J. Phys. Ther. Sci. 34: 172–176, 2022

The Journal of Physical Therapy Science

Original Article

Immediate effects of neuromuscular joint-facilitation bridging exercises on walking ability and balance function in stroke patients

Lei Chen, PT, MS[1, 2], Jianjian Sun, PT[2], Shan Liu, PT, MS[1], Danyang Zhou, PT, MS[3], Mingdong Zhang, PT, PhD[1], Yang Gao[3], Yu Bu[4], Hualong Xie, PT, PhD[5]*, Ming Huo, PT, PhD[6], Ko Onoda, PT, PhD[1], Hitoshi Maruyama, PT, PhD[1]

[1)] *Department of Physical Therapy, International University of Health and Welfare: 2600-1 Kitakanemaru, Otawara city, Tochigi 324-8501, Japan*
[2)] *The First Hospital of Jili University, China*
[3)] *Jilin Province Power Hospital, China*
[4)] *Ningan People's Hospital of Heilongjiang Province, China*
[5)] *Wangjing Hospital of China Academy of Chinese Medical Sciences, China*
[6)] *Department of Physical Therapy, Faculty of Medical Health, Himeji Dokkyo University, Japan*

Abstract. [Purpose] This study aimed to examine the immediate effects of a pelvic neuromuscular joint-facilitation intervention on the walking and balance ability of patients with hemiplegia caused by cerebrovascular accidents. [Participants and Methods] A total of 15 patients with hemiplegia caused by cerebrovascular accidents underwent a neuromuscular joint-facilitation lumbar-pattern intervention (intervention group), a bridge exercise (bridge intervention group), or a neuromuscular joint-facilitation bridge intervention (neuromuscular joint-facilitation bridge group). Each intervention was randomly administered at 7-day intervals. Measurement items included the timed up-and-go test, functional reach test, 10-m maximum walking speed test, and load in the standing position. Measurements were taken before and after the intervention in each group. [Results] The timed up-and-go test result was significantly shorter in the neuromuscular joint-facilitation intervention group. Timed up-and-go test results, functional reach, 10-m walking time, and standing load (non-paralyzed side) significantly improved in the neuromuscular joint-facilitation bridge group. [Conclusion] The neuromuscular joint-facilitation bridge intervention was immediately effective in patients with hemiplegia caused by cerebrovascular accidents and improved their walking and balance ability.

Key words: Neuromuscular joint facilitation, Cerebrovascular accident, Walking ability

(This article was submitted Apr. 28, 2021, and was accepted Jun. 6, 2021)

INTRODUCTION

Neuromuscular joint facilitation (NJF) is a new exercise therapy that aims to improve joint movement using passive, automatic, and resistance movements and integrating the facilitating elements of proprioceptive neuromuscular facilitation and joint constituent movements based on the knowledge of kinematics. As a result of searching for a combination of motions that can be theorized, NJF comprises a collective motion pattern with spiral and diagonal motions. In particular, the arthrokinematic approach is used, which focuses on the resistance composition movement for the joint capsule associated with bone movement in the arthrokinematic approach and the proximal resistance composition movement for the joint capsule being added to the diagonal spiral movement pattern[1].

*Corresponding author. Hualong Xie (E-mail: longyuzhektt@126.com)

Cerebrovascular accident may cause paralysis of half of the body; this is associated with somatosensory disorder and muscle weakness, which are linked to diminished balance function, reduced walking ability, and restricted movement in daily life[2, 3]. Balance, walking, basic movement, independence in activities of daily living (ADL), and functional activity evaluations are strongly related to core performance, and the importance of evaluation/intervention regarding the trunk has been reported[4, 5].

The trunk is considered important for the performance of daily activities, such as providing support in the anti-gravity position of the whole body, getting up, stable sitting, and turning over by fixing the proximal body during limb exercises[5]. The importance of trunk function is recognized in the rehabilitation of hemiplegic patients; in particular, re-education about trunk muscles is emphasized for the acquisition of basic movements and ADL[6, 7].

Previous studies reported that NJF to the knee joint in healthy adults increased the muscle strength during flexion and extension, shortened the reaction time, and improved the muscle contraction agility[8, 9]. NJF intervention on the pelvis in patients with hemiplegia due to cerebrovascular disorders was shown to improve both dynamic and static balance[10]. NJF inputs proprioceptive sensations through the muscles and joints and the intervertebral space simultaneously, leading to a joint mobilization effect[1]. From these previous findings, it is considered that NJF to the pelvis may be performed to improve trunk performance, balance function, and walking ability. Therefore, this study aimed to investigate the immediate effects of an NJF intervention on the walking and balance ability of patients with hemiplegia due to cerebrovascular accident.

PARTICIPANTS AND METHODS

A total of 15 patients with hemiplegia caused by cerebrovascular accident (11 males, 4 females; age: 54.2 ± 13.4 years; height: 168.8 ± 5.6 cm; weight: 72.2 ± 8.9 kg [mean ± standard deviation]) participated in this study. The time from cerebrovascular accident was 3–6 months (3.9 ± 1.4 months). Four patients had cerebral hemorrhage, whereas 11 patients had cerebral infarction; 11 had right hemiplegia, whereas 4 had left hemiplegia. Based on the Brunnstrom recovery stage of the lower limbs, 11 cases were classified as stage III, 2 as stage IV, and 2 as stage V.

The inclusion criteria for participants were as follows: 1) Brunnstrom stage III and above; 2) ability to wear an ankle foot orthosis and walk alone without a cane, even if not practical walking; 3) ability to perform all measurements and intervention tasks in this study; and 4) previous cerebrovascular accident. In contrast, the exclusion criteria were unstable general condition and neurological symptoms, osteoarthritis, dementia, and psychiatric disorders. In addition, patients unable to understand the study instructions were excluded, as were those with brain stem lesions, bilateral lesions, or respiratory/circulatory disorders associated with restricted movement. This study was approved by the International University of Health and Welfare Ethics Review Committee (approval number: 19-Io-146). The purpose and content of this study were explained to the participants in advance, and informed consent was obtained from all participants prior to the start of this study.

All participants underwent the following interventions: an NJF lumbar pattern intervention (NJF intervention group), a bridge exercise (bridge group), and an NJF bridge intervention (NJF bridge group). Each intervention was randomly performed at 7-day intervals. The participants were informed in advance of the purpose and contents of the study, approval was obtained, and the measurement was started. The following measurements/tests were performed: timed up and go test (TUG), functional reach test (FRT), 10-m maximum walking speed test, and load on the left and right feet while standing. Each measurement was performed before and after the intervention in each group. Two-way repeated-measures analysis of variance (ANOVA) was used to test for statistically significant differences between the intervention and control groups.

The TUG measurement involved standing up from a chair, walking 3 m, changing direction, walking back 3 m, turning, and sitting back in the chair; the time taken by the participants to perform these tasks was measured[11].

For the FRT measurement, the closed-leg standing position next to a whiteboard was the starting point. Both arms were extended forward to a horizontal position (shoulder joint 90° flexion) at the height of the shoulder peak; the third fingertip position was marked on the whiteboard, and the arm farthest from the whiteboard was subsequently lowered. The fingers of the extended arm were kept at the same height; the participants were asked to reach as far forward as possible without moving their legs, and the maximum reach was marked. The distance from the starting position to the maximum forward extension was measured and recorded[12].

In the measurement of the maximum walking time of 10 m, we instructed participants to walk as fast as possible; the walking path was set to 13 m, which included a 1.5 m runway at the starting- and end points, and the time that it took the participants to walk 10 m was measured[13].

The load (in the standing position) was measured in the standing position using two commercially available weight scales, with each foot placed on a weight scale in the standing position. The participants maintained a stable posture for 5 sec, and the load (kg) on each leg was measured. The interventions were performed by a therapist who had been performing NJF for 7 years and was qualified as an NJF instructor.

For the NJF bridge group, the intervention was as follows: The upper limbs on both sides were placed on the bed in the supine position, the knee joints were flexed at 90°, and the legs were opened to shoulder width. As the buttocks were not raised, manual resistance was applied to the hip joint head via the large trochanter in the opposite direction of hip joint extension (Fig. 1). The final position of the bridge targeted the abdominal muscle group. To activate the muscles around the hip joint, the hip joint was not fully extended but in a slightly flexed position, and the pelvic slightly posterior limb position to stop. The oral instructions at the time of implementation were as follows: "Contract the abdomen while exhaling. Please lift your bottom slowly".

For the NJF intervention group, bilateral pelvis plus lumbar fixation (anterior elevation–lumbar fixation, posterior inferiority–lumbar fixation, anterior inferiority–lumbar fixation, and posterior elevation–lumbar fixation) were randomly performed five times each.

For the bridge group, both upper limbs were placed on the bed in the supine position, the knee joints were flexed at 90°, and the legs were opened to shoulder width. Resistance was applied via the upper anterior iliac spine in the starting limb position. The participants slowly raised the buttocks as much as possible (Fig. 2). The oral instructions at the time of implementation were as follows: "Please exhale, contract your abdomen, and slowly lift your hips".

Data from the TUG, FRT, 10-m maximum walking speed test, and load in the standing position before and after the intervention in each group were analyzed. The mean values and standard deviations were calculated for each group before and after the intervention. If any significant interaction was observed, the paired t-test was performed to compare the outcome indicators before and after the intervention. Data were analyzed using IBM SPSS statistics for Windows ver. 23.0 (IBM Corp.: Armonk, NY, USA), and values of $p<0.05$ were considered statistically significant.

RESULTS

The measured values of the variables for each group are presented in Table 1. In the TUG, a significant effect was observed by comparing the results before and after the intervention: in the NJF and NJF bridge groups, the time required for the TUG was significantly shortened after the intervention ($p<0.05$). As for the FRT, the results obtained indicated an interaction. A significant increase in extension after the intervention was observed in the NJF bridge group ($p<0.01$), unlike the control and

Fig. 1. The neuromuscular joint facilitation (NJF) bridge group.
Arrows indicate the direction of resistance.

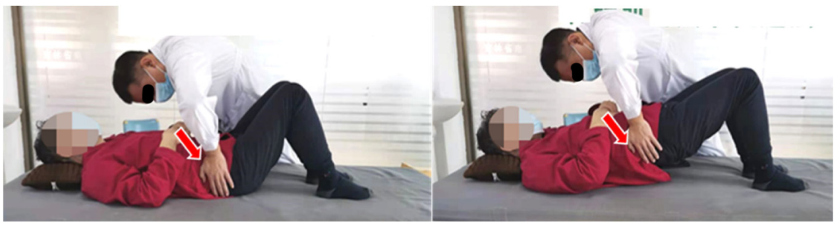

Fig. 2. The bridge group.
Arrows indicate the direction of resistance.

Table 1. Results for each measurement item before and after the intervention

		Bridge group		NJF group		NJF bridge group	
		Pre-intervention	Post-intervention	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
TUG (sec)		30.3 ± 17.1	35.6 ± 16.0	30.9 ± 16.3	27.6 ± 14.7**	30.8 ± 16.8	28.7 ± 16.0*
FRT (mm)		29.2 ± 5.4	27.4 ± 3.9	28.2 ± 5.1	28.7 ± 5.5	27.5 ± 5.0	31.3 ± 4.4**
10-m walking time (sec)		28.5 ± 18.1	31.0 ± 21.0	30.1 ± 19.4	27.9 ± 19.6	31.4 ± 19.9	28.2 ± 18.5*
Load in the standing position (kg)	Paralyzed side	35.8 ± 9.2	35.3 ± 8.7	36.0 ± 9.0	34.8 ± 6.7	36.0 ± 9.1	32.9 ± 8.0
	Non-paralyzed side	37.8 ± 6.4	38.0 ± 6.4	37.7 ± 6.6	39.2 ± 6.6	37.9 ± 6.2	40.8 ± 6.1*

NJF: neuromuscular joint facilitation; TUG: timed up and go test; FRT: functional reach test.
Mean ± standard deviation; before and after the intervention: *$p<0.05$; **$p<0.01$.

bridge groups. Regarding the 10-m walking time, the results obtained indicated an interaction. A significantly shortened time following the intervention was observed in the NJF bridge group ($p<0.05$), unlike the control and bridge groups. Moreover, regarding the amount of load in the standing position, an interaction was observed in the results obtained. The load in the standing position was significantly increased on the non-paralyzed side after the intervention in the NJF bridge group ($p<0.05$), unlike the control and bridge groups (Table 1).

DISCUSSION

In this study, we investigated the immediate effects of an intervention involving NJF on the pelvis on the balance function and walking ability of hemiplegia patients.

Our results indicated significant improvements in the TUG in the NJF and NJF bridge groups and in the FRT measurement, 10-m walking time, and load on the non-paralyzed side in the standing position in the NJF bridge group after the intervention. Thus, the NJF bridge group showed significant effects on all measurements. This suggests that the NJF bridge movement intervention is immediately effective among hemiplegia patients.

NJF is thought to have improved trunk performance and TUG by performing near-normal movements, with distal resistance predominantly promoting helical movements. In the NJF lumbar pattern intervention, distal resistance diagonal spiral movement was promoted, lumbar joint composition movement was promoted in proximal resistance, and opposite direction mobilization was practiced. The NJF lumbar intervention improves muscle strength around the lumbar spine and mobilization of the trunk facet joint-by-joint composition movement simultaneously.

The results indicated that the NJF bridge intervention improved participants' performance in the TUG, FRT, 10-m walking time, and load in the standing position (non-paralyzed side). According to previous research, in the NJF bridge intervention with healthy participants, the multifidus and transversus abdominis muscles contracted significantly[14)] and similarly contributed to the stability of the trunk function. It was considered that the inner muscle is contracted in the NJF intervention and can contribute to improving standing balance function. From this viewpoint, the intervention of the NJF bridge exercise gives the hip joint head a resistance to the rotation of the hip joint extension in the opposite direction during the bridge exercise. In addition, NJF proximal resistance increases abdominal pressure by facilitating the activation of the multifidus and transverse abdominal muscles by resistance to the hip head, and the lower limbs engage in more efficient muscle contraction and trunk performance and balance, leading to improved function and walking ability. A previous report indicated the relationship between trunk muscle strength and balance ability in patients with hemiplegia due to cerebrovascular accident[15)]. Balance ability requires instantaneous movement, particularly in the back muscles, and muscular strength has been suggested to be required[16)]. Therefore, improving the trunk function of patients with cerebrovascular accident is an important factor in promoting balance, walking ability, and ADL. As such, it is necessary to establish effective rehabilitation of the trunk in patients with hemiplegia due to cerebrovascular accident[17)]. Based on our results, the NJF bridge intervention provided an NJF proximal counterforce to the hip head, improving balance function and walking ability.

As a limitation of this study, trunk muscle and trunk function were not assessed after the NJF bridge intervention . Thus, it is necessary to further clarify the effects of intervention on the trunk. In the future, we would like to verify the effects of the NJF bridge intervention on other diseases among athletes.

Our results suggest the importance of trunk function in the rehabilitation of hemiplegic patients. The NJF bridge intervention was immediately effective among hemiplegic patients and improved their walking and balance ability.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or nonprofit sectors.

Conflict of interest

None.

REFERENCES

1) Huo M: Neuromuscular joint facilitation method. Tokyo: IPEC, 2010, pp 3–16.
2) Patterson KK, Parafianowicz I, Danells CJ, et al.: Gait asymmetry in community-ambulating stroke survivors. Arch Phys Med Rehabil, 2008, 89: 304–310. [Medline] [CrossRef]
3) Bonan IV, Colle FM, Guichard JP, et al.: Reliance on visual information after stroke. Part I: Balance on dynamic posturography. Arch Phys Med Rehabil, 2004, 85: 268–273. [Medline] [CrossRef]
4) Verheyden G, Vereeck L, Truijen S, et al.: Trunk performance after stroke and the relationship with balance, gait and functional ability. Clin Rehabil, 2006, 20: 451–458. [Medline] [CrossRef]
5) Toshiyuki F: Evaluation and prognosis of trunk function of stroke. J Clin Rehabil, 2002, 11: 942–946.
6) Collin C, Wade D: Assessing motor impairment after stroke: a pilot reliability study. J Neurol Neurosurg Psychiatry, 1990, 53: 576–579. [Medline] [CrossRef]
7) Davies PM: Right in the middle: selective trunk activity in the treatment of adult hemiplegia. Berlin: Springer Verlag, 1990.

8) Ge M, Huo M, Maruyama H: The immediate effect of neuromuscular joint facilitation (NJF) treatment on knee muscle force. J Phys Ther Sci, 2012, 24: 157–159. [CrossRef]
9) Huo M, Ge M, Li D, et al.: Effects of neuromuscular joint facilitation on electromechanical reaction time of rectus femoris. J Phys Ther Sci, 2012, 24: 55–57. [CrossRef]
10) Xie H, Huo M, Huang Q, et al.: Immediate effects of lumbar spine patterns after neuromuscular joint facilitation on balance in stroke patients. J Phys Ther Sci, 2019, 31: 979–982. [Medline] [CrossRef]
11) Podsiadlo D, Richardson S: The timed "Up & Go": a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc, 1991, 39: 142–148. [Medline] [CrossRef]
12) Duncan PW, Weiner DK, Chandler J, et al.: Functional reach: a new clinical measure of balance. J Gerontol, 1990, 45: M192–M197. [Medline] [CrossRef]
13) Adell E, Wehmhörner S, Rydwik E: The test-retest reliability of 10 meters maximal walking speed in older people living in a residential care unit. J Geriatr Phys Ther, 2013, 36: 74–77. [Medline] [CrossRef]
14) Zhou B, Huang Q, Zheng T, et al.: Effects of neuromuscular joint facilitation on bridging exercises with respect to deep muscle changes. J Phys Ther Sci, 2015, 27: 1417–1419. [Medline] [CrossRef]
15) Karatas M, Cetin N, Bayramoglu M, et al.: Trunk muscle strength in relation to balance and functional disability in unihemispheric stroke patients. Am J Phys Med Rehabil, 2004, 83: 81–87. [Medline] [CrossRef]
16) Takahashi E, Ishida K, Ueshima R, et al.: Relationship between trunk muscle strength exertion time and balance. Phys Ther Sci, 2013, 28: 209–214.
17) Hsieh CL, Sheu CF, Hsueh IP, et al.: Trunk control as an early predictor of comprehensive activities of daily living function in stroke patients. Stroke, 2002, 33: 2626–2630. [Medline] [CrossRef]