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Original Article

The Effect of Trunk Stabilization Exercise Using an Unstable Surface on the Abdominal Muscle Structure and Balance of Stroke Patients

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Abstract. [Purpose] This study investigated the effect of unstable surface trunk stabilization exercise on the abdominal muscle structure and balance of stroke patients. [Subjects] The subjects were divided into two groups: an unstable surface trunk stabilization exercise group (n=13), and a stable surface trunk stabilization exercise group (n=11). [Methods] Both groups performed trunk stabilization exercise for 30 minutes, 3 days per week for 6 weeks. Abdominal muscle thickness and the Berg Balance Scale (BBS) were measured at the baseline and after 6 weeks. [Results] There was a significant improvement in the internal oblique muscle thickness, transversus abdominis thickness and balance ability of the unstable surface trunk stabilization exercise group. [Conclusion] The unstable surface trunk stabilization exercise improved the internal oblique and transversus abdominis muscles and balance ability. These results suggest that unstable surface trunk exercise is useful in the rehabilitation stroke patients.
Key words: Unstable surface, Trunk stabilization exercise, Muscle thickness

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INTRODUCTION

Stroke patients with balance and gait disorders are characterized by decreases in physical function[1)]. It is important for stroke patients to improve their muscle strength and balance ability for functional recovery and activities of daily living (ADL)[2)]. In particular, stroke patients with reduced body movement and stability require trunk training[3)]. Trunk training is the most widely used method in trunk stabilization exercise therapies. Trunk stabilization exercises strengthen the muscles associated with maintaining the posture of the limbs and give increased stability[4)]. Previous studies have reported the positive effects of trunk stabilization exercises on unstable surfaces possibly due to stimulation of the proprioceptors of the joint and muscle[5, 6)]. Also, trunk stabilization training on an unstable surfaces activates the postural muscles around the abdomen and pelvis, more than that on a stable surface. It has been reported that stroke patients showed improvements of balance and gait ability after trunk stabilization exercise on an unstable surface[7)].

The effect of exercise on an unstable surface is too small to improve balance ability and movement of the body[8)]. The study of the effects of unstable trunk stabilization exercises by patients with stroke and their effect on abdominal muscle thickness is still insufficient.

Recently, ultrasound imaging of muscle thicknesses, cross-sectional areas, and muscle morphology has become widespread in rehabilitation[9–11)]. Ultrasound imaging is a relatively simple and objective method for measuring the muscle thicknesses of the abdominal muscles[12)]. Thus, the purpose of this study was to investigate the effect of unstable surface trunk stabilization exercise on the abdominal muscle structure and balance ability of patients with stroke.

SUBJECTS AND METHODS

This study used a single-blind randomized pretest and posttest control design. Thirty patients with stroke were recruited at S Stroke Rehabilitation Hospital in Seoul. This study was approved by the Ethics Committees of Sahmyook University Institutions. Before the experiment, participants were provided with sufficient explanation about the study. The participants signed a consent form before the experiment was conducted. Inclusion criteria were: at least 6 months since unilateral stoke, standing ability of more than 30 seconds without assistance, and a Mini-Mental Status Examination (MMSE) score of over 24 points. Exclusion criteria were: an inability to understand the study and its requirements, self-reported problems with device use (orthopedic, medical, and/or painful conditions), a Body Mass Index (BMI) greater than 31 kg/m^2.

All the participants performed a 30-minute trunk stabilization exercise, 3 times per week for 6 weeks. The participants were divided into an unstable-surface trunk stabilization exercise (UTSE, n=15) group and a stable-surface trunk stabilization exercise (STSE, n=15) group. Trunk sta-

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bilization exercises included bridging and the dead bug position. The STSE group performed the exercises on a fixed mat, the UTSE group was performed them on an unstable board. A reasonable break time was provided between exercises to prevent fatigue.

An ultrasound imaging device (Medison Mysono U5, KOREA) was used to measure abdominal muscle thicknesses. Ultrasound is a relatively simple and accurate method of measuring muscle thickness[11]. Participants' abdominal muscles were measured in a comfortable supine position. Measurements were made at the end of expiration to reduce the impact of respiration[13]. We used a linear transducer with a 7 MHz frequency[9]. A dot was drawn at a from the edge of the transversus abdominus muscle (TrA) on the ultrasound image. Then, a vertical line from the dot was drawn upwards to measure the muscle thickness[10]. The thickness of the TrA, internal oblique (IO) and external oblique (EO) muscles were measured. The Berg Balance Scale (BBS) was used to assess balance ability[14]. In this study the BBS was used as an optional item for intervention measurement. Seven of the 14 BBS items were selected giving a maximum possible score of 28 points. The items were: sitting to standing, standing unsupported, sitting with back unsupported but feet supported on floor or on a stool, standing to sitting, standing unsupported with eyes closed, standing unsupported with feet together, placing alternate foot on stool while standing unsupported.

SPSS version 15.0 software was used for statistical analyses. The t-test and the χ^2 test were used to compare participants characteristics. Data were also analyzed using the independent t-test to examine group differences between UTSE and STSE. The paired t-test was used to compare values between before and after exercise. Statistical significance was accepted for values of $p<0.05$.

RESULTS

Thirty subjects were recruited, but only 24 (UTSE group, 13; STSE group, 11) participated in this study. The demographic and clinical characteristics of the 2 groups did not differ significantly (Table 1). Comparisons of abdominal muscle thickness and balance ability within groups and between groups are summarized in Table 2. There were significant improvements in the IO thickness, TrA thickness ($p<0.05$), and balance ability of the UTSE group ($p<0.05$).

DISCUSSION

Trunk stabilization exercises to strengthen the muscles of the abdomen, help to maintain dynamic stability of the body. Trunk stabilization exercises using functional movements are important[15]. In particular, trunk exercise is necessary for stroke patients with difficulties with gait and balance. Recently, trunk stabilization exercises on an unstable surface, which activate a variety of trunk muscles, have been used in a lot of ways[16–18]. The purpose of this study was to investigate the effect of unstable surface trunk stabilization exercise on muscle thicknesses and balance of patients with stroke. In this study, TrA, IO and EO muscle thicknesses were measured using ultrasound, and the BBS was evaluated and used as an index of balance. Teyhen et al.[19] reported that IO and TrA thicknesses, measured by ultrasound imaging, increased in 120 subjects after they performed 6 trunk stabilization exercises. Seo et al.[20] reported that trunk stabilization exercises for 30 minutes a day, 5 times a week, for 5 weeks, significantly improved

Table 1. Characteristics of study participants

Parameters	UTSE (n=13)	STSE (n=11)
Gender Male/Female (%)	6/7 (46.1/53.9)	6/5 (54.5/45.5)
Affected Side Left/Right (%)	7/6 (53.9/46.1)	8/3 (72.7/27.3)
Disease duration, months	30.4 (13.5)	26.1 (12.9)
Age, years	64.1 (9.6)	71.3 (8.42)
Height, cm	163.3 (3.8)	161.9 (5.5)
Weight, kg	66.4 (6.5)	66.0 (8.5)

Values are n (%) or mean (SD)
UTSE, Unstable-surface Trunk Stabilization Exercise; STSE, Stable-surface Trunk Stabilization Exercise

Table 2. Comparison of muscle thicknesses and balance within groups and between groups

Parameters		Values				Change Values	
		UTSE (n=13)		STSE (n=11)		UTSE (n=13)	STSE (n=11)
		Pre	Post	Pre	Post	post-pre	post-pre
Muscle Thickness (mm)							
TrA	NA	1.77 (0.60)	2.10 (0.50)*	1.48 (0.38)	1.59 (0.30)	0.33 (0.33)*	0.11 (0.16)
	A	1.76 (0.36)	2.07 (0.41)*	1.46 (0.41)	1.44 (0.35)	0.31 (0.31)**	−0.02 (0.15)
IO	NA	4.21 (1.29)	4.76 (1.60)*	3.75 (0.77)	3.88 (0.72)	0.55 (0.67)*	0.13 (0.23)
	A	3.90 (1.38)	4.53 (1.64)*	3.58 (0.94)	3.57 (0.98)	0.63 (0.77)	−0.01 (0.09)
EO	NA	3.00 (1.10)	3.13 (1.10)	2.40 (1.06)	2.47 (1.10)	0.13 (0.22)	0.07 (0.10)
	A	2.76 (0.85)	2.67 (0.86)	2.67 (1.22)	2.69 (1.31)	−0.09 (0.27)	0.02 (0.14)
BBS (score)		19.76 (3.08)	25.46 (2.69)***	18.81 (2.71)	22.27 (2.24)***	5.69 (1.03)***	3.45 (1.12)

Values are mean (SD), *p<0.05, **p<0.01, ***p<0.001
TrA, Transversus Abdominis; NA, Non-Affected side; A, Affected-side; IO, Internal Oblique; EO, External Oblique; BBS, Berg Balance Scale

IO and TrA muscle thicknesses as measured by ultrasound ($p<0.05$).

In this study, after the UTSE, the EO muscle thickness did not show a significant improvement. But, IO muscle thicknesses on both the affected and non-affected sides showed significant improvements ($p<0.05$), and TrA muscle thickness after UTSE also showed significant improvements on both side ($p<0.05$).

Caroline[21] reported that trunk stabilization exercise on an unstable surface was effective at improving proprioception in a muscle retraining exercise plan. Also, Kim et al.[22] reported that trunk asymmetry improved as a result of training on an unstable surface. Thus, we consider that UTSE probably had an effect on the thickness of the abdominal muscles. Training with a ball or balance board causes co-contraction of muscles to maintain balance. The TrA muscle plays an important role in trunk stabilization. It activates to maintain stability under perturbations sway conditions, and heavy TrA use seems to increase the thickness of the muscle. In this study, EO muscle thickness showed no significant change, possibly because of the extension pattern of the trunk stabilization exercise.

Trunk stabilization exercise resulted in significant improvements in balance ability in both groups ($p<0.001$). In particular, the UTSE group showed a more significant improvement in balance ability than the STSE group ($p<0.001$). This result corresponds with those of previous studies showing that performance of trunk stabilization exercises by stroke patients leads to improvements in their balance ability[7, 20]. Bae et al.[23] reported that exercise on an unstable surface better enhanced the size of the trunk muscles and balance ability than exercise on a stable surface. We consider the reason for the significant improvement in the balance ability of the UTSE group was that trunk stabilization exercise on the unstable surface improved abdominal muscle activation to maintain the center of gravity and also promoted trunk proprioceptive sensory stimulation aiding in the alignment of the trunk.

The results of this study cannot be generalized to all stroke patients, and trunk stabilization exercise related to the other deep abdominal muscles were not measured. In future studies, measurement of the deep abdominal muscles should be performed after trunk stabilization exercise on an unstable surface for a more detailed study.

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