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Original Article

Effects of trunk rotation induced treadmill gait training on gait of stroke patients: a randomized controlled trial

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Abstract. [Purpose] This study was conducted to find out the effect of arm swing during treadmill training on the gait of stroke patients. [Subjects and Methods] This study subjects were 20 stroke subjects patients who were randomly assigned to either the experimental group (EG) or the control group (CG), 10 subjects in each group. Therapists induced arm swing of affected side of EG subjects using Nordic poles, while subjects in CG had the affected arm restricted to prevent arm swing. Training was performed for 30 minutes, 3 times a week for 4 weeks. The timed up and go test (TUG), the dynamic gait index (DGI) and the 6-minute walk test (6MWT) were assessed before and after the training. [Results] After the training, there were no significant differences in the TUG times of EG and CG. There were significant differences in the DGI and the 6-minute walking distance of EG, but not of CG. There were also significant differences in the improvements of the DGI and the 6-minute walking distance between the groups. [Conclusion] Arm swing training had a positive effect on patients' gait ability. Further studies are required to generalize the results of this study.
Key words: Arm swing, Gait, Stroke

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INTRODUCTION

To maintain a functional and repetitive gait pattern, it is important to not only increase stride length but also to recover gait symmetry[1]. However, hemiplegic patients have a problem with gait symmetry due to the asymmetry of the lower limbs and restrictions to the movements in the upper extremity of the paretic side during gait[2]. In normal gait, rotational compensation of the arms in the direction opposite to pelvic rotation plays a role in maintaining body balance[3]. Maintaining body balance is thought to reduce the overall energy consumption used by the body[4]. Jackson et al. reported that energy consumption is reduced in terms of the overall body, despite energy consumption by the muscles of the upper extremities involved in swing motion of the arms during a gait cycle[5]. This is because the swing of the upper extremities during the gait cycle induces trunk rotation which helps to maintain body balance, thereby minimizing energy consumption. It has been reported that treadmill gait-training programs are effective at improving the gait and balance abilities of hemiplegic patients[6–8]. Therefore, this study aimed to prove the clinical effect of treadmill gait training with active arm swings, which can induce trunk rotation in the direction opposite to pelvic rotation. This maintains body balance[3, 9, 10] and minimizes the deviation of the body's center of gravity[4, 11, 12].

SUBJECTS AND METHODS

This study enrolled 20 hemiplegic patients attending W Hospital in Daejeon. The subjects were randomly assigned to a control group of 10 subjects who performed treadmill gait training with their arms fixed, and an experimental group of 10 subjects who performed treadmill gait training with arm swings. All subjects were informed of the purpose of this study and they each gave their consent to participation. All of the protocols used in this study were approved by the University of Daejeon. Before participation, the procedures, risks, and benefits were explained to all of the participants, who gave their informed consent. The participants' rights were protected according to the guidelines of the University of Daejeon. The general characteristics of the study subjects are shown in Table 1.

The timed up and go (TUG) test, the dynamic gait index (DGI), and the 6-minute walk test (6MWT) were conducted before and after the intervention. In the TUG, functional mobility and balance ability are evaluated. It has been reported that the intra-rater and inter-rater reliabilities of the TUG test

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are r=0.99 and 0.98, respectively, which are high values[13]. DGI is used to evaluate gait control abilities in response to task changes in external environments[14]. DGI evaluates the balance and gait of chronic stroke patients[15]. The intra-rater and inter-rater reliabilities of DGI are r=0.98 and r=0.96, respectively, which are high values[14]. 6MWT is a method used to evaluate functional capacity and gait endurance[16].

The experimental group performed arm swings during treadmill gait training. For the intervention program of this study, the gait training implemented by Behrman et al. and Stephenson et al. served as references[17, 18]. The subjects held Nordic poles in both hands during treadmill (M90T, Motus, Korea) gait training, while the experimenter also held Nordic poles behind the subject and walked together with the subject, counting out loud to help the subject swing the upper limbs. The gait velocity was increased gradually in accordance with the individual gait abilities of the study subjects, and without interfering with gait independence or stability. If degradation of gait independence or stability of a study subject was noticed, the velocity was reduced to its previous value. The Nordic pole was fixed with a bandage if a subject could not hold the grip of the pole using the hand on the affected side. Arm swing treadmill gait training was performed by the experimental group for 30 min, three times a week for four weeks.

The control group performed arm-fixed treadmill gait training in the same way as the experimental group, but with their hands holding the treadmill grip. If the affected hand could not hold the grip, a bandage was used to fix it to the grip. Starting at a velocity that did not interfere with gait independence or stability, the walking aped was gradually raised from 1.0 Km/h initially up to 3.0 Km/h, according to the individual gait abilities of the subjects. The velocity was increased in increments of 5%[19], and if gait independence or stability were compromised due to the increased velocity, the velocity was reduced to its previous value. Arm fixed treadmill gait training was performed for 30 min, three times a week for four weeks. The average speeds of the experimental and control groups were (mean±SD) 2.8±0.4 and 2.1±0.7 km/h, respectively, and there was no significant difference between them.

The paired t-test was conducted to test the significance of differences in each group between before and after the training, while the independent t-test was conducted to test the significance of differences between the groups before and after the training. A significance level to 0.05 was chosen for statistical analysis.

Table 1. General characteristics of the subjects

Variables		EG (n=10)	CG (n=10)
Gender	Male	7 (35.0)[a]	8 (40.0)
	Female	3 (15.0)	2 (10.0)
Stroke type	Hemorrage	1 (5.0)	5 (25.0)
	Infarction	9 (45.0)	5 (25.0)
Affected side	Lt	5 (25.0)	3 (15.0)
	Rt	5 (25.0)	7 (35.0)
Age (years)		51.5±11.9[b]	55.2±9.5
Onset (months)		17.3±14.5	18.7±6.9

[a]The number of persons (%), [b]Mean±SD, EG: experimental group, CG: control group

RESULTS

Table 2 presents the values of TUG, DGI, and 6MWT of the two groups. The TUG values were not significantly different between before and after the training in the two groups. The DGI values were significantly different ($p<0.05$) after the training in the arm-swing treadmill gait training group, but not in the arm-fixed treadmill gait-training group. The 6MWT values were significantly different ($p<0.05$) after the training in the arm-swing treadmill gait-training group, but not in the arm-fixed treadmill gait training group.

DISCUSSION

No significant difference was found in the TUG values of the arm-swing and arm-fixed treadmill gait training groups before or after the experiment. However, the improvement in the arm-swing treadmill gait training group after the intervention had a p-values of 0.06, which was close to the significance level, whereas that of the arm-fixed treadmill

Table 2. Comparison of the TUG and DGI and 6MWT values of the experimental and control groups

		EG (n=10)	CG (n=10)
TUG (seconds)	Pre-test	20.6±13.6[a]	20.5±7.5
	Post-test	16.5±7.9	18.8±7.2
	Pre-post difference	−4.1±6.0	−1.7±2.8
DGI	Pre-test	13.5±3.9[a]	14.7±5.1
	Post-test	17.0±4.3*	15.0±4.8
	Pre-post difference	3.5±1.7*	1.5±1.7
6MWT (metres)	Pre-test	239.6±98.8[a]	215.8±102.4
	Post-test	278.5±99.3*	219.4±105.3
	Pre-post difference	38.9±19.3*	3.6±12.0

[a] Mean±SD, *$p<0.05$, EG: experimental group, CG: control group, TUG: timed up and go test, DGI: dynamic gait index, 6MWT: 6-minute walk test

gait training group was 0.10. The arm-swing treadmill gait training group showed a significant improvement in DGI compared to the arm-fixed treadmill gait training group after the intervention. Arm-swing during gait helps hemiplegic patients to concentrate on awareness of the upper limb on the affected side[9]. Furthermore, arm-swing helps hemiplegic patients to recognize their arms as a feedback mechanism, which is good for postural adaptation and balance maintenance[9, 10], as well as for minimizing the deviation of the body's center of gravity, thereby reducing muscle effort and energy consumption during gait[4]. Thus, arm- swing treadmill gait training can be considered a method that improves the overall gait and dynamic balance abilities of hemiplegic patients.

The arm-swing treadmill gait training group showed a significant improvement in 6MWT from 239.6±98.8 to 278.5±99.3 m, which was significantly better than that of the arm-fixed treadmill gait training group. The movements of the upper limbs of hemiplegic patients can induce trunk rotation and influence stride length during gait. According to the study of Stephenson et al., the simultaneous harmonic movements of the upper limbs during the gaits of hemiplegic patients induce trunk rotation and increase the range of movement of the ankle joints, thereby increasing stride length[18]. Moreover, Wagenaar and van Emmerik reported that when the movements of the upper limbs of hemiplegic patients are restricted, trunk rotation is limited, thereby reducing stride length, weakening muscle power, and impairing coordination[2]. Accordingly arm-swing treadmill gait training for hemiplegic patients induces trunk rotation leading to increases in stride length, muscle power, coordination, and gait endurance[18].

The limitations of this study are that the study results cannot be generalized to all hemiplegic patients due to the small number of study subjects. Also, the results do not guarantee the long-term effect of arm-swing treadmill gait training, as the effect was studied after only a four-week intervention. Therefore, it will be necessary to conduct research that includes more subjects and analyzes the long-term effects.

REFERENCES

1) Park IM, Oh DW, Kim SY, et al.: Clinical feasibility of integrating fast-tempo auditory stimulation with self-adopted walking training for improving walking function in post-stroke patients: a randomized, controlled pilot trial. J Phys Ther Sci, 2010, 22: 295–300. [CrossRef]
2) Wagenaar RC, van Emmerik RE: Dynamics of pathological gait. Hum Mov Sci, 1994, 13: 441–471. [CrossRef]
3) Ohsato Y: Relationships between trunk rotation and arm swing in human walking. Nippon Seikeigeka Gakkai Zasshi, 1993, 67: 440–448. [Medline]
4) Umberger BR: Effects of suppressing arm swing on kinematics, kinetics, and energetics of human walking. J Biomech, 2008, 41: 2575–2580. [Medline] [CrossRef]
5) Jackson KM, Joseph J, Wyard SJ: A mathematical model of arm swing during human locomotion. J Biomech, 1978, 11: 277–289. [Medline] [CrossRef]
6) Dean CM, Richards CL, Malouin F: Task-related circuit training improves performance of locomotor tasks in chronic stroke: a randomized, controlled pilot trial. Arch Phys Med Rehabil, 2000, 81: 409–417. [Medline] [CrossRef]
7) Indredavik B, Fjaertoft H, Ekeberg G, et al.: Benefit of an extended stroke unit service with early supported discharge: a randomized, controlled trial. Stroke, 2000, 31: 2989–2994. [Medline] [CrossRef]
8) Takami A, Wakayama S: Effects of partial body weight support while training acute stroke patients to walk backwards on a treadmill—A controlled clinical trial using randomized allocation. J Phys Ther Sci, 2010, 22: 177–187. [CrossRef]
9) Faghri PD, Rodgers MM, Glaser RM, et al.: The effects of functional electrical stimulation on shoulder subluxation, arm function recovery, and shoulder pain in hemiplegic stroke patients. Arch Phys Med Rehabil, 1994, 75: 73–79. [Medline]
10) Yavuzer G, Ergin S: Effect of an arm sling on gait pattern in patients with hemiplegia. Arch Phys Med Rehabil, 2002, 83: 960–963. [Medline] [CrossRef]
11) Eke-Okoro ST, Gregoric M, Larsson LE: Alterations in gait resulting from deliberate changes of arm-swing amplitude and phase. Clin Biomech (Bristol, Avon), 1997, 12: 516–521. [Medline] [CrossRef]
12) Ford MP, Wagenaar RC, Newell KM: The effects of auditory rhythms and instruction on walking patterns in individuals post stroke. Gait Posture, 2007, 26: 150–155. [Medline] [CrossRef]
13) 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]
14) Shumway-Cook A, Gruber W, Baldwin M, et al.: The effect of multidimensional exercises on balance, mobility, and fall risk in community-dwelling older adults. Phys Ther, 1997, 77: 46–57. [Medline]
15) Jonsdottir J, Cattaneo D: Reliability and validity of the dynamic gait index in persons with chronic stroke. Arch Phys Med Rehabil, 2007, 88: 1410–1415. [Medline] [CrossRef]
16) Mossberg KA: Reliability of a timed walk test in persons with acquired brain injury. Am J Phys Med Rehabil, 2003, 82: 385–390, quiz 391–392. [Medline] [CrossRef]
17) Behrman AL, Harkema SJ: Locomotor training after human spinal cord injury: a series of case studies. Phys Ther, 2000, 80: 688–700. [Medline]
18) Stephenson JL, De Serres SJ, Lamontagne A: The effect of arm movements on the lower limb during gait after a stroke. Gait Posture, 2010, 31: 109–115. [Medline] [CrossRef]
19) Yang YR, Tsai MP, Chuang TY, et al.: Virtual reality-based training improves community ambulation in individuals with stroke: a randomized controlled trial. Gait Posture, 2008, 28: 201–206. [Medline] [CrossRef]