38 ± 6.88	21.66 ± 7.41	0.00
<b>Hip flexion (Degrees)</b>	Baseline	21.38 ± 6.88	21.66 ± 7.41	0.83
	4th weeks	25.44 ± 6.26	46.38 ± 11.74	0.00
	8th weeks	37.66 ± 8.75	71.61 ± 13.66	0.00
<b>Hip extension (Degrees)</b>	Baseline	11.44 ± 4.39	10.33 ± 3.91	0.67
	4th weeks	17.77 ± 4.60	30.72 ± 6.29	0.00
	8 <sup>th</sup> weeks	21.77 ± 4.64	45.83 ± 3.53	0.00
<b>Knee flexion (Degrees)</b>	Baseline	25.44 ± 6.26	26.11 ± 6.50	0.74
	4th week	47.16 ± 6.08	80.00 ± 7.07	0.00
	8th week	88.33 ± 6.41	122.22 ± 11.27s	0.00
<b>Knee extension (Degrees)</b>	Baseline	27.00 ± 6.74	28.94 ± 6.06	0.40
	4th week	45.55 ± 7.64	77.88 ± 9.88	0.00
	8th week	85.50 ± 6.12	127.78 ± 11.90	0.00
<b>Ankle dorsiflexion (Degrees)</b>	Baseline	17.22 ± 3.96	18.44 ± 4.42	0.35
	4th week	22.94 ± 4.20	32.77 ± 7.55	0.00
	8th week	24.27 ± 4.68	51.55 ± 3.92	0.00
<b>Ankle plantar flexion (Degrees °)</b>	Baseline	17.72 ± 3.95	17.22 ± 4.62	0.10
	4th weeks	35.44 ± 6.96	61.16 ± 7.35	0.00
	8 <sup>th</sup> weeks	50.27 ± 6.52	78.88 ± 11.31	0.00

Data presented as mean ± SD or n (%); P < 0.05 considered significant

Neurodynamic techniques focus on mobilizing nerves to reduce tension and enhance neural function. These techniques aim to improve nerve gliding, alleviate restrictions, and restore mobility. Both groups show improvement in stroke patients according to the data. Similar results were reported in an investigation where they discovered that using IASTM as a therapy strategy, followed by use of the supplied insoles for shoes, improved bending in the ankle among adolescents.<sup>17</sup> Movements performed better in those who received IASTM than in those who received neuro dynamic technique when comparing the impact on the range of motion. According to research done in 2021 by Cho et al., IASTM is superior to self-

stretching for reducing muscle thickness and enhancing muscle flexibility because it works quickly to promote muscle flexibility.<sup>18</sup> Additionally, the current study demonstrates that improving muscular spasticity only requires an eight-week IASTM intervention. An earlier study with similar findings revealed that the flexion, extension and inversion were enhanced after a four-week course of procedures as well as that it is advantageous to those with a flexed foot.<sup>19</sup> In contrast, Guimaraes et al. found that in comparison with people, which received no therapy, 6 weeks of training for lower-extremity muscles in adulthood had no appreciable effect on enhancing active flexion range of motion. The cause of this can

**Table 3: Friedman test for within group analysis**

Variables	Measurement time	Mean rank Group A	Mean rank Group B	P-value
<b>10 min walk test</b>	Base line	2.83	1.28	< 0.001
	4th weeks	2.11	1.81	
	8th weeks	1.06	2.91	
<b>Modified Ashworth scale</b>	Baseline	2.72	3.00	< 0.001
	4th weeks	2.11	2.00	
	8th weeks	1.17	1.00	
<b>Berg balance scale</b>	Baseline	1.00	1.00	< 0.001
	4th weeks	2.00	2.00	
	8th weeks	3.00	3.00	
<b>Hip Flexion</b>	Baseline	1.28	1.00	< 0.001
	4th weeks	1.81	2.00	
	8th weeks	2.92	3.00	
<b>Hip Extension</b>	Baseline	2.06	1.00	< 0.001
	4th weeks	1.11	2.03	
	8th weeks	2.83	2.97	
<b>Knee Flexion</b>	Baseline	1.0	1.00	< 0.001
	4th weeks	2.0	2.00	
	8th weeks	3.0	300	
<b>Knee Extension</b>	Baseline	1.06	1.00	< 0.001
	4th weeks	1.94	2.00	
	8th weeks	3.00	3.00	
<b>Ankle Dorsiflexion</b>	Baseline	1.00	1.11	< 0.001
	4th weeks	2.25	1.89	
	8th weeks	2.75	3.00	
<b>Ankle Planter flexion</b>	Baseline	1.00	1.00	< 0.001
	4th weeks	2.00	2.08	
	8th weeks	3.00	2.92	

be because the hamstrings' flexibility wasn't sufficiently increased by the treatment used to increase their flexibility.<sup>20</sup>

Since Balance was significantly improved in the IASTM group, the improvement in posture may have resulted from that improvement. Dynamic balance and foot pronation go hand in hand. Instructors or therapists who assist patients with past experiences of falling in functional rehabilitation may find these data useful. Additionally, although no differences in dynamic stability were found, those with a flat foot group was observed to have higher static stability than the neutral foot group.<sup>21</sup> This study compares the

effects of IASTM and NYDC exercises on balance and shows a significant impact on stroke patients' lower extremities. Mean ranks of berg balance scale for within group analysis of both groups was three and the difference was less than 0.06 or zero. Thus, both therapies showed same results in improving the balance.

The neural dynamics technique (NDYT) helps the nerve and soft tissue recover by reducing stress in the neural tissue by facilitating the neural sliding phenomena and by facilitating the flow of blood through the nerve while In order to restore movements of the corresponding muscle, the (IASTM) method soothes the skin, fibrous tissue, and tightened tissues; the therapy's principle involves inducing a partial inflammatory reactions to the area in order to resynthesize blood, fiber glia, and collagen as well as to reduce stress of the muscular tissue for aiding efficient motion with increased flexibility and efficiency. Lee et al. studied patients with spasticity to investigate the immediate impact on the reciprocal inhibitory and innervations, IASTM was applied to the gastrocnemius. They observed enhanced tibialis anterior muscle activation and decreased gastrocnemius muscle activation.<sup>22</sup> Our findings suggest a significant difference in the mechanical characteristics of the gastrocnemius and hamstrings between the IASTM group and the NDYT group of 1.17 and 1.00, respectively when measured through MAS in stroke patients.

According to Markovic, in the IASTM group of young soccer players compared with the group undergoing static stretching, joint motion range was enhanced and muscle tone was lowered.

They reasoned that raising the local area's temperature while applying stroking causes the fascia layer to slide off more easily and reduces collagen resistance. Our investigation confirmed the findings of the earlier study by showing that the participants in the IASTM group produced less muscle tone than the NDYT group did. It was added that because the IASTM affects the inner layer of fascia's mechanoreceptor and transforms that into proprioceptive activation to affect the central nervous system, muscle tone is also decreased.<sup>23</sup> Kweon et al. claim that IASTM makes use of the target's restricted surface area to perform deeper penetration, with stimulating intensity for receptor getting distinct from

that of an additional approach, which is consistent with our study's findings.<sup>24</sup>

Prioritize individualized treatment programs by customizing procedures to patient needs for optimal results. Integrate modern neuroimaging methods to better understand therapy effects and uncover underlying causes. Investigate synergistic techniques that combine soft tissue mobilization with new therapeutics to potentially enhance rehabilitative outcomes.

## 5. LIMITATIONS

The limited sample size could restrict the generalizability and statistical accuracy of the results. Single blinding may introduce bias due to potential participant and assessor knowledge. A short follow-up period may overlook potential long-term impacts of therapies. Homogeneous participant features may limit the application to various stroke groups.

## 6. CONCLUSION

It has been shown that both instrument-assisted soft tissue mobilization and neurodynamic technique exhibit significant efficacy in improving lower extremity spasticity, range of motion, balance, and gait challenges in chronic stroke patients. Particularly, soft tissue mobilization demonstrated a significantly increased therapeutic benefit, highlighting its potential as the primary treatment modality in this setting.

## 7. Data availability

The numerical data generated during this research is available with the authors.

## 8. Conflict of interest

All authors declare that there was no conflict of interest.

## 9. Funding

The study utilized the hospital resources only, and no external or industry funding was involved.

## 10. Authors' contribution

AS: Conception, design and drafting of the work.

ZA: Proofreading of final submitted manuscript.

\*HSA: Reviewed critically for important intellectual content.

Q, SSF: Interpretation of data.

ZS: Drafting and Revision of work.

## 11. REFERENCES

1. Abiodun A. Stroke (Cerebrovascular Accident (CVA) or brain attack) and its management:

literature review. *Int J Innov Healthc Res.* 2018;6:1-9.

2. Domínguez-Durán E, Mármol-Szombathy I, López-Urbano MJ, Palomo-Sánchez A, Alarcón-Balanza F, Palmero-Olmo E, et al. Balance disorders as potential confounders associated with increased risk of acute cerebrovascular accidents. *Eur Arch Otorhinolaryngol.* 2021;278:3763-72. [PubMed](#) DOI: [10.1007/s00405-020-06465-y](https://doi.org/10.1007/s00405-020-06465-y)
3. Feske SK. Ischemic stroke. *Am J Med.* 2021;134(12):1457-64. [PubMed](#) DOI: [10.1016/j.amjmed.2021.07.027](https://doi.org/10.1016/j.amjmed.2021.07.027)
4. Kuriakose D, Xiao Z. Pathophysiology and treatment of stroke: present status and future perspectives. *Int J Mol Sci.* 2020;21(20):7609. [PubMed](#) DOI: [10.3390/ijms21207609](https://doi.org/10.3390/ijms21207609)
5. Dichgans M, Pulit SL, Rosand J. Stroke genetics: discovery, biology, and clinical applications. *Lancet Neurol.* 2019;18(6):587-99. [PubMed](#) DOI: [10.1016/S1474-4422\(19\)30043-2](https://doi.org/10.1016/S1474-4422(19)30043-2)
6. Kang YN, Shen HN, Lin CY, Elwyn G, Huang SC, Wu TF, et al. Does a mobile app improve patients' knowledge of stroke risk factors and health-related quality of life in patients with stroke? A randomized controlled trial. *BMC Med Inform Decis Mak.* 2019;19(1):1-9. [PubMed](#) DOI: [10.1186/s12911-019-1000-z](https://doi.org/10.1186/s12911-019-1000-z)
7. Hugues A, Di Marco J, Ribault S, Ardaillon H, Janiaud P, Xue Y, et al. Limited evidence of physical therapy on balance after stroke: a systematic review and meta-analysis. *PLoS One.* 2019;14(8):e0221700. [PubMed](#) DOI: [10.1371/journal.pone.0221700](https://doi.org/10.1371/journal.pone.0221700)
8. Cheatham SW, Baker R, Kreiswirth E. Instrument assisted soft-tissue mobilization: a commentary on clinical practice guidelines for rehabilitation professionals. *Int J Sports Phys Ther.* 2019;14(4):670. [PubMed](#)
9. Seffrin CB, Cattano NM, Reed MA, Gardiner-Shires AM. Instrument-assisted soft tissue mobilization: a systematic review and effect-size analysis. *J Athl Train.* 2019;54(7):808-21. [PubMed](#) DOI: [10.4085/1062-6050-481-17](https://doi.org/10.4085/1062-6050-481-17)
10. Zamurd N, Baig MO. Neurodynamics for motor recovery after stroke: a review article. *Health Sci J.* 2023;17(4):1-6. [Full Text](#)
11. Anandhraj J, Kumaresan A. Effect of neurodynamic sliding technique on hemiplegic stroke subjects with hamstring tightness. *Indian J Public Health Res Dev.* 2020;11(1):251-4. [Full Text](#)
12. Kim MJ, Kim TH. Effect of neurodynamic technique and instrument-assisted soft tissue

- mobilization on lower extremity muscle tone, stiffness, static balance in stroke patients. *J Korean Phys Ther.* 2020;32(6):359-64. DOI: [10.18857/jkpt.2020.32.6.359](https://doi.org/10.18857/jkpt.2020.32.6.359)
13. Suhail M, Prakash A, Sonali D, Sangeeta M. Effectiveness of dynamic soft tissue mobilization vs passive stretching to improve hamstring flexibility in stroke patients: a comparative study. *Int J Phys Educ Sports Health.* 2022;9(1):346-9. [Full Text](#)
  14. Seid AA, Moloro AH. Effectiveness of neurodynamic interventions in patients with stroke: protocol for a systematic review and meta-analysis. *JMIR Res Protoc.* 2022;11(9):e38956. [PubMed](#) DOI: [10.2196/38956](https://doi.org/10.2196/38956)
  15. Laudner K, Compton BD, McLoda TA, Walters CM. Acute effects of instrument assisted soft tissue mobilization for improving posterior shoulder range of motion in collegiate baseball players. *Int J Sports Phys Ther.* 2014;9(1):1. [PubMed](#)
  16. Sharma S, Balthillaya G, Rao R, Mani R. Short term effectiveness of neural sliders and neural tensioners as an adjunct to static stretching of hamstrings on knee extension angle in healthy individuals: a randomized controlled trial. *Phys Ther Sport.* 2016;17:30-7. [PubMed](#) DOI: [10.1016/j.ptsp.2015.03.003](https://doi.org/10.1016/j.ptsp.2015.03.003)
  17. Rowlett CA, Hanney WJ, Pabian PS, McArthur JH, Rothschild CE, Kolber MJ. Efficacy of instrument-assisted soft tissue mobilization in comparison to gastrocnemius-soleus stretching for dorsiflexion range of motion: a randomized controlled trial. *J Bodyw Mov Ther.* 2019;23(2):233-40. [PubMed](#) DOI: [10.1016/j.jbmt.2018.02.008](https://doi.org/10.1016/j.jbmt.2018.02.008)
  18. Cho SH, Kim CH, Lee JH. Immediate effect of instrument-assisted soft tissue mobilization and self-stretching on gastrocnemius muscle thickness and range of motion. *J Int Korean Phys Ther Assoc.* 2021;12(3):2419-25.
  19. Javeria H, Rasool D, Mallick U. The effectiveness of instrument-assisted soft tissue mobilization technique on musculoskeletal soft tissue injuries: a systematic review and meta-analysis. *Pak J Rehabil.* 2023;12(1). [Full Text](#)
  20. Guimarães JS, Arcanjo FL, Leporace G, Metsavaht LF, Conceição CS, Moreno MV, et al. Effects of therapeutic interventions on pain due to plantar fasciitis: a systematic review and meta-analysis. *Clin Rehabil.* 2023;37(6):727-46. [PubMed](#) DOI: [10.1177/02692155221143865](https://doi.org/10.1177/02692155221143865)
  21. Lee HW, Beak HJ, Yoon EJ, Kim J. Effect of instrument-assisted soft tissue mobilization on ankle range of motion and balance in older women: a preliminary study. *Asian J Kinesiol.* 2021;23(2):2-8. [Full Text](#)
  22. Lee JJ, Lee JJ, Kim DH, You SJH. Inhibitory effects of instrument-assisted neuromobilization on hyperactive gastrocnemius in a hemiparetic stroke patient. *Biomed Mater Eng.* 2014;24(6):2389-94. [PubMed](#) DOI: [10.3233/BME-141052](https://doi.org/10.3233/BME-141052)
  23. Markovic G. Acute effects of instrument assisted soft tissue mobilization vs foam rolling on knee and hip range of motion in soccer players. *J Bodyw Mov Ther.* 2015;19(4):690-6. [PubMed](#) DOI: [10.1016/j.jbmt.2015.04.010](https://doi.org/10.1016/j.jbmt.2015.04.010)
  24. Kweon M, Kim J. Comparison of immediate effects of myofascial release and fascial distortion model on range of motion, pain pressure threshold, and balance in healthy adults. *J Bodyw Mov Ther.* 2023;35:33-7. [PubMed](#) DOI: [10.1016/j.jbmt.2023.04.067](https://doi.org/10.1016/j.jbmt.2023.04.067)