Does training sitting balance on a platform tilted 10° to the weak side improve trunk control in the acute phase after stroke? A randomized, controlled trial

【要約】

Introduction

Trunk performance is an important indicator of future functional outcome after stroke.[1-3] Sitting ability is one of the most important factors to improve independence in activities of daily living (ADLs) for persons with acute-phase stroke. A cross-sectional study showed that significant relationships are evident among trunk performance, body balance, gait capacity, and functional ability after stroke.[4] Moreover, trunk performance was the most important predictor of ADL evaluated by the Barthel Index at 6 months after stroke.[5] Thus, clear evidence regarding the importance of trunk function after stroke has been provided.

Only a few acute-phase stroke rehabilitation studies for trunk dysfunction have been reported.[6,7] These studies showed that trunk exercise had a positive effect in the acute phase, but the interventions consisted of several exercises. Cabanas-Valdes et al[8] in a systematic review that there was moderate evidence that trunk training exercises improve trunk performance and dynamic sitting balance in persons with sub-acute and chronic stroke.

On the other hand, Nes et al[9] reported that the root mean square of the center-of-pressure velocity values, which is a standardized balance parameter, was significantly higher in the lateral direction than in the antero-posterior direction in persons with stroke. Verheyden et al[10] performed kinematic analysis of sideways reaching with the unaffected arm while seated in the sub-acute phase after stroke. The results showed that patients reached less far and moved at a slower speed than the control group. Verheyden et al emphasized the importance of the treatment strategy to improve lateral trunk control.

These above-mentioned studies suggest that training for lateral trunk control in the acute phase after stroke may effectively recover impaired trunk functions. However, to the best of our knowledge, there is no evidence of a focus on lateral trunk control after stroke. Therefore, we hypothesized that physical therapy focusing on trunk control with lateral sitting training on a tilting platform to the paretic side will improve trunk impairment after stroke. The purpose of the present study was to examine the effects of lateral sitting training on a tilting platform on trunk functions in persons with acute stroke.

Participants and Methods

Participants

Participants who attended the inpatient rehabilitation program and had hemiparesis after stroke at the Saitama Medical University International Medical Center were recruited. The physicians confirmed the diagnosis of stroke by CT or MRI.

Participants had to meet the following criteria: (1) over 20 years old; (2) no past history of stroke; (3) supratentorial lesion of the brain; (4) stable neurological symptoms and general condition; (5) ability to sit without support; (6) the trunk function evaluation (described below) score was not maximal at the start of study; (7) no dementia or psychiatric disorder; (8) ability to understand instructions; (9) no orthopedic problem that would interfere with the ability to perform lateral sitting training; and (10) able to provide informed consent. All participants received an explanation about the purpose of the study and provided their consent in writing. The study was approved by the Saitama Medical University International Medical Center and Tokyo Metropolitan University Ethics

Committees (09-078).

Design and Randomization

The design of this study was an assessor-blinded, randomized, controlled trial. Patients were divided into an experimental group and a control group by block randomization. The method of allocation was concealed in sequentially numbered, sealed, opaque envelopes. Randomization was done by an individual who was unrelated to the assessment or treatment of the patients. The third author (K.F.) undertaking the assessment of the outcome measurements did not know which group the patients were in. Outcomes were evaluated twice, before training and after 1 week of training, and they did not depend on the subjective judgment of the therapist.

Intervention

Patients in both groups received the conventional stroke rehabilitation program. The conventional program is patient-specific and consists of usual physiotherapy, occupational therapy, neuropsychological therapy, speech therapy, and nursing care. Usual physiotherapy includes mobilization, sit-to-stand training, gait training, and ADL training.

In addition to conventional therapy, patients received standardized lateral sitting training. The experimental group sat without leg support on a platform tilted 10 degrees to the paretic side in the frontal plane, while the controls sat on a horizontal platform. The angle of inclination of the platform was determined from clinical judgment, based on the fact that patients were not able to maintain a sitting position at an angle greater than 10 degrees. As a visual clue, a vertical string was placed in front of the wall. Both groups were asked to move their trunk laterally from the paretic side to the non-paretic side. After lateral movement of the trunk to a vertical visual target, patients were tilted (back) to the paretic side as much as possible under their own control. Patients were instructed to gaze at a visual clue and to refrain from rotating their trunk. This training was focused on the patients controlling their posture actively and was set to a comfortable speed for the patients. This training program was performed 60 times per session, with 6 sessions in one week. One session was completed in about 15 minutes in both groups. Patients in both groups received conventional physiotherapy and occupational therapy for 1 hour each per day.

Assessments

Clinical measurements.

Patients were evaluated using the Stroke Impairment Assessment Set (SIAS),[11] which is a standardized measure of stroke impairment consisting of the subcategories of motor function, muscle tone, sensory function, range of motion (ROM), pain, trunk function, visuospatial function, speech, and unaffected side function. There are 22 items in total, and each item is rated from 0 (severely impaired) to 3 (normal) for muscle tone, sensory, ROM, pain, trunk, higher cortical function, and unaffected side function or to 5 (normal) for motor function (total score range, 0 to 76).

The Trunk Control Test (TCT) was used to evaluate trunk function.[12] The TCT examines four axial movements: rolling from a supine position to the paretic side and to the non-paretic side, sitting up from a lying-down position, and sitting in a balanced position on the edge of the bed with feet off the ground for 30 seconds. The scoring is as follows: 0, unable to perform movement without assistance; 12, able to perform movement but in an abnormal manner; and 25, able to complete movement normally (total score range, 0 to 100).

Kinematic analysis

The ability to move the trunk laterally was evaluated kinematically. In both groups, patients sat on a horizontal platform and were asked to move the trunk laterally to the left or right as much as they could (trunk laterally task), twice on each side. Patients were instructed to gaze at a visual clue to minimize the compensatory movement by rotation or flexion of the head and trunk. Tasks were performed a total of four times, starting with the non-paretic side, and then from the paretic side, and continued in ABBA order. Each task was measured for 20 seconds from the start signal. For the purpose of image analysis, video was recorded by a digital video camera (NV-GS300-S, Panasonic, Tokyo, Japan), which was placed 4 meters posterior to the subject at a height of 110 cm. Five reflective markers were placed on the head (external occipital protuberance) and spines (seventh cervical vertebra (C7), and the fourth lumbar spinous process (L4)) of the patients, as well as at both ends of the platform. The markers were attached to tight black clothes that the participants wore for the experiments. The images were transferred to a personal computer, and two-dimensional coordinates were calculated with motion analysis software (Frame-DIAS IV, DKH Corp, Tokyo, Japan). The head orientation was defined as the angle formed by the line connecting the head and C7 (head–C7) and the vertical axis. The angle formed by C7-L4 and the vertical axis was defined as the body axis. The vertical axis was defined as the angle formed by the line connecting both ends of the platform. The angle change of the non-paretic side was regarded as the positive direction in the image analysis. Postural angle data of pictures captured over 3 seconds at a stable maximal lateral shifting position in the trunk laterally task were analyzed. The mean postural angle was calculated for both the paretic and the non-paretic sides in the trunk laterally task.

Statistical analysis

Variables collected to describe the sample were age, sex, time since stroke onset, diagnosis (infarction or hemorrhage), paretic side, and initial SIAS and TCT scores. To assess the effect of the randomization procedure, differences between the 2 groups for the variables mentioned above were evaluated by independent *t*-tests or chi-square tests. To analyse the results, two-way repeated measures analysis of variance was used. The changes in clinical measurements and the trunk laterally task were investigated by two-way ANOVA. Data analysis was performed using PASW for Windows version 18.0 (SPSS Inc, Tokyo, Japan). The level of significance for all analyses was set at $p < 0.05$.

To determine the power of the main effects and the interaction, a post hoc power calculation was performed using G*Power3 (Heinrich Heine University, Düsseldorf, Germany) [13]. The power ($1-\beta$) was calculated from the number of samples in the study (n=30), the effect size (f=0.4) according to the criteria of Cohen, and the significance level (p=0.05).[14]

Results

Participants

Over the 11-month period (June 2010 to April 2011), 289 patients were attending the stroke rehabilitation program. A total of 246 patients were ineligible for inclusion. Thus, 43 patients were assigned to either the experimental group or the control group. Seven subjects in the experimental group and six subjects in the control group were excluded from the study due to discharge to another hospital or deterioration of neurological symptoms. Therefore, 30 patients (experimental group, n = 15; control group, n = 15) were finally included in the study. No significant differences were observed between the experimental and control groups.

Outcome measures

For the SIAS, the main effect of time was significant ($p<0.01$). This result showed the functional improvement after training. On the other hand, in the SIAS, the main effect of group and the interaction between group and time were not significant ($P>0.05$).

In the TCT, the group×time interactions were significant ($p<0.01$). Moreover, the test of simple main effects in the TCT showed no significant difference before and after training in the control group, but a significant difference in the experimental group ($p<0.01$). In the TCT, although the main effect of group was not significant, the main effect of time was ($p<0.01$). This result showed that the magnitude of the increase was significantly greater in the experimental group than in the control group.

In the trunk laterally task of lateral transfer to the paretic side, the head orientation for the main effect of each factor and interaction were not significant in both groups, but the body axis had a significant difference only for the main effect of time ($p<0.01$). In other words, this result showed the expansion of the angles from the midline to the paretic side after training.

In the trunk laterally task of lateral transfer to the non-paretic side, the group×time interactions for the head orientation and the body axis were significant ($p<0.05$). Moreover, the test of simple main effects in the trunk laterally task of lateral transfer to the non-paretic side showed no significant difference before and after training in the controls, but a significant difference was observed in the experimental group ($p<0.05$). In the trunk task of lateral transfer to the non-paretic side, the main effect of group was not significant both for the head orientation and the body axis, but the main effect of time was significant ($p<0.01$).

Post hoc power calculation

The power of the main effect of each factor and interaction was 0.69 for group and 0.98 for time and interaction.

Discussion

This study demonstrated that mass practice of trunk control on a tilted platform is more effective than mass practice on a level platform in acute stroke patients.

For the SIAS, which is a general evaluation of stroke, the main effect of time was significant, but the interaction was not in the present study. The SIAS includes not only trunk function, but also many other items; therefore, the effect of trunk training in this study was not reflected in the interaction with the SIAS.

However, the TCT improved significantly in the experimental group compared with that in the control group. These results indicate that lateral sitting training on the inclined seat surface improved trunk performance in the short term. It has been reported that the TCT is strongly associated with the prognosis for walking capacity and ADL. Previous studies have shown a significant relationship between trunk performance measured at 14 days after stroke or on admission to the rehabilitation center and functional ability measured at discharge from the rehabilitation center and even 6 months after stroke.[1,2] In addition, the TCT on admission is an important factor related to walking capacity at discharge.[3] The present results suggest that treatment to improve impaired trunk performance in the acute phase may result in a beneficial effect on functional long-term prognosis.

On the other hand, in the kinematic analysis of the trunk laterally task to the non-paretic side of the experimental group, the angle of head orientation was significantly decreased, but the angle of the body axis was significantly increased after training. These results suggest that lateral sitting training induced not only expansion of body movement to the non-paretic side, but also the optical righting reaction of postural control. Since this study was intended for early-onset stroke patients, bias due to spontaneous recovery may be included. However, the above results suggest that the additional effect was caused by tilting the platform.

The training program of the present study was focused on actively inducing the patient's own postural control and using it in the daily rehabilitation setting. It could be argued that the method of the trunk laterally task is similar to the training program; therefore, the result of kinematic analysis is thought to be a natural result. In other words, the most important point is that the movement required for ADL will be induced by task-specific exercise in the acute phase.

In the trunk laterally task of lateral transfer to the paretic side, the main effect of time on the body axis was significant. This result indicates that stability of the trunk muscles of lateral trunk control to the non-paretic side is obtained before that to the paretic side is recovered. We would like to clarify this in our next study.

In the patients involved in the present study, impaired trunk function was evaluated as moderate by the TCT score. The present results may depend on the severity of trunk dysfunction. Therefore, it would be useful for the next study to increase the number of cases to evaluate treatment for patients with varying severities of trunk dysfunction.

This study has some limitations. First, the efficacy of tilted platform alone or horizontal platform alone interventions for trunk control after stroke was not investigated prior to this study. This decreases the strength of this comparative effectiveness trial. Second, only the short-term effects of training sitting balance on a platform tilted 10° to the weak side were evaluated. In addition, there was a lack of follow-up of patients to determine if the improvement persisted. Moreover, it is necessary to examine whether the treatment period was appropriate. Third, this study had a relatively small sample size. Thus, further studies will include examination of the long-term effects of training sitting balance on a platform tilted 10° to the weak side on standing balance, gait function, and ADL with a larger number of patients. Fourth, neither the patients nor the physiotherapists who delivered the interventions were blinded, which may have introduced a bias in the results. Fifth, this study had many patients who were ineligible for inclusion. This training was focused on patients controlling their posture actively; therefore, it was necessary that patients be able to complete the training and assessment tasks. Further research is required to discover effective interventions for those who cannot sit unsupported.

Conclusion

This study compared the effectiveness of training sitting balance on a platform tilted 10° to the weak side to postural alignment on a horizontal platform in stroke patients. The results demonstrated that practicing trunk movements to either side on a platform sloping towards the weak side leads to greater recovery of trunk control than the same practice on a level platform in patients with acute stroke. It was shown that lateral sitting training on a tilting platform is useful for improving trunk performance. This suggests that there is therapeutic potential for lateral trunk control in stroke rehabilitation.

Moreover, lateral trunk control during sitting in the acute phase after stroke might be first stabilized on the non-paretic side and then on the paretic side. In general, it is important to gain postural control on the non-paretic side first in stroke rehabilitation during the acute period. The results of the present study support this strategy of rehabilitation from the acute phase.

References

[1] Franchignoni FP, Tesio L, Ricupero C, Martino MT. Trunk control test as early predictor of stroke rehabilitation outcome. *Stroke.* 1997; 28: 1382–1385.

[2] Hsieh CL, Sheu CF, Hsueh IP, Wang CH. Trunk control as an early predictor of comprehensive activities of daily living function in stroke patients. *Stroke.* 2002; 33: 2626–2630.

[3] Masiero S, Avesani R, Armani M, Verena P, Ermani M. Predictive factors for ambulation in stroke patients in the rehabilitation setting: A multivariate analysis. *Clin Neurol Neurosurg*. 2007; 109: 763–769.

[4] Verheyden G, Vereeck L, Truijen S, Troch M, Herregodts I, Lafosse C, et al. Trunk performance after stroke and the relationship with balance, gait and functional ability. *Clin Rehabil*. 2006; 20: 451–458.

[5] Verheyden G, Nieuwboer A, De Wit L, Feys H, Schuback B, Baert I, et al. Trunk performance after stroke: an eye-catching predictor of functional outcome. *J Neurol Neurosurg Psychiatry.* 2007; 78: 694-698.

[6] Karthikbabu S, Nayak A, Vijayakumar K, Misri Z, Suresh B, Ganesan S, et al. Comparison of physio ball and plinth trunk exercises regimens on trunk control and functional balance in patients with acute stroke. *Clin Rehabil*. 2011; 25: 709–719.

[7] Saeys W, Vereeck L, Truijen S, Lafosse C, Wuyts FP, Heyning PV. Randomized controlled trial of truncal exercises early after stroke to improve balance and mobility. *Neurorehabil Neural Repair.* 2012; 26: 231–238.

[8] Cabanas-Valdés R, Cuchi GU, Bagur-Calafat C. Trunk training exercises approaches for improving trunk performance and functional sitting balance in patients with stroke: A systematic review. *NeuroRehabilitation.* 2013; 33: 575-592.

[9] Van Nes IJ, Nienhuis B, Latour H, Geurts AC. Posturographic assessment of sitting balance recovery in the subacute phase of stroke. *Gait Posture.* 2008; 28: 507–512.

[10] Verheyden G, van Duijnhoven HJ, Burnett M, Littlewood J, Kunkel D, Ashburn AM. Kinematic analysis of head, trunk, and pelvis movement when people early after stroke reach sideways. *Neurorehabil Neural Repair.* 2011; 25: 656–663.

[11] Tsuji T, Liu M, Sonoda S, Domen K, Chino N. The stroke impairment assessment set: Its internal consistency and predictive validity. *Arch Phys Med Rehabil.* 2000; 81: 863–868.

[12] Collin C, Wade DT. Assessing motor impairment after stroke: a pilot reliability study. *J Neurol Neurosurg Psychiatry.* 1990; 53: 576–579.

[13] Faul F, Erdfelder E, Buchner A, Lang AG. Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods.* 2009; 41: 1149–1160.

[14] Cohen J. Statistical power analysis for the behavioural sciences. 2nd ed. Hillsdale, NJ:

Lawrence Erilbaum; 1988.