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Purpose The of this study was to investigate the influence of Lower-Trunk Stability Strengthening Exercise on balance in Stroke Patients ***Method*** 14 stroke patients participated in this study. These patients were divided into two groups(a core stability group and a control group). There were 7 subjects in each groups They participated in Lower-Trunk Stability Strengthening Exercise for 3 weeks. Timed Up and Go Test(TUG) and Messen Trairuieren Dokumentieren(MTD) Systems for balance were measured and compared before and after the treatment ***Result*** Lower-trunk stability strengthening exercise on stroke patients for three weeks was effective for the treatment to improve balance of the core stability group. ***Conclusion*** The effort to apply the lower-trunk stability strengthening exercise for stroke patients is thought to be necessary.

Key words Lower-Trunk Stability, Strengthening Exercise, Balance.

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Ⅰ. Introduction

Stroke is one of the three major causes of death for mankind along with malignant tumor and heart disease, and in Korea, it is the second only behind malignant tumor. Even when not causing death, stroke, with sequela and complications, greatly influences the patient, family, and moreover, the society. In line with the increase in average life expectation due to the improvement in the standard of living and development of medicine, the number of patients with strokes are increasing (Kim, 2003). Also, the patients diagnosed with strokes see deterioration in the physical function and quality of life (Kwon, 2007). The most general symptom following a stroke is muscle attenuation of the palsied side which also appears on the trunk muscle of the palsied side. This imbalance of muscular strength causes asymmetrical posture, reduction in the ability to maintain the center of weight above the weight-supporting surface and righting reaction necessary for maintaining symmetric posture to cause serious disability to posture control which is crucial in everyday lives (Ikai et al, 2003). In order to maintain various postures during everyday lives, it is very important to maintain appropriate muscular strength and endurance of trunk muscle, (Handa et al, 2005), and the abdominal and trunk muscles are related to the lower-trunk stability, and important to the trunk movement and posture control (Hodges et al, 2002; Mok et al, 2004). When executing vertebrae stabilization exercise, the exercise maintaining the precise contraction of abdomen transverse muscle and deep muscles is important to the vertebra stabilization, and reduces back pain and limitations in everyday lives (Suzuki et al, 1999). The lower-trunk stabilizing exercise of a stroke patient is effective in strengthening trunk stability

and improving posture control (Lee et al, 2007). Lower-trunk refers to the portion combining lumbar vertebra, pelvis, and hip joint, located at the center of weight of the body where movement begins. This provides the optimal neuromuscular efficiency in overall chain movement to enable optimal acceleration, deceleration, and dynamic stability of overall chain movement when executing functional movements. Also, it provides stability of proximal joints for efficient limb movement (William, 2005), and the lower-trunk stabilization influences active movement and function improvement (Kim, 2005). The muscles involved in lower-trunk stability contracts for any movement to provide trunk stability (Oh et al, 2003), and influences active movement, function improvement (Kim, 2005), and balance and gait by participating in posture control (Verhryden, 2006).

Lee et al (2007) executed trunk-muscle strengthening exercises on elderly subjects, and as the result, static/dynamic balances were improved, and gait speed was reported to be increased as well. These study results indicates that trunk stability has an important influence on balance and gait. Kim et al (2007) reported that in the trunk control using hip joint movement of stroke patients, the sole pressure ratio of the palsied side and the non-palsied side went from asymmetrical to symmetrical, and the muscular activity of hip joint hamstring and evertor increased, in turn securing stability.

Balance refers to the ability to maintain center of gravity above base of support with an upright posture (O`Sullivan, 1994), and is maintained through continuous adaptation of muscular activity to the environmentaus change throught the body, the compensation of the shift center of gravity due to the motion is achieved through movement of another part(Massion, 1992). any action, change of center of gravity is necessary to continuous posture control, and even a small change is responded to by modifying the muscule tone throughout the body (Bobath, 1990).

Balance is the ability to continuously maintain equilibrium when the body is in motion (Nasher, 1990), and also a complex process which controls the posture during voluntary motion and maintains the posture in response to external movement (Berg, 1992), and the ability to control body posture and balance in a space becomes the basis for any movement of human body (Shumway and Woollacott, 1995).

Stroke patients have reduced balance-control ability through inappropriate posture control (Bohannon and Smith, 1987), and the proprioceptive sensory disturbance and abnormal muscle tone cause deterioration in balance-control ability (Ryerson and Levit, 1997). Characteristic symptoms are the reduction in the limit of stability defined as the maximum distance the center of weight can be moved while maintaining balance without letting both feet off the ground (Geiger et al, 2001), and the increase in the postural sway when standing up (Horak and Diener, 1994). Also, stroke patients experience more difficulty in the ability to move center of weight in the palsied side compared to the non-palsied side, causing deteriorated balance/gait ability. Laura et al (2005) reported that focused balance training of the palsied side for 6 hours for 2 weeks to a patient within 1 year of a stroke changed weight support from asymmetrical to symmetrical, improving the balance control and in turn reducing the risk factor of a fall. Since having a stroke, asymmetrical weight support caused difficulties in balance control so that a fall was experienced within 2 months and 6 months; while there was almost no physical damage due to the fall, the fear of the fall and passive activities were observed (Kwon, 2008).

Such reduction in balance ability hinders the functional movement of a stroke patient, and the balance treatment for functional improvement of the patient is also clinically important (Kwon and Jeong, 2002). Therefore, this study intends to examine the influence of lower-trunk stability strengthening exercise on balance in stroke patients.

II. Result

1. Research Subjects

The subjects for this research were stroke patients hospitalized at Bobath Memorial Hospital, located at Bundang, Seongnam-si, Gyeonggi-do, for the two-month period from Feb. 2009 to Apr. 2009, and 16 patients were chosen for whom it has been 6 months since their strokes in order to minimize the possibility of natural recovery.

The subjects were selected so that they had no cognitive/perceptive disability, were able to perform tasks according to

the directions of the researcher, had no history of trauma, fracture, etc in the joints of lower limb, had no regressive disorder, had no history of internal disorder such as diabetes, were able to walk independently for more than 15m, and voluntarily agreed to participate in this study.

2. Research Method

This research was conducted from Feb. to Apr. of 2009; balance treatment of weight load/weight movement and general exercise treatment to strengthen muscles were conducted for the conservative exercise group of 8, and lower-trunk stability strengthening exercise was conducted for the trunk exercise group of 8. Each group executed respective exercises for 30 minutes, 5 times a week, for three weeks.

1) Treatment Method

Lower-trunk stability strenghtening exercise was based on the abdominal muscle hollowing exercise of Richardson and Jully (1995), and promotes activity of abdomen transverse muscle, abdomen oblique muscle, multifidus muscle, hip joint extensor, etc.

(1) Trunk curl-up exercises

① Let the patients lie down straight and both feet must be touching the floor.
② Pull the jaws to the front and have the scapula abducted so that both upper limbs can rotated externally.
③ Let both upper limbs face the direction of the knees, and at the same time, let the head and the upper trunk be lifted above the floor.

(2) Bridge up exercise using a ball

① Let the patients lie straight on the ball and bend the knees to be 90 degrees to prevent pelvic anterior tilt, and have both upper limbs on the aiding stool, and pull the jaw to the front.
② Pull the jaw to the front and let the pelvis be in posterior tilt, and maintain the hip joints and knees to form a straight line.

(3) Pelvis tilt exercise

① Adjust the height of the coach to match the height of the patient's knees and sit the patient at the end of the edge at the 1/2 point of femur.
② The therapist should be behind the patient and execute the pelvis tilt exercise in the order of passive exercise, active aided exercise, and active exercise.

2) Measurement Method

Balance ability assessment was measured with the weight support level of the palsied side and the non-palsied side through MTD (Messen Trainerieren Dokumentieren, MTD Balance, Germany), and TUG (Timed Up and Go) was assessed for time variable to measure the balance ability level.

3. Data Analysis

The data collected in this research was analyzed using SPSS (Statistical Package for the Social Science) ver. 14.0.

The general characteristics of the research subjects were analyzed for average, standard variance, and frequency, and in order to analyze the level of improvement in the balance ability in stroke patients after lower-trunk stability strengthening exercises, Wilcoxon signed-rank test was executed. Also, to compare to average difference for before and after regarding balance variables between the groups of trunk exercises and conservative exercises, Mann-Whitney U test was executed, and the significance level of all data processing was α=0.05.

III. Result

1. General Characteristics of Research Subjects

This research was conducted with 16 subjects in two groups of 8, each group engaging in trunk exercises and conservative exercises respectively. Average age of the subjects were 53.37, and the gender was 8 each for male and female; onset period was 12.38 months. The diagnosis name was 9 cerebral hemorrhage and 7 cerebral infarction; palsy site was 8 for each of left and right(Table 1).

Table 1. General characteristics of subjects

	Core stability (n=8)	Control (n=8)
Age (year)	54.86±5.48	51.87±5.05
Duration (month)	13.11±3.94	11.65±2.62
Type		
Infarction	4	3
Hemorrhage	4	5
Paretic side		
Right	5	5
Left	3	3
Sex		
Male	5	3
Female	3	5

2. Change in Weight-Support Rate Before and After Lower-Trunk Stability Strengthening Exercises

After execution of lower-trunk stability strengthening exercise in trunk exercise group and consecrative exercise group, the change in weight-support rate was a statistically significant increase for the former (38.62% →47.62%; $p < 0.01$), and was insignificant for the latter as it decreased (42.75% → 71.75%; $p > 0.05$) (Table 2).

In the comparison of trunk exercise group and conservative exercise group before and after executing lower-trunk stability strengthening exercises, the change in the weight-support rate showed a significant difference. ($p< 0.01$) (Table. 2)

3. Change in TUG before and after Lower-Trunk Stability Strengthening Exercises

After execution of lower-trunk stability strengthening exercises in trunk exercise group and consecrative exercise group, the comparison of change in TUG time was found to be significantly ($p<0.05$) reduced for trunk exercise group (44.69s →33.35s), while it was found to be reduced for the conservative exercise group (47.69s →44.92s), but was insignificant ($p > 0.05$). (Table 3)

There was a significant difference in the change in TUG time when comparing the two groups after executing lower-trunk stability strengthening exercises ($p<0.01$). (Table 3)

IV. Discussion

The muscular activity for lower-trunk stability is involved in the limb movements, running, kicking a ball, throwing and such (Kibler et al, 2006), and controls the response to sudden loads and movements or unexpected falls, and also needs CNS system(Barr et al, 2005). At this CNS system makes the trunk muscle to execute its pre-planned function of maintain the dynamic balance and equilibrium to perform the task(Winters and Cargp, 2000). Control of center of gravity achieve posture/space according the trunk

Table 2. Comparison of balance ability following weight bearing

	Core stability group (n=8)		z	Control group (n=8)		z	†p
	pre	post		pre	post		
weight bearing (%)	38.62±5.39	47.62±2.82	-2.524 *	42.75±5.70	41.75±7.44	-.211	.023†

*p<0.05
†comparison between the trunk exercise group and the conservative exercise group

Table 3. Comparison of balance ability following TUG*

	Core stability group (n=8)		z	Control group (n=8)		z	†p
	pre	post		pre	post		
TUG (sec)	44.69±17.02	32.35±13.79	-2.521 *	47.69±9.74	44.92±11.65	.000	.036

*TUG: Timed up and go test
p<0.05
†comparison between the trunk exercise group and the conservative exercise group

location and pre-planned postural control before limb movement (Hodges and Richardson, 1999). When flexing the arm, the muscle activity of a stroke is 23~36% in EMG measurement of erector spine, and 32~36% for conservation treatment group: when movement of the arm on the paralysis side, the external oblique and rectus abdominalis that the muscle activity was delayed for stroke, thus , patients with CNS damage shows delay in muscle activity for posture control(Dickstein, 2004). It is difficult for stroke to shift of center of gravity to avoide obstacle of front while walking, and It is because it reason of balance disability(Catherine et al, 2007). The ability to maintain body balance above BOS to perform various tasks in given environument important in ADL, and the unstable balance in standing position is needs treatment to maintain stability of stroke (Carr and Shepherd, 2004). Also, the recovery of weight support of the palsied side is saidpto be relatedpto the increase in the balance and gait ability (Haart et al, 2004). Jae-Hyun Kim (2007) reportedpthat in a static standing position, the weight support of the palsied side was found to be 37.12% for stroke group with no sensory disturbance, 34.17% for stroke group with sensory disturbance, and 27.03% for stroke group with hemineglect, and Jung et al (2006) reported that pelvic exercises increased the weight support rate of the palsied side when standing up from a seated position. Likewise, the muscles of waist, hip joint, and abdomen are anti-gravity muscles and influence the balance through involvement with movement of trunk control and postural control (Verheyden et al, 2006). Byung-Yong Hwang (2002), in the study regarding the characteristics of stability limitation and body fluctuation of stroke patients, reported that the test for stability limitation assessing the ability to move the center of weight to front/rear and left/right found that the results were 84.2% in stroke group while it moved 138.7% for the conservative treatment group, and coronal view was also 148.6% for stroke group while it was 182.8% for the conservative treatment group; he reported that such results indicated the necessity in the increase in stability limitation ability through muscular tone normalization of lower limbs and trunk of the palsied side to improve the balance and gait ability of the stroke group.

In this study, the lower-trunk stability strengthening exercise was conducted on stroke patients for three weeks, after which the weight support rate of the palsied side of the trunk exercise group was significantly increased from 38.62% to 47.62%, while the conservative exercise group decreased from 42.75% to 41.75%, showing no statistical significance. Such results show that there was a greater improvement in the balance control ability in the trunk exercise group compared to the conservative exercise group. Hip joint muscle strengthening exercises were conducted for a stroke group and general exercises were conducted for another, and the TUG test results showed that the general exercise group decreased from 22.88s to 22.40s, while the Hip joint muscle strengthening exercise group decreased from 22.52s to 22.16s (Kang, 2006). TUG test is a tool to measure functional motility, movability, and balance, useful for a stroke patient. TUG results over 20s indicates that auxiliary device is not required for walking and there is no problem with movement, and results for 30s requires auxiliary device for walking as independent walking is difficult and there are problems with movement (Podsiadlo, 1991). Hwang reported that after conducting proprioceptive exercise and visual feedback exercise on stroke patients, the former became faster from 18.70s to 14.50s while the latter went from 18.00s to 16.50s, and that such results showed the improvement in balance/walking ability in the former group, and the treatment for improving balance/walking ability must be composed of a dynamic situation close to actual function, for which muscular tone improvement of anti-gravity muscles of the palsied side is necessary. For this study, lower-trunk stability strengthening exercise was conducted on stroke patients for three weeks, and the comparison of TUG time change showed that the trunk exercise group showed a significant reduction (44.69s→32.35s) while the conservative exercise group showed an insignificant change (47.69s→44.92s). Such results indicate that the former group showed more improvement than the latter as it saw a greater reduction in TUG time.

As shown, the trunk-exercise group which executed lower-trunk stability strengthening exercise found it effective for balance as the ability to move weight to the palsied side was improved and the balance control ability was improved as shown in TUG test. Also, further researches on the effect of lower-trunk stability strengthening exercise on

stroke patients are thought to be necessary.

V. Conclusion

This study intended to examine the effectiveness of lower-trunk stability strengthening exercise on stroke patients after 6 months of stroke, and as the weight support rate of the palsied side in the trunk exercise group increased from 38.62% before the exercise to 47.62% after the exercise while the conservative group saw a decrease from 42.75% to 41.75%, showing that the trunk exercise group had a greater increase in weight support rate of the palsied side. Also, the comparison of change in TUG time showed that the trunk exercise group decrease 44.69s to 32.35s while the conservative group decrease rom 47.69s to 44.92s, indicating that the former had a greater reduction in TUG time. The comparison between the two groups was statistically significant. From these results, it was found that the lower-trunk stability strengthening exercise on stroke patients for three weeks was effective for the treatment to improve balance of the trunk exercise group. Therefore, the effort to apply the lower-trunk stability strengthening exercise for stroke patients is thought to be necessary.

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