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Original Article

The effect of modified trampoline training on balance, gait, and falls efficacy of stroke patients

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Abstract. [Purpose] This research was conducted to investigate the effects of modified trampoline training on the balance, gait, and falls efficacy of stroke patients. [Subjects] Twenty-four stroke patients participated in this study. The subjects were randomly allocated to one of two groups: the trampoline group (n=12) or the control group (n=12). [Methods] Both groups participated in conventional physical therapy for thirty minutes per day, three times a week for six weeks. The trampoline group also took part in trampoline training for thirty minutes per day, three times a week for six weeks. We evaluated balance (Berg balance scale, timed up and go test), gait (dynamic gait index), and falls efficacy (falls efficacy scale-K) to confirm the effects of the intervention. [Results] Both the trampoline and the control group showed significant improvements in balance, gait, and falls efficacy compared to before the intervention, and the improvements were significantly greater in the trampoline group than in the control group. [Conclusion] Modified trampoline training resulted in significantly improved balance, dynamic gait, and falls efficacy of stroke patients compared to the control group. These results suggest that modified trampoline training is feasible and effective at improving balance, dynamic gait, and falls efficacy after stroke.
Key words: Trampoline, Stroke, Rehabilitation

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INTRODUCTION

Stroke is a sudden loss of neurological function caused by the disturbance of cerebral blood flow. Clinically, various impairments appear including changes in levels of consciousness, and sensory, motor, cognitive, perceptual, and language impairments[1)]. Aspects of disability due to stroke vary depending on the degree and area of the damage. Generally, disorders such as a decrease in muscular strength of hemiplegic patients[2)], a slowing of the rate at which power is generated[3)], and muscle weakness are seen, along with a possible limitation of the joint range of motion[4)]. The aforementioned problems result in decreases in walking speed and walking ability, balance impairment, altered balance confidence, and reduced mobility due to worries about falling[5)]. Therefore, an important focus of rehabilitation for chronic stroke patients is the development of interventions to promote balance and functional movement[6)]. Recently, a trampoline training program was reported to be effective for various target groups, improving postural control, balance and exercise performance. The trampoline is a balance training device that requires strong integration of the neuromuscular system. It is frequently used because of its affordability, transportability, ease of use, and simplicity of set up[7)]. Movements that can be performed on a trampoline can enhance physical factors, such as trunk stability, muscular coordination reactions, range of joint movements, and spatial orientation[8)]. The trampoline is a rehabilitation method that can stimulate proprioception and enhance a person's ability to balance[9)]. Training on a trampoline was shown to improve the ability of elderly patients to recover their balance after falling forward[8)], and trampoline training is an effective intervention for promoting balance and other movements in children with intellectual disabilities[10)]. In particular, predefined mini-trampoline training stroke patients produced a significant increase in their balance. Although the improvements were not statistically significant, trampoline use also improved their mobility and activities of daily living[11)]. The stroke patients in that study performed the trampoline training, without holding onto anything while they jumped or, hit a balloon. It would be difficult to use this method for stroke patients with low physical abilities. In addition, the effectiveness of trampoline training in preventing falls and improving the walking ability and balance of stroke patients has not been reported. Therefore, this study used a modified trampoline training program for stroke patients and analyzed its effects on balance, gait, and falls efficacy.

SUBJECTS AND METHODS

The study subjects were 28 adult stroke patients who had been admitted to Hospital B, which is in Incheon. The inclu-

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sion criteria were single onset of stroke, an MMES-K score of at least 24 points, and the ability to walk minimum of two minutes or more with or without walking aids. The exclusion criteria were a history of other neurologic or circulatory diseases or disorders, a cardiovascular system abnormality, or a history of visual or auditory sense disorders.

This study used a randomized pre- and post-test, two-group design. Subjects were randomly allocated to a trampoline training group (TG; n=14) or a control group (CG; n=14). All 24 participants completed the intervention. Prior to the subjects' participation, all the procedures were explained, and each subject provided his or her written informed consent to participate. This study was approved by the Sahmyook University Institutional Review Board.

The training group performed modified trampoline training for 30 min three times a week for 6 weeks. Trampoline training sessions were performed one-on-one with a physical therapist to instruct the participants on how to use the trampoline (Baleno Inc., diameter: 45 inch) with a handle. To increase the difficulty of training, patients closed their eyes or did not hold onto the handle. Rest periods were allowed according to the patient's needs. The details of the modified trampoline training programs are described in Table 1. The control group did not take part in the trampoline training program; however, both groups received general physiotherapy.

The Berg balance scale (BBS) and the timed up and go (TUG) test were used to evaluate patients' balance abilities. The dynamic gait index was used to assess their walking ability, and the falls efficacy scale was used to measure the falls efficacy of the subjects.

SPSS ver. 18.0 statistical software was used for all analyses. Descriptive statistics were used to describe the patients' characteristics after confirming that the data were normally distributed. Comparisons of both groups' general characteristics were performed using the independent t-test or χ^2 test. Pre- and post-data were analyzed using the paired t-test to test within-group differences and the independent t-test to test differences between the groups. A significance level of 0.05 was used for all analyses.

RESULTS

The subjects' general characteristics are presented in Table 2. No significant differences in general characteristics were observed between the TG and the CG (age: 53.17 and 55.75 years; height: 165.09 and 168.27 cm; weight: 62.64 and 69.09 kg; respectively).

Differences in pre- and post-test values within groups and between groups are summarized in Table 3. Specifically, TG showed a significant increase in the BBS ($p < 0.05$) and a significant decrease in the TUG test time ($p < 0.05$). The improvements were significantly greater than those in the CG. In addition, the TG showed a significant increase in the dynamic gait index ($p < 0.05$), and this difference was also significantly greater than that of the CG. The falls efficacy scale was also significantly different between the pre- and post-test in the TG, and the improvement in the TG was significantly greater than that in the CG ($p < 0.05$).

Table 1. Content of the modified trampoline training

Standing	in place
	with feet in a walking stance
	with the right or left foot in front of the other foot
	with the feet together
	one supporting leg
Weight shifting	to the front, back, right, and left in place
	to the front, and back with the feet in a walking stance
	to the front, and back with the right or left foot in front of the other foot
	to the front, back, right, and left with the feet together
	lifting the heel
Hopping	in place
	with the feet in a walking stance
	with the right or left foot in front of the other foot
	with the feet together
Walking	stance, one supporting leg, alternate steps to the front and to the back of the opposite leg
	in place
	jogging in place
Jumping	in place
	to the front and back, and right and left
	with the feet in a walking stance
	with the right or left foot in front of the other foot
	with the feet together
	to the front and back, and right and left with the feet together
	to the front and back, and right and left with scissor steps
Performing a task	Tossing a balloon between the patient and therapist
	Throwing a small ball between the patient and therapist
	Throwing a small ball to pick up on the trampoline

DISCUSSION

Balance is the ability to maintain the gravity line of the body with a minimum degree of deviation within the base of support[12]. It is important to provide treatment to increase the balance abilities of stroke patients[13]. A previous study found a significant change in postural sway in athletes following balance training on a trampoline[7]. That study reported improvements in muscle endurance, sensorimotor control, and reaction times within the muscles of the ankle complex due to challenges to the neuromuscular system and specific movements of the ankle joint muscle after a trampoline training program. In another previous study, a trampoline intervention resulted in significant improvements in the motor performance and balance of children with intellectual disabilities[10]. During trampoline training, the participants are forced to continuously respond to changes in gravity, and this provides deep proprioception as well as other sensory inputs. In addition, performance improvements in balance tasks may be the result of alterations in the complex sensory motor stimulation due to participants' efforts to adapt to the trampoline's unstable surface and maintain balance. An another previous study conducted trampoline training for patients with stroke[11], and reported a significant improvement in the BBS. In that study, participants tried to stabilize their bodies while maintaining their center of gravity on the base of support and responding to different environments and tasks. The reported improvements were attributed to the participants being forced to keep their balance on the elastic and unstable ground[11].

Table 2. General characteristics of the participants

Parameters	TG (n=12)	CG (n=12)
Gender		
Male/Female (%)	8/4 (66.7/33.3)	6/6 (50.0/50.0)
Affected Side		
Lt/Right (%)	6/6 (50.0/50.0)	6/6 (50.0/50.0)
Disease duration, months	14.8 (9.6)	13.9 (6.0)
Age, years	53.2 (11.2)	55.75 (8.8)
Height, cm	165.1 (5.2)	168.3 (8.5)
Weight, kg	62.64 (8.2)	69.09 (9.4)

Values are n (%) or mean (SD).
TG: trampoline training group; CG: control group

In the present study, significant improvements were found in the BBS and the TUG test after the intervention. We used different subjects and a different training method from previous studies. The participants in our study had to maintain their balance while performing various operations on the unstable ground. This task likely contributed to improving the patients' ability to balance due to the repeated sensory feedback and the continuous experience to postural sway. In addition, the modified trampoline training consisted of not only static balance training, such as standing and weight shifting, but also dynamic balance training, such as hopping, walking, jumping, and performing a task. Significant improvement was seen in the BBS, a measure of dynamic balance, as well as in the TUG test, a measure of static balance. In the study of Miklitsch et al., the BBS showed a significant improvement, but the TUG test did not, despite improvement in the BBS. However, in our study, participants resolutely performed high difficulty dynamic activities because they used the handle. Therefore, both the BBS and the TUG test significantly improved.

Twenty percent of stroke patients need a wheelchair for tasks in everyday life after 3 months, and almost 70% decrease their walking speed or step length when they resume walking[14]. Walking speed affects the degree of daily living participation of stroke patients[15]. Therefore, rehabilitation for the recovery of walking ability is very important for the development of a patient-dependent gait after stroke[14]. In a previous study, stroke patients could jump for the first time in many years due to the availability of assistance, which was the motivation for them to participate in an exercise program[16]. In addition, patients reported increased leg strength on the affected side after jumping training, and all patients felt that they regained control of the affected leg. In another previous study, the mechanical efficiency increased and energy costs reduced when the patients jumped on an elastic surface[17]. It was also reported that subjects could jump from a little crouching stance on a trampoline, therefore the elastic energy loss decreased and the speed of movement was facilitated, allowing the subjects to use maximum leg muscle power during the jump action[18]. The experimental subjects in that study were able to complete these actions, because it is easier to jump on a trampoline than it is to jump on solid surface. In this study, a significant increase in the dynamic gait index was seen. The dynamic gait index is the tool used to assess the ability to control the reactions when walking

Table 3. Comparison of BBS, TUG, DGI, FES within groups and between groups

Parameters		Values			
		TG (n=12)		CG (n=12)	
		Pre	Post	Pre	Post
Balance	BBS	33.8 (8.2)	44.3 (7.5) *†	34.6 (7.1)	41.8 (6.3)*
	TUG	31.7 (13.2)	26.3 (11.0)*†	32.8 (11.3)	30.7 (11.2)*
Gait	DGI	11.1 (3.4)	17.7 (3.2) *†	12.2 (2.5)	15.5 (3.3)*
Falls efficacy	FES	51.3 (15.4)	63.9 (13.2)*†	52.8 (11.8)	57.1 (13.0)*

Values are means (SD). *Within-group difference ($p<0.05$). †Significantly greater than the CG ($p<0.05$).
TG: trampoline training group; CG: control group; BBS: Berg balance scale; TUG: timed up and go test; DGI: dynamic gait index; FES: falls efficacy scale

tasks change in response to the external environment. Therefore, training the patients to carry out various movements on the unstable surface of the trampoline, would have improved their postural control and balance abilities, as evidenced by the dynamic gait index, which would also have improved their walking abilities.

Falls occur frequently among stroke patients due to their reduced ability to balance[19]. Most falls are caused by a loss of stability in the forward direction[20]. After elderly patients completed the trampoline training program of a previous study, they showed an increased ability to regain their balance when suddenly falling forward[8]. In the present study, the falls efficacy scale significantly increased after the trampoline training. In addition, a score of 20 points or less on the BBS can be interpreted as a high risk of falls, a score between 21 and 40 points as a medium risk of falls, and score of 41 to 56 points suggest a low risk of falls[21]. In the present study, the trampoline training group had a mean BBS score of 33.83, indicating a medium risk of falls before the intervention, and a mean BBS score of 44.25, indicating a lower risk of falls, after the intervention. Balance training using a trampoline is effective at equalizing the muscles and helping them to maintain balance as well as improving the balance of their power and strength[9]. The current study demonstrated that trampoline training improved the falls efficacy by reducing this imbalance, and the result was not ipsilateral to contralateral. Participants performed the various actions on the unstable surface using the handle attached to the trampoline. In addition, performing operations such as hopping or jumping on a trampoline should give patients more experience to help them avoid falls during activities on a solid surface in their homes.

This study had some limitations. First, there was a temporary increase of spasticity in some patients during trampoline training. However, no further increase or continuous degradation was observed when the intervention was suspended. Second, the results of this study cannot be generalized to other populations because of the small sample size and the small area from which the patients were sampled. Therefore, we suggest that further studies be conducted using larger sample sizes as well as considering the muscle tone of patients.

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