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The Effects of Core Stabilization Exercise on Dynamic Balance and Gait Function in Stroke Patients

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Abstract. [Purpose] The purpose of this study was to determine the effects of core stabilization exercise on dynamic balance and gait function in stroke patients. [Subjects] The subjects were 16 stroke patients, who were randomly divided into two groups: a core stabilization exercise group of eight subjects and control group of eight subjects. [Methods] Subjects in both groups received general training five times per week. Subjects in the core stabilization exercise group practiced an additional core stabilization exercise program, which was performed for 30 minutes, three times per week, during a period of four weeks. All subjects were evaluated for dynamic balance (Timed Up and Go test, TUG) and gait parameters (velocity, cadence, step length, and stride length). [Results] Following intervention, the core exercise group showed a significant change in TUG, velocity, and cadence. The only significant difference observed between the core group and control group was in velocity. [Conclusion] The results of this study suggest the feasibility and suitability of core stabilization exercise for stroke patients.

Key words: Stroke, Core stabilization, Gait

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INTRODUCTION

A stroke is the rapidly developing loss of brain function due to a disturbance in the blood supply to the brain. This can be due to ischemia caused by blockage or due to a hemorrhage[1)]. After a stroke, motor, sensory, perceptual, or cognitive deficits may occur, and these impairments can have various impacts on individual functioning through generation of disabilities and affect rehabilitation potential[2)].

Stroke survivors have difficulty in balance and postural control for standing upright because they are impaired by asymmetric posture, abnormal body imbalance, and deficit of weight transfer[3)]. Asymmetric movement also decreases ability to stand upright, disorients the body midline and space, and hinders appropriate alignment between vertebrae, trunk rotation, selective movement between trunk and extremities, anterior-posterior tilt of the pelvis during weight transfer, protective reaction, and equilibrium reaction[4)]. Previous studies have demonstrated the particular importance of trunk control in stable walking and decreasing falling risk in stroke patients[5, 6)].

Core strengthening has been rediscovered in rehabilitation. The term has come to connote lumbar stabilization and other therapeutic exercise regimens. In essence, it describes the muscular control required around the lumbar spine for maintenance of functional stability. The “core” has been described as a box, with the abdominals in the front, paraspinal and gluteal muscles in the back, the diaphragm as the roof, and the pelvic floor and hip girdle musculature as the bottom[7)]. Particular attention has been paid to the core because it serves as a muscular corset that works as a unit to stabilize the body and spine, with and without limb movement. In short, the core serves as the center of the functional kinetic chain. In the world of alternative medicine, the core has been referred to as the “powerhouse”, the foundation or engine of all limb movement[8)]. With regard to impaired trunk control and poor balance, previous studies have advocated efficient neuromuscular control for trunk stability and accurate trunk muscle recruitment patterns for control of spinal load in relation to a given task and posture[9, 10)].

Many recent studies have reported on core stability and its affect on athletes and patients with low back pain[8)], however, few studies on the relationship between core stability and balance ability and gait in patients with hemiplegia have been reported. Therefore, the purpose of this study was to examine the effect of core stabilization exercise on dynamic balance and gait functions in stroke patients.

SUBJECTS AND METHODS

A total of 16 stroke patients who voluntarily agreed to active participation were included in this study. The selection criteria were: 1) independent gait ability with or without walking aid for a minimum of 15 m; 2) a Mini-Mental State Examination score greater than 24/30[11)]; 3) adequate vision and hearing for completion of the study protocol, as indicated by the ability to follow written and oral instruc-

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Table 1. Characteristics of the subjects (N=16)

		Core stabilization exercise group (n=8)	Control group (n=8)
Gender (%)	Male	5 (62.5)	7 (87.5)
	Female	3 (37.5)	1 (12.5)
Age (y)		44.37 (9.90)	48.38 (9.72)
Height (cm)		166.50 (9.21)	168.50 (5.63)
Weight (kg)		63.83 (9.33)	66.11 (10.97)
Months after stroke		12.88 (7.16)	9.63 (4.86)
Side of hemiplegia (%)	Right	4 (50.0)	3 (37.5)
	Left	4 (50.0)	5 (62.5)
Type of stroke (%)	Infarction	6 (72.5)	4 (50.0)
	Hemorrhage	2 (25.5)	4 (50.0)

n (%) or mean (SD)

tions during screening; and 4) the capacity to understand and follow instructions. Exclusion criteria were 1) a history of previous stroke or other neurologic diseases or disorders; 2) patients with pusher syndrome (defined as leaning to the hemiparetic side and giving resistance to any attempt at passive correction); 3) terminal illness; and 4) pain, limited motion, or weakness in the non-paretic lower extremity that affected performance of daily activities (by self-report). Each participant signed an informed consent prior to participation. The subjects were randomly divided into the core stabilization exercise group (eight subjects) and the control group (eight subjects). Subjects in both groups participated in a general training program for five sessions, 60 minutes per week, during a period of four weeks. Subjects in the core stabilization exercise group practiced additional core stabilization exercises for three sessions of 30 minutes per week, for a period of four weeks. General characteristics of the core stabilization exercise group and control group are shown in Table 1.

The core stabilization exercise consisted of three subparts, bed exercises, wedge exercises, and ball exercises using a Swiss ball. First, the bed exercises without devices consisted of bridge exercise, bridge exercise with legs crossed, bridge exercise with one leg, curl-ups with straight reaching, curl-ups with diagonal reaching, bird dog exercise, and side bridge exercise. Second, the wedge exercises consisted of curl-ups with straight reaching, curl-ups with diagonal reaching, and curl-ups with arms crossed. Finally, the ball exercises consisted of bridge exercise, bridge exercise to the side, bridge- ups, abdominal curl-ups, bird dog exercise, and push-ups.

Dynamic balance ability was measured using the Timed Up and Go test (TUG). Subjects were seated in a chair with armrests and then instructed to stand (using the armrests, if desired) and walk as quickly and as safely as possible for a distance of 3 m. Subjects then turned around, returned to the chair, and sat down. The time from the point at which their spine left the back of the chair until they returned to that same position was recorded using a stopwatch. A practice trial was provided, followed by three test trials. The average time of the test trials was calculated. High intrarater (ICC=0.99) and interrater (ICC=0.99) reliability have been demonstrated using this measure[12].

Gait function was measured using a GAITRite system (GAITRite, CIR system Inc., Havertown, Pennsylvania, USA). The standard GAITRite walkway contained six sensor pads encapsulated in a rolled-up carpet with an active area of 3.66 m in length and 0.61 m in width. As the subject walked along the walkway, the sensors captured each footfall as a function of time and transferred the gathered information to a personal computer for processing of the raw data into footfall patterns. The GAITRite system was used to measure the spatiotemporal parameters, including gait velocity, cadence, step length, and stride length[13].

The SPSS statistical package, version 18.0, was used in performance of all statistical analyses. The dependent variables were dynamic balance test and gait function. General characteristics of the subjects and variables followed a normal distribution. The Paired t-test was used to determine whether there were changes in balance and gait function between before and after the training. The independent t-test was used for analysis of changes between groups of dependent variables. Results were considered significant at $p<0.05$.

RESULTS

Differences in balance and gait function after exercise are shown in Table 2. The before and after TUG scores for subjects in the core stabilization exercise group showed a significant decrease, from 33.06±18.39 sec to 27.64±13.73 sec ($p=0.029$); the control group showed no significant difference, (from 30.33±12.58 sec to 24.85±8.76 sec, $p=0.057$).

Gait parameters in the core stabilization exercise group showed significantly increased gait velocity (from 44.83± 18.83 cm/s to 58.91±18.21 cm/s, $p=0.024$) and cadence (from 74.55±13.85 steps/min to 84.07±14.00 steps/min, $p=0.041$), however, no significant increase was observed in affected side step length (from 35.98±12.95 cm to 41.54±10.58 cm, $p=0.160$) and stride length (from 69.51±21.99 cm to 87.71±18.89 cm, $p=0.075$). The only significant difference observed between the core group and control group was in

Table 2. Comparison of balance and gait measures within groups and between groups (N=16)

Parameters	Values				Change values	
	Core stabilization exercise group (n=8)		Control group (n=8)		Core stabilization exercise group (n=8)	Control group (n=8)
	Before	After	Before	After	After - Before	After - Before
Balance parameters						
TUG (sec)	33.06 (18.39) [a]	27.64 (13.73) *	30.33 (12.58)	24.85 (8.76)	5.42 (5.61)	5.48 (6.80)
Gait parameters						
Velocity (cm/s)	44.83 (18.83)	58.91 (18.21) *	37.69 (11.03)	37.39 (10.11)	−14.09 (13.90) *	0.30 (11.24)
Cadence (steps/min)	74.55 (13.85)	84.07 (14.00) *	75.90 (11.73)	77.51 (10.68)	−9.52 (10.76)	−1.61 (7.56)
Step length (cm)	35.98 (12.95)	41.54 (10.58)	29.49 (5.25)	30.92 (8.05)	−5.55 (10.00)	−1.44 (5.73)
Stride length (cm)	69.51 (21.99)	87.71 (18.89)	53.77 (16.59)	58.40 (14.54)	−18.20 (24.64)	−4.63 (8.59)

Values are [a] means (SD). TUG, Timed Up and Go test. *p<0.05

velocity (p=0.039). The control group did not show a significant increase in gait velocity (from 37.69± 11.03 cm/s to 37.39±10.11 cm/s) and cadence (from 75.90±11.73 steps/min to 77.51±10.68 steps/min), affected side step length (from 29.49±5.25 cm to 30.92±8.05 cm), and stride length (from 53.77±16.59 cm to 58.40±14.54 cm).

DISCUSSION

This study examined the effect of core stabilization exercise on dynamic balance and gait functions of stroke patients. In this study, TUG was used to evaluate dynamic balance. Ranges of TUG scores have been reported for various samples of elderly people. In a previous study, men and women without known pathology, aged 70 to 84 years (mean=75 years), had a mean TUG score of 8.50 seconds (range=7–10)[12]. Geiger et al.[14] reported that conduction biofeedback and conventional physical therapy programs resulted in a decrease in TUG from 23.08 before participation in an exercise program to 14.62 after participation in an exercise program. In our study, the before and after TUG score for subjects in the core stabilization exercise group showed a significant decrease, from 33.06±18.39 sec to 27.64±13.73 sec (p=0.029); no significant difference (from 30.33±12.58 sec to 24.85±8.76 sec) was observed in the control group (p=0.057). Core training presumably improved the balance of the lumbo-pelvic-hip complex, corrected postural alignments, and increased balance of the whole body. As a result, dynamic balance ability for transfer of center of gravity (COG) showed gradual improvement[15].

More than 85% of stroke survivors eventually walk with or without assistance[16]. The common features of walking after stroke include decreased gait velocity and asymmetrical gait pattern[17, 18]. Achievement of normal gait patterns and speed is usually the ultimate goal of gait training. Bohannon et al.[19] reported that mean comfortable gait speed ranged from 127.2 cm/sec for women in their 70s to 146.2 cm/sec for men in their 40s. Mean maximum gait speed ranged from 174.9 cm/sec for women in their 70s to 253.3 cm/sec for men in their 20s. Both gait speed measures were reliable (coefficients≥0.903) and showed significant correlation with age ($r \geq -0.210$), height ($r \geq 0.220$), and the strengths of lower extremity muscle actions (r=0.190–0.500). Holden et al.[20] reported that the velocity of gait in hemiparetic subjects (n=10) was 41% of normal. Duncan et al.[21] investigated the effect of a home program aimed at improvement of endurance, balance, and strength for stroke subjects whose mean duration after onset was 66 days. After eight weeks, mean gait speed increased by 25 cm/sec among patients. Yang et al.[22] studied dual task programs in stroke subjects and measured the speed of 5 m of walking. They found that gait speed showed a significant increase after participation in the dual task program, from 86.52 cm/sec to 115.35 cm/sec in chronic patients after stroke (p<0.05). In our study, the core stabilization exercise group showed a significantly increased gait velocity (from 44.83±18.83 cm/s to 58.91±18.21 cm/s, p=0.024) and cadence (from 74.55±13.85 steps/min to 84.07±14.00 steps/min, p=0.041), and the only significant difference observed between the core group and control group was in velocity (p=0.039). These findings are consistent with those of previous studies and suggest that core stabilization exercise increased posterior tilt of the pelvis and COG transfer during the swing phase through core training. Lamoth et al.[23] studied that trunk coordination has an effect on gait parameters and that flexible adaptations in trunk coordination to changes in walking velocity are considered a hallmark of unaffected gait. And as found for cadence, the core stabilization exercise group showed a larger increased than the control group but there was no significant difference between groups. We suggest that core training might improve the stability of the lower trunk and pelvis and result in increased ability with regard to static balance, dynamic balance, and weight support of the more affected side and ultimately may contribute to a more stable gait.

Through this research, the core stabilization exercise was found to be effective in balance and gait functions of stroke patients. We expect that this core stabilization exercise will be used at stroke patient care centers in physical therapy as an effective form of training for balance and gait functions. Further research is needed in order to confirm the generalization of these findings and to identify which stroke patients might benefit from treadmill gait training.

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