

The Effects of Core Stability Exercise on the Ability of Postural Control in Patients With Hemiplegia

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Abstract

Core stability exercises for patients with hemiplegia have become increasingly important and a variety of exercises have been developed over the years to give the hemiplegic patients more stable postural control. This study examined the therapeutic effects of the core stability exercises on the ability of static and dynamic postural control. Fifteen hemiplegic patients (7 males, 8 females, age ranging from 46 to 76 years) hospitalized in a Daejeon rehabilitation hospital were enrolled in this study. Nine and 6 patients had a cerebral infarction and cerebral hemorrhage, respectively. The subjects participated in a core stability exercise program consisting of a total of 12 sessions 3 times each week over a 4-week period with each exercise lasting approximately 15 minutes. The ability of static and dynamic postural control by Berg Balance Scale (BBS) and Timed Up and Go (TUG), respectively, were measured before and after the core stability exercise. A Wilcoxon signed ranks test was used to compare the effects of the ability of static and dynamic postural control before and after core stability exercise in patients with hemiplegia. The $\alpha=.05$ level of significance was used for the statistical tests. Core stability exercises were effective in improving the ability of static postural control; BBS ($p<.05$). Core stability exercises were also effective in improving the ability of dynamic postural control; TUG ($p<.05$). Overall, core stability exercise is believed to be an important therapeutic method in rehabilitation programs for hemiplegic patients.

Key Words: Berg balance scale; Core stability exercise; Postural control; Timed up and go.

Introduction

The World Health Organisation defines stroke as “rapidly developing clinical signs of focal (or global) disturbance of cerebral function, with symptoms lasting 24 hours or leading to death, with no apparent cause other than vascular origin” (WHO, 1988). A majority of the survivors from stroke have a combination of sensory, motor, cognitive and emotional impairments leading to restrictions in their capacity to perform basic activities of daily living (Hochstenbach et al, 1996). After a stroke, the ability to control balance in the sitting and standing positions is a fundamental skill of motor behavior for achieving autonomy in everyday activities. The pos-

tural performance of patients soon after a stroke has been found to be closely correlated with long-term functional improvement (Feigin et al, 1996). Because it may help in establishing the severity and prognosis of a stroke, the early assessment of balance in stroke survivors is an important part of the clinical examination (Benaim et al, 1999). Comparative studies of the standing balance of subjects with hemiplegia and normal controls have produced significant differences in balance coefficients, subjects with hemiplegia having greater sway and asymmetry of weight distribution. Among many biological and functional characteristics, postural control is the best predictor of achieving independent living (Lin et al, 2001) and shows the highest correlation ($r=.70$) with

person-perceived disability after discharge from rehabilitation unit (Desrosiers et al, 2002). Loss of postural control has been recognised as a major health problem in individuals with stroke resulting in a high incidence of falls both during rehabilitation and thereafter, particularly in those patients with both motor and sensory deficits (Forster and Young, 1995). Rapid and optimal improvement of postural control in patients with stroke is, therefore, essential to their independence, social participation and general health.

Core strengthening has been rediscovered in rehabilitation. In essence, all terms describe the muscular control required around the lumbar spine to maintain functional stability. The “core” has been described as a box with the abdominals in the front, paraspinals and gluteals in the back, the diaphragm as the roof, and the pelvic floor and hip girdle musculature as the bottom (Richardson et al, 1999). The development of techniques enabling measurement of transverse abdominis (TrA) electromyographic (EMG) activity using finewire electrodes inserted under the guidance of ultrasound imaging has allowed the direct investigation of the recruitment of this muscle (Cresswell et al, 1992; De Troyer et al, 1990; Goldman et al, 1987). When subjects performed isometric trunk flexion in side lying, all of the abdominal muscles were active, including TrA. In addition, TrA was recruited continuously during flexion and extension of the trunk in standing whereas the other abdominal muscles and erector spinae (ES) were phasically active to initiate and decelerate the trunk movement (Cresswell et al, 1992). The TrA has been shown to activate before limb movement in healthy people, theoretically to stabilize the lumbar spine (Akuthota and Nadler, 2004). In various studies it has been proven that there is a relationship between the core stability exercises for athletes which attest to the effects of core stability. Providing those as bases, Physical Therapists have taken core stability exercise into consideration in most sessions of treatment. However, there is a different approach to be deliberated depending on the patient's case and status,

which Physical Therapists encounter in the clinical sessions. Such considerations might include patients who have got injuries from musculoskeletal or cerebrovascular lesions. Accordingly, a further understanding of the effects of core stability exercise affecting the ability of postural control is essential for the effective treatment of patients with hemiplegia. This study examined the effects of core stability exercise, which improves the ability of postural control.

Methods

Participants and Period

This study included 15 patients with hemiplegia aged 46 to 76 who were hospitalized in Daejeon rehabilitation hospital and diagnosed with stroke resulting in hemiplegia at least in the previous 3 months, and completed the following from January 16th 2009 to February 13th 2009.

The inclusion criteria were as follows: 1) Gait independently, 2) no orthopedic problems on the lower limb, 3) no major cognitive or perceptual problems, 4) no cardiovascular problems, 5) no visual problems, and 6) the ability to understand instructions.

Flow Diagram

Core stability exercises have been carried out 3 times per week over a 4-week period and measured mean of Berg Balance Scale (BBS) and Timed Up and Go (TUG) before and after core stability exercises. Subjects were initially recruited 17 for this study, but 2 subjects were dropped out in the process because of inappropriate inclusion criteria and discharge respectively. Flow diagram of the study is given in figure 1.

Core Stability Exercises

Core stability exercises were as follows: The core stability exercises consisted of a total of 12 sessions 3 times each week over a 4-week period with each exercise lasting for approximately 15 minutes.

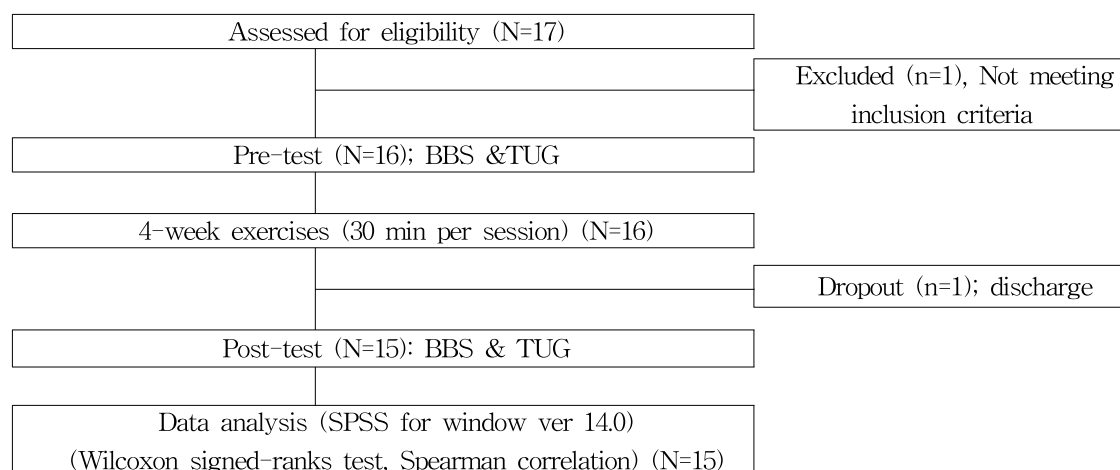


Figure 1. Flow diagram.

1. Modified breathing exercise

This exercise facilitates the TrA in that the mechanical effect of TrA contraction can control the abdominal content (Goldman et al, 1987; De Troyer et al, 1990). Figure 2 and 3 shows the procedure for the core stability exercise using modified breathing exercise.

- ① Relax the patient's muscle tone on the back of the neck.
- ② Maintain both knee joints at 45 degrees of flexion and spread both knees out to the width of the pelvis.
- ③ Put the therapist's hands on the patient's abdominal area and then press slightly (Abdominal breathing).
- ④ Make the patient lift the abdominal area while inhaling.
- ⑤ Make the umbilicus move down and rostrally while exhaling.
- ⑥ Have the patient practice this three of four times and then rest.
- ⑦ Make the therapist's hands move onto both lower ribs (Intercostal breathing).
- ⑧ Make the patient's ribs expand while inhaling and narrow while exhaling.
- ⑨ Have the patient practice this three of four times and then rest.

2. Core stability exercise by using a wedge

This exercise facilitates the activation of TrA and oblique abdominis to stabilize the lower abdominal muscle (Liebenson, 1998). Figures 4 and 5 outline the procedure of the core stability exercise using a wedge.

- ① Put a wedge below patient's knee joints to prevent compensation of the lower limbs while exercising on the supine position
- ② Make patient's pelvis tilt posteriorly for to maintain the muscle tone of the lower abdominis
- ③ Maintain the length of the muscle on the back of the neck but neck not to flex it.
- ④ Release the muscle tone of the rhomboid muscles on the medial boarder of both scapulars to reduce the retraction of the upper limbs.
- ⑤ Stabilize the upper chest to induce the muscle tone of the lower abdominal muscle.
- ⑥ Guide both upper limbs to be protracted by holding the patient's hands.
- ⑦ Guide the patient by the therapist.

Measurements

1. The ability of static postural control; Berg Balance Scale (BBS)



Figure 2. Abdominal breathing.



Figure 3. Intercostal breathing.



Figure 4. Protraction of both upper limbs.



Figure 5. Contraction of transverse abdominus.

The BBS was developed as a performance-oriented measure of balance in elderly individuals. The BBS grades 14 tasks on a scale from 0 to 4 for each task, with 0 indicating an inability to complete the task entirely. Scores can range from 0 to 56. (Berg, 1995).

2. The ability of dynamic postural control; Timed Up & Go Test (TUG)

The TUG measures the time it takes a subject to stand up from an armchair, walk a distance of 3 m, turn, walk back to the chair, and sit down (Mathias, 1986). Podsiadlo and Richardson (1991) modified the original test by timing the task (rather than scoring it qualitatively) and proposed its use as a short test of basic mobility skills for frail community-dwelling elderly.

Data Analysis

All the data was analyzed using SPSS (Statistical Package for the Social Science) Version 14.0 for Windows. A Wilcoxon signed ranks test was used to compare the effects of the ability of static and dynamic postural control before and after the core stability exercise in patients with hemiplegia. The $\alpha = .05$ level of significance was used for the statistical tests.

Results

General Characteristics of Subjects

Seventeen subjects were initially enrolled in this study. However, 2 subjects dropped out because of inappropriate inclusion criteria and discharge, respectively. The remaining 15 subjects aged 46 to 76 included 7 males (47%) and 8 females (53%). Nine (60%) and 6 (40%) had a cerebral infarction and cerebral hemorrhage, respectively. Eight and 7 subjects had right and left hemiplegia, respectively. The time since the stroke was 3 (20%) below 12 months and 9 (60%) between 13 months to 24 months, and 3 more than 25 months (Table 1).

The Effects of Core Stability Exercises

1. Variations of the ability of the static and dynamic postural control

In the BBS scores of the subjects before and after the core stability exercises, the scores were improved by approximately 7 from 40.80 ± 8.30 before the core stability exercises to 47.33 ± 6.24 after the core stability exercises, indicating a significant variation ($p < .05$).

In the TUG score of subjects before and after the core stability exercise, the scores were reduced by approximately 7 from 35.33 ± 25.64 before the core

Table 1. General characteristics of the subjects at the baseline (N=15)

Subject	Sex	Age (yrs)	Paretic side	Lesion of site	Time since stroke (month)
1	M	52	Left	CI ^a (Lt. BG ^b)	22
2	M	51	Left	CI (Rt. MCA ^c , PCA ^d)	21
3	M	52	Right	ICH ^e (Lt. BG)	18
4	M	64	Right	CI (Lt. MCA)	5
5	M	59	Right	CI (Lt. BG)	17
6	M	57	Left	ICH	26
7	M	66	Left	CI (Rt. BG)	4
8	F	72	Right	CI (Pons)	20
9	F	62	Left	SAH ^f	14
10	F	76	Left	CI (Rt. BG)	11
11	F	46	Right	ICH (Lt. BG)	21
12	F	65	Right	ICH (Lt. Thalamus)	46
13	F	60	Left	ICH	22
14	F	64	Right	CI (Lt. Thalamus)	15
15	F	54	Right	CI	30

^aCerebral infarction, ^bBasal ganglia, ^cMiddle cerebral artery, ^dPosterior cerebral artery, ^eIntracerebral hemorrhage, ^fSubarachnoid hemorrhage.

Table 2. Changes in BBS and TUG before and after the core stability exercises (N=15)

	Before exercise	After exercise	Z	p
BBS	40.80±8.30 ^a	47.33±6.24	-3.11	.002
TUG	35.33±25.64	28.18±17.17	-2.10	.036

^aMean±SD.

stability exercises to 28.18±17.17 after the core stability exercise, which shows significant variation statistically ($p<.05$) (Table 2).

Table 3 shows the individual variations of BBS and TUG before and after the core stability exercises.

Discussion

Stroke survivors present with deficits in different systems, including sensory, musculoskeletal, perceptual, and cognitive, which decrease postural stability (Duncan, 1994; Wade et al, 1992). Balance is diminished in people with hemiplegia and hemiparesis (Bohannon, 1987; Liston and Brouwer, 1996). Postural sway for pa-

tients with hemiplegia can be twice that of their age-matched peers (Nichols, 1997). Normal limits of stability describe a theoretical cone extending around a person's feet, with a maximal displacement angle equal to 6 to 8 degrees anteriorly, 4 degrees posteriorly, and 8 degrees laterally to each side (Liston and Brouwer, 1996; Nichols, 1997; Hamman et al, 1992).

Strong abdominal muscles could provide support for the lumbar spine (Robinson, 1992). Recently the focus has turned to TrA, the deepest of the abdominal muscles, with the assumption that this component of the abdominal muscle group provides a specific contribution to spinal stability (O'Sullivan et al, 1997). Due to this horizontal fiber orientation, contraction of TrA results in a reduction of abdominal circumference with a resultant increase in tension in the thoracolumbar fascia and an increase in intra-

Table 3. Individual variations of the BBS and TUG before and after the core stability exercises (N=15)

Subject	BBS		TUG	
	Before exercise	After exercise	Before exercise	After exercise
1	25	31	51.85	43.06
2	28	38	50.35	59.20
3	33	45	34.10	28.97
4	47	24	86.72	26.86
5	48	50	17.81	12.75
6	51	25	16.83	34.81
7	48	54	20.57	12.95
8	41	44	61.68	45.87
9	39	45	21.70	16.25
10	48	46	24.76	23.35
11	47	49	113.07	61.96
12	43	51	25.00	17.76
13	34	52	16.72	12.00
14	33	53	15.18	12.52
15	47	53	23.61	14.37

abdominal pressure (if displacement of the abdominal contents is prevented) (McGill, 1996).

This study examined the effects of the core stability exercise on improving the ability of postural control. Seventeen subjects were initially recruited, but 2 dropped out because of inappropriate inclusion criteria and discharge, respectively.

Geiger et al (2001) have shown that conducting biofeedback and conventional physical therapy programme resulted in improving BBS by 45.69 before performing exercise program to 51.54 after performing exercise program. In this study, a mean BBS score of 40.80 before the core stability exercises was increased to a mean BBS score of 47.33 after. These results show that the core stability exercises was effective in improving the ability of static postural control in patients with hemiplegia. Ranges of TUG scores have been reported for various samples of elderly people. In the previous study by 10 men and women without known pathology, aged 70 to 84 years ($X=75$ years), had a mean TUG score of 8.50 seconds (range=7-10) (Podsiadlo & Richardson, 1991). In this study, a mean TUG score of 35.33 seconds before the core stability

exercises was reduced to 28.17 seconds after. This suggests that the core stability exercises were effective in improving the ability of dynamic postural control in patients with hemiplegia.

This study is focused and limited to the effects of core stability exercise on the ability of postural control in patients with hemiplegia. The study is bounded to subjects who just enrolled from a definite hospital in Daejeon. In addition, the subjects were part of a small group sample size as 15 subjects with no control group to be able to compare the effects of the treatment. Moreover, core stability exercises were used 3 days a week, and this study did not take into consideration the effects of other treatment methods used on the other days, so the results may not be solely due to the core stability exercises. Therefore this study is limited to generalize the results of this study to whole patients with hemiplegia.

The hypotheses in this study were as follows: 1) Core stability exercises such as modified breathing exercise and exercise using a wedge that stimulates transverse abdominis will be effective in improving the ability of static postural control in patients with

hemiplegia; 2) Core stability exercises, such as modified breathing exercise and exercise using a wedge that stimulates transverse abdominus, will be effective in improving the ability of dynamic postural control in patients with hemiplegia. Therefore, these results highlight the need for a further consideration of core stability exercises in a physical therapy setting to improve the static and dynamic postural control of patients with hemiplegia.

Conclusion

This study was performed over a one month period from the 16th of January 2009 to the 13th of February 2009 to determine the effects of the core stability exercise on improving the ability of postural control. The subjects were patients with hemiplegia from stroke and the duration from stroke to exercise was more than 3 months. The changes in the ability of postural control were measured after carrying out core stability exercises over a 4-week period. Core stability exercises were effective in improving the ability of static postural control; BBS ($p < .05$). Core stability exercises were effective in improving the ability of dynamic postural control; TUG ($p < .05$). These results showed that the core stability exercises are effective in improving the ability of postural control in patients with hemiplegia from stroke.

References

- Akuthota V, Nadler SF. Core strengthening. Arch Phys Med Rehabil. 2004;85(3 suppl 1):S86-S92.
- Berg KO, Maki BE, Williams JI, et al. Clinical and laboratory measures of postural balance in an elderly population. Arch Phys Med Rehabil. 1992a;73(11):1073-1080.
- Berg KO, Wood-Dauphinee SL, Williams JI, et al. Measuring balance in the elderly: Validation of an instrument. Can J Public Health. 1992b;83(suppl 2):S7-11.
- Berg K, Wood-Dauphinee S, Williams JI. The balance scale: Reliability assessment with elderly residents and patients with an acute stroke. Scand J Rehabil Med. 1995;27(1):27-36.
- Bogle Thorbahn LD, Newton RA. Use of the Berg Balance Test to predict falls in elderly persons. Phys Ther. 1996;76(6):576-583.
- Bohannon RW. Gait performance of hemiparetic stroke patients: Selected variables. Arch Phys Med Rehabil. 1987;68(11):777-781.
- Benaim C, Alain D, Jacqueline P et al. Validation of a standardized assessment of postural control in stroke patients: The Postural Assessment Scale for stroke patients (PASS), Stroke. 1999;30(9):1862-1568.
- Cresswell AG, Grundstrom H, Thorstensson A. Observations on intra-abdominal pressure and patterns of abdominal intra-muscular activity in man. Acta Physiol Scand. 1992;144(4):409-418.
- Desrosiers J, Noreau L, Rochette A, et al. Predictors of handicap situations following post-stroke rehabilitation. Disabil Rehabil. 2002;24(15):774-785.
- De Troyer A, Estenne M, Ninane V, et al. Transversus abdominis muscle function in humans. J Appl Physiol. 1990;68(3):1010-1016.
- Duncan PW. Stroke disability. Phys Ther. 1994;74(5):399-407.
- Feigin L, Sharon B, Czaczkes B, et al. Sitting equilibrium 2 weeks after a stroke can predict the walking ability after 6 months. Gerontology. 1996;42(6):348-353.
- Forster A, Young J. Incidence and consequences of falls due to stroke: A systematic inquiry. BMJ. 1995;311(6997):83-86.
- Geiger RA, Allen JB, O'Keefe J, et al. Balance and mobility following stroke: Effects of physical therapy interventions with and without biofeedback/forceplate training. Phys Ther. 2001;81(4):995-1005.
- Goldman JM, Lehr RP, Millar AB, et al. An electromyographic study of the abdominal muscles during postural and respiratory manoeuvres. J

- Neurol Neurosurg Psychiatry. 1987;50(7):866-869.
- Hamman RG, Mekjavic I, Mallinson AI, et al. Training effects during repeated therapy sessions of balance training using visual feedback. Arch Phys Med Rehabil. 1992;73(8):738-744.
- Hochstenbach J, Donders R, Mulder T, et al. Long-term outcome after stroke: A disability-orientated approach. Int J Rehabil Res. 1996;19(3):189-200.
- Lin JH, Hsieh CL, Hsiao SF, et al. Predicting long-term care institution utilization among post-rehabilitation stroke patients in Taiwan: A medical centre-based study. Disabil Rehabil. 2001;23(16):722-730.
- Liebenson C. Spinal stabilization training: The transverse abdominus. Journal of Bodywork and Movement Therapies. 1998;2(4):218-223.
- Liston RA, Brouwer BJ. Reliability and validity of measures obtained from stroke patients using the Balance Master. Arch Phys Med Rehabil. 1996;77(5):425-430.
- Mathias S, Nayak US, Isaacs B. Balance in elderly patients: The "get-up and go" test. Arch Phys Med Rehabil. 1986;67(6):387-389.
- McGill SM. A revised anatomical model of the abdominal musculature for torso flexion efforts. J Biomechan. 1996;29(7):973-977.
- Nichols DS. Balance retraining after stroke using force platform biofeedback. Phys Ther. 1997;77(5):553-558.
- O'Sullivan PB, Phytz GD, Twomey LT, et al. Evaluation of specific stabilizing exercise in the treatment of chronic low back pain with radiologic diagnosis of spondylolysis or spondylolisthesis. Spine. 1997;22(24):2959-2967.
- Podsiadlo D, Richardson S. The timed "Up & Go": A test of basic functional mobility for frail elderly persons. J Am Geriatr Soc. 1991;39(2):142-148.
- Richardson C, Jull G, Hodges P, et al. Therapeutic exercise for spinal segmental stabilization in low back pain: Scientific basis and clinical approach. Edinburgh, Churchill Livingstone, 1998.
- Robinson R. The new back school prescription: Stabilization training. Part I. Occup Med. 1992;7(1):17-31.
- 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(1):46-57.
- Wade DT, Collen FM, Robb GF, et al. Physiotherapy intervention late after stroke and mobility. BMJ. 1992;304(6827):609-613.
- WHO. The World Health Organisation MONICA Project (Monitoring trends and determinants in cardiovascular disease): A major international collaboration. WHO MONICA Project Principal Investigators. J Clin Epidemiol. 1988;41:105-114.

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