J Int Acad Phys Ther Res 2021; 12(1): 2359~2364
ISSN 2092-8475
www.iaptr.org
https://doi.org/10.20540/JIAPTR.2021.12.1.2359

Combined Effect of Joint Mobilization and Active Stretching on Gait Speed and Ability after Stroke

Background: Patients with stroke have limited ankle range of motion (ROM) due to soft tissue abnormalities around the ankle and thus experience functional impairment. Increased muscle tension and reduced ankle ROM impair gait and hinder the activities of daily living. Joint mobilization and stretching are effective interventions that improve gait performance by enhancing the ankle ROM.
Objectives: To investigate the effects of ankle joint mobilization and calf muscle stretching on gait speed and gait performance in patients with stroke.
Design: This was a randomized controlled trial.
Methods: Twenty patients with stroke patients were randomized into two groups. The joint mobilization group (JMG) underwent anteroposterior mobilization of the talocrural joint and the joint mobilization stretching group (JMSG) underwent calf muscle stretching in addition to joint mobilization. Gait speed and gait parameters were measured using the 10-meter walk test and the GAITRite.
Results: Both the JMG and JMSG groups showed significant improvements in gait speed, affected-side step length, and cadence after the intervention ($P<.05$).
Conclusion: Joint mobilization and stretching were effective interventions for improving gait performance by enhancing ankle function in patients with stroke.

Keywords: *Patient with stroke; Joint mobilization; Stretching; Gait*

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Received : 05 April 2021
Revised : 17 May 2021
Accepted : 20 May 2021

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INTRODUCTION

When a stroke occurs, the blood supply to the brain is blocked, and the consequent failure to deliver oxygen and glucose to neurons leads to their death, thereby inducing functional impairments in cognitive abilities and muscle coordination.[1] Such brain injuries and consequent functional impairment not only increase joint stiffness by causing problems in the synovial fluid and connective tissues, but also induces muscle tone abnormalities that lead to problems in contractile and inert tissues and limitations in ankle range of motion (ROM).[2] In particular, weakening of the calf muscles and spasticity affect the gait speed and spatial variables in stroke patients.[3] In addition, patients with stroke also experience ankle instability,[4] which consequently leads to balance and gait problems.[5]

In recent years, joint mobilization and stretching have been researched as potential interventions for resolving ankle ROM, balance, and gait problems in patients with stroke.[6,7] Maitland joint mobilization, a type of joint mobilization technique, defines the process of measurement, assessment, and treatment of neurological and musculoskeletal disorders as a brick wall concept.[8] It was found to be effective in improving ankle ROM and balance in patients with reduced functional capacity of the ankle.[9] Ankle joint mobilization was effective in improving gait performance in patients with stroke with movement restrictions.[10] It also helps to improve the joint ROM and muscle strength and increases postural stability.[11] The

Evjenth–Hamberg stretching technique isometrically contracts and then passively extends the target muscle, followed by isometric contraction of the antagonistic muscle,[12] and it was reported to be effective in improving gait performance of patients with stroke.[13] Stretching alters the mechanical properties of the gastrocnemius muscle in patients with stroke, particularly the pennation angle, H–reflex latency, and muscle thickness.[14] Stretching reduces dorsiflexion in patients with stroke through these changes, which in turn strengthens the calf muscle and increases the ROM of the ankle.[5]

Few recent studies have applied and compared the effects of joint mobilization and stretching on the ankles in patients with stroke.[6,7] Although one study reported that patients undergoing joint mobilization did not show changes in their gait parameters,[6] another study reported that joint mobilization did alter the gait parameters.[7] As study findings remain inconsistent and there is a clear correlation between gait and quality of life in patients with stroke, this is an important topic of discussion.[15] Thus, the aim of this study was to provide various pieces of clinical evidence by comparing more diverse parameters.

SUBJECTS AND METHODS

Subjects

The inclusion criteria were a minimum of 6 months since stroke onset, ability to understand the purpose of this study and follow verbal instructions (Mini–Mental Status Examination–Korea score of 24 or higher), low mobility confirmed through the talocrural joint posterior gliding test, a passive dorsiflexion ROM of 〈 10 degrees, Modified Ashworth Scale test score of 1–3, and ability to walk at least 10 meters (m) independently. The participants were inpatients of S hospital in the city of Osan, and informed consent was obtained from all the participants. Twenty participants were randomized to the joint mobilization group (JMG, n=10) or the joint mobilization and stretching group (JMSG, n=10). Participants were assigned to two groups using a randomization tool (https://www.randomizer.org) assigned to each group. Both groups underwent a baseline test. A post–intervention test was performed after 6 weeks of additional intervention (three sessions per week) while maintaining the existing treatment regimen. The additional intervention consisted of 20 minutes of Maitland anteroposterior joint mobilization on the talocrural joint for the JMG, and 10 minutes of Maitland anteroposterior joint mobilization on the talocrural joint, followed by 10 minutes of Evjenth–Hamberg stretching for the JMSG. The participants' general characteristics are shown in Table 1. This study was approved by the Institutional Review Board of Yong–in University (No. 2–1040966–AB–N–01–2104–HSR–218–1).

Measurement Instruments

The 10–m walk test

The 10–m walk test (10 MWT), a reliable gait test for patients with stroke, was used to analyze the gait speed.[16] The test was performed on a flat surface. The starting and finish points were marked for a total distance of 14 m, and additional markings were placed 2 m after the starting point and 2 m before the finish point. As conscious pausing during the study will affect the results, the time to passing 2 m from the starting point and 2 m ago the finish were excluded from analysis in consideration of possible acceleration and deceleration of gait at each point, respectively. The participants were instructed to walk from the starting point to the finish 14 m away from the starting point with their normal gait speed. Gait speed was measured using the stopwatch feature on a smartphone (iPhone Apple, USA).

Table 1. General characteristics of subjects

	JMG (n=10)	JMSG (n=10)	*P*
Age (years)	59.60 ± 17.38	63.70 ± 11.44	.542
Height (cm)	166.80 ± 11.43	165.60 ± 8.46	.793
Weight (kg)	66.30 ± 11.27	67.69 ± 8.51	.759

JMG: Joint mobilization group, JMSG: Joint mobilization and stretching group

GAITRite

Gait was analyzed using the GAITRite system (CIR Systems Inc., USA). GAITRite is an electronic walkway that measures 366 × 61 cm, with six sensor pads inside the mat and special sensors on the walkway. This sensor pad contains 2,304 sensors arranged in a grid pattern (48 × 48) spaced 1.27 cm apart. The participants were instructed to walk on thise walkway, and the load thus applied by the participants' walking was collected at a sample rate of 80 Hz. The participants stood 1 m in front of the walkway and began walking at the therapist's cue until stopping at 1 m past the walkway. Three measurements were taken and the average value was used.[17]

Interventions

Joint mobilization

Maitland joint mobilization is performed in the direction of low mobility. To increase ankle ROM in this study, we first identified the direction with low mobility of the talocrural joint and applied grade III Maitland joint mobilization.[8] The participants lay on the bed in the supine position, with their feet and ankles hanging outside the bed. The therapist stood at the side of the participant's feet, fixed the joint at the point that limits further dorsiflexion (the direction of low physiological mobility) with their thigh, and mobilized the talocrural joint in the anteroposterior direction (the direction of low accessory movement of the talocrural joint). Joint mobilization was performed at a rate of 60 Hz. One round consisted of 1 minute (min) of joint mobilization followed by 1 min of rest to reduce residual pain. The JMG underwent 10 rounds of ankle joint mobilization.

Joint mobilization and stretching

The JMSG underwent five rounds of joint mobilization, followed by stretching. To improve ankle ROM, the JMSG underwent stretching of the gastrocnemius of the affected side using the Evjenth-Hamberg technique.[12] When applying the Evjenth-Hamberg stretching, the participants stood in an upright position, had their arms extended forward to assist with balance, held onto the therapy mat, and stood in a lunge position. In a lunge position with the unaffected leg in the front and the affected leg in the back, the participants were told to stand with their feet touching the ground. To stretch the gastrocnemius muscle, the participants were instructed to push their affected leg as far as possible without lifting their foot from the ground, and they performed dorsiflexion isometric contraction in that position. The isometric contraction was maintained for 6 seconds (s), followed by 10 s of rest in an upright position. Stretching was performed repeatedly for 10 minutes.

Data Analysis

All statistical analyses were performed using SPSS software (version 20.0; SPSS Inc., Chicago, IL, USA). The normality of the data was determined using the Shapiro-Wilk test, and the homogeneity of variables was tested using the independent t-test.

Non-normally distributed data were analyzed using nonparametric tests, and normally distributed data were analyzed using parametric tests. The changes within the two groups were analyzed using the Wilcoxon rank test or paired t-test, and the differences between the two groups were analyzed using the Mann-Whitney U test or independent t-test. The statistical significance was set at α=.05.

RESULTS

Changes in the groups after intervention

Both the JMG and JMSG showed significant improvements in gait speed measured using the 10 MWT after the intervention, with a shorter 10 MWT time at the post-intervention test compared to the baseline test ($P<.05$). Both groups also showed significantly increased step length on the affected side, increased velocity ($P<.05$), and increased cadlearaence ($P<.05$) after the interventionand (Table 2).

Changes between the groups after intervention

The JMSG showed a significantly greater improvement in step length on the affected side than ondid the JMG ($P<.05$) after the intervention (Table 3).

Table 2. Changes in muscle tone and muscle activity after intervention

Variables	JMG (n=10)		JMSG (n=10)	
	Before	After	Before	After
10 MWT (sec)	19.37 ± 2.27	14.05 ± 3.66*	18.60 ± 3.35	12.76 ± 3.04*
Affected–side step length (cm)	38.41 ± 3.34	43.94 ± 3.24*	40.41 ± 5.82	46.40 ± 5.63*
Velocity (cm/sec)	40.73 ± 3.47	44.88 ± 3.32*	42.90 ± 6.39	47.07 ± 6.40*
Cadence (steps/min)	79.88 ± 1.94	86.87 ± 1.85*	82.51 ± 3.71	89.63 ± 3.65*

*P<.05
JMG: Joint mobilization group, JMSG: Joint mobilization and stretching group, 10 MWT: 10–m walk test

Table 3. Differences in changes in muscle tone and muscle activity between the groups after the intervention

Variables	Change after intervention		*P*
	JMG (n=10)	JMSG (n=10)	
10 MWT (sec)	5.31 ± 1.90	5.84 ± .59	.207
Affected–side step length (cm)	5.53 ± .23	5.99 ± .60	.018*
Velocity (cm/sec)	4.15 ± .21	4.17 ± .18	.441
Cadence (step/min)	6.99 ± .72	7.12 ± .66	.339

*P<.05
JMG: Joint mobilization group, JMSG: Joint mobilization and stretching group, 10 MWT: 10–m walk test

DISCUSSION

Patients with stroke experience reduced ankle ROM and increased stiffness as the pennation angle of their calf muscle is reduced and their muscle shortened.[18] These lead to gait problems, and conversely, when they are addressed, gait performance improves.[5] In an attempt to resolve these problems for patients with stroke, past studies examined the effects of joint mobilization of the talocrural joint and gastrocnemius stretching and reported that they led to improvements in ankle ROM, balance, and gait parameters. However, the effects of joint mobilization and stretching on gait parameters of patients with stroke remain unclear,[6,7] and relevant research is scarce. Thus, this study aimed to investigate and compare the effects of Maitland joint mobilization and Evjenth–Hamberg stretching on the gait parameters of patients with stroke.

Both groups showed significant improvements in the 10 MWT, affected–side step length, velocity, and cadence after their respective interventions, with only the changes in the affected–side step length significantly varyingdiffered between the two groups. This is consistent with previous findings that joint mobilization and stretching improves gait speed and cadence and similar to findings that concurrent joint mobilization and stretching increases step length.[6,7] Ankle tension has a grave impact on gait in patients with stroke.[19] When joint mobilization is performed on patients with stroke, it stimulates their joint receptors, which reflexively suppresses muscle tension and detects dynamic movement.[20] This is speculated to have contributed to the positive effects of joint mobilization on gait parameters observed in this study.

The Evjenth–Hamberg stretching technique used in this study included muscle contraction. When a muscle contracts, its antagonistic muscle is relaxed due to reciprocal inhibition,[21] and stretching reduces the excitability of α–motor neurons, thereby reducing muscle tone.[22] In addition, stretching the gastrocnemius muscle diminishes the tone of muscles around the ankle, improves ankle ROM, and strengthens the calf muscle in patients with stroke.[5] According to a previous study, reduced muscle tone around the ankle in patients with stroke has a positive effect on gait speed, affected-side step length, and cadence.[23] These reasons seem to explain the improvements in gait parameters observed in this study. However, the findings of this study cannot be generalized to the entire stroke population because of the small sample size.

CONCLUSION

This study aimed to investigate the effects of joint mobilization and Evjenth-Hamberg stretching on gait in 20 patients with stroke patients. Twenty minutes of the intervention led to improvements in gait parameters compared to the baseline in both the JMG and JMSG. In addition, the JMSG showed significantly greater improvement in the affected-side step length than did the JMG, but changes in gait speed and cadence did not differ between the two groups. Subsequent studies should employ additional experimental instruments, such as plantar pressure analysis and electromyographic analysis, on a larger sample to obtain more detailed data on this topic.

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