THE EFFECT OF EYE TRACKING MOVEMENT TRAINING ON BALANCE ABILITY FOR STROKE PATIENT

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ABSTRACT*--Stroke patients show delay in visual-spatial recognition and visual perception because of neurological deficit. 30 stroke patients were randomly divided into a eye tracking exercise group and a general exercise therapy group for six weeks, eye tracking program is consisting of saccade, optokinetic, vestibulo, eye tracking, and eye fixation. And the results were compared before and after the intervention using a balanced analysis device. There was a statistically significant difference in path length, path velocity, and Area 95% in an eye tracking exercise group compared with general exercise group(p<0.05). Thus, muscle strengthening and coordination training are important to maintain the static balance of stroke patients, an approach in terms of sensory integration, such as visual perception and vestibular sensory are needed.*

Keywords*-- Balance, Eye movement exercise, Eye tracking exercise, Stroke*

I. INTRODUCTION

Stroke survivor suffer from disabilities and sequelae and experience difficulties in performing continuous movements and with their daily activities for the rest of their lives (Buntin et al. 2010). The most common causes for stroke include occlusion and bleeding of the artery branches, which supply oxygen to the internal carotid artery, mesencephalic artery, or cerebral hemisphere's primary motor area (Basmajian et al., 1987). Decreased sensation, loss of exercise ability, and impaired cognitive ability due to neurological damage result in difficulty with maintaining the balance of body and controlling the posture, which leads to frequent falls (Ikai et al. 2002). In addition, stroke patients with a lesion in the left hemisphere experience delays in visually recognizing space and performing visual perception (Badke and Duncan 1983). Further, the visual perception problem causes difficulty with straight standing, spatial recognition of the body, performing a task, and acquiring new information as well as other issues in everyday life such as difficulty with judging distance to an object at the paralyzed side (Ralph et al. 1987).

With equilibrioception, a person recognizes his or her body within space through sensory aspects, including the somatosensory system, the visual sensory system, and vestibular systems (Goldie et al., 1996). Especially, spatial cognition has a significant correlation with control of balance, and enhances the stability of the body within the space, by providing information to adjust position and motion of each part of the body at the point the movement occurs (Taylor, 1990). The vestibular system especially oversees more functions in maintaining the balance. The vestibular system supports subconscious interaction between vestibular senses and visual sense through vestibulo-

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ocular reflex and vestibulospinal reflex, enabling the human body to maintain the direction of sight as we desire. Also, the vestibular system enhances the stability of the body by creating smooth coordination between the somatosensory system (Morimoto et al. 2011). Hence, an appropriate arrangement between visual and vestibular sensory systems to effectively maintain the body balance (Bente and Bassoe, 2008).

Eye tracking exercise is a part of the training regiment to improve visual cognition function, and it stimulates vestibulo-ocular reflex. It is the reflective reaction that fixes eyeball by arousing interior rectus muscle on the direction of the head is rotating towards, as well as the lateral rectus muscle (Fetter, 2007). Such a vestibular function allows the body to adjust against gravity by controlling the movement of not only ocular but also the limbs, torso, and neck (Susan and Schmitz, 2007). That is, controlling the ocular movement stimulates vestibular organs and posture control. Warren et al. (1993) showed improvement in balancing function when 10 patients who suffer from brain damage were instructed to perform tracking movement training, saccadic movement training, rotating movement training. While many precedent pieces of research on stroke rehabilitation treatments focus on strengthening limb muscles to improve balancing function, a limited number of studies approach from visual cognition and vestibular senses. Even such achievements are mostly based on an individual type of ocular movements. Hence, through this research, we aim to ascertain how simultaneous training in trajectory tracing, saccadic movement, and rotating movement affects the balancing function of stroke patients.

II. METHOD

Subjects

The 30 subjects of this research were selected among the patients diagnosed with stroke and admitted to a hospital in a metropolitan city, after December 2019, and satisfies the selection requirements presented below. Subjects in eye tracking exercise group, and General exercise group, were randomly selected to perform a therapeutic intervention.

The participants of this study were explained with the purpose and methods of the research and submitted the consent form indicating the intention of voluntary participation. Selection was a person who has been diagnosed with stroke by the physical specializes in rehabilitation medicine for 6 months or longer, a person who is at 3rd or higher stages in Brunnstrome recovery stage, a person who can maintain upright posture independently 5 minutes or longer, and a person who is not suffering from catastrophic loss of sight. The general characteristics of the subject are as follows (Table 1).

Table 1: General characteristic of the subjects.

	Eye tracking exercise group	General exercise group	*p*
Age(year)	69.93±11.73	63.93±13.09	0.19
Height(cm)	163.93±7.07	163.40±9.78	0.86

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Weight(kg)		61.40±10.01	62.40±12.76	0.81
Gender	Male	6	9	
	Female	9	6	
Stroke type	Hemorrhage	7	9	
	Infarction	8	6	

procedure

Eye tracking exercise

Sensoneck (Redcord, Inc., Norway) program used for this study is inspired by the achievements of Pertuseviciene (2007). Numbers were added on the track board to facilitate the understanding of the subject. Considering the height of the subject, we positioned the subject within 2~3 meters from the track board and made participants wear a headband with a laser pointer attached (Fig 1). The subject stares at 0, and then follow the trajectory of the objectives as instructed by the experimenter (Fig 2). Instructions include following only with eyes after fixing the head and following with both eyes and head. The shape of the trajectory consists of X shape, ellipses, + shape, and the shape of 8 rotated by 90 degrees. 1 session lasted 3 minutes, and 3 sessions were given with 1-minute intermittent rests.

The program is as follows, first, saccade eye movement. With your head fixed, move your eyes 15 times between the numbers 0 and 7. Next, with your head fixed, move your eyes 15 times between the numbers 7 and 8. And repeat in several directions, as just shown in the previous. Second, optokinetic eye movement. With your head fixed, move your eyes according to the overall shape. Third, vestibulo eye movement. Keep an eye on the number 0, then fix your eyes and move your head. Fourth, eye tracking movement. Move the head and eyes so that the laser pointer dose not deviate from the line. Fifth, eye fixation. Keep the laser pointer steady, keep an eye on number 0 and hold for 1 minute.

Figure 1: Laser pointer (left) and eye tracking exercise (right)

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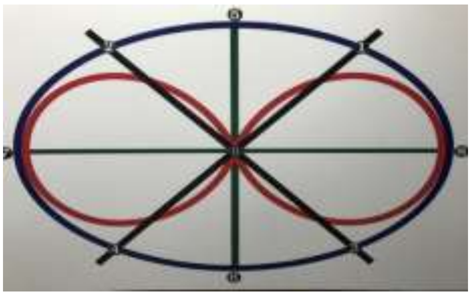

Figure 2: Sensoneck track board

General exercise program

First, while in a position, where the patient is lying down straight, the therapist performs stretching and range of motion exercise for 5 minutes, and patient is lying down straight, the patient is instructed to bend the knees by 60 degrees while maintaining the waist in the neutral position. The sole, as well as the arms, are placed conveniently on the floor, the patient is asked to maintain the balance by lifting the pelvis. The exercise is performed for 15 minutes by adjusting steps and methods based on the patient's status. Next, a pillow is placed under the knees to block the compensation reaction of hip flexor, also, both sides of the shoulder relax by placing towels under the shoulder joint. Then, prevent a pectoralis major from compensating, then make the abdominal muscle contract by having a patient look at the knees by lifting up the head. Finally, while in a position, where the patient is lying down straight, the therapist performed 5 minutes of stretching and range of motion exercise.

Equipment

We utilized the Nintendo Wii Balance Board (RVL-021, Japan) and Balancia 2.0 (Mintosys, Korea) balancing measurement programs to analyze the balancing function while the subjects are in an upright standing position. Wii balance board continuously collects pressure center information from 4 load cells and transmits to computing equipment through Bluetooth. Collected pressure center data are analyzed by Balancia software. Variables we used in this research is the overall path length, evaluated by summing up all path length of pressure center, an average of path velocities, evaluated by dividing path velocity by overall path lengths. And 95% path area, evaluated with the area of pressure center distribution in the shape of ellipses to assess the spatial aspect of the balance.

The subjects are allowed 30 seconds to feel comfortable to the balance board after standing on it with shoes off. Measurement began as soon as the experimenter notifies the subject of the commencement of the experiment the subject is instructed not to make a black dot on the screen deviate from the center as much as possible. For safety, 2 therapists observed the experiment besides the patient. The equipment retained a higher confidence level in measurement and remeasurement with ICC 0.64-0.94 (Clark et al. 2010), Balancia analysis software also maintained higher confidence level upon stroke patients between measurers and validity, with 0.79-0.96, and ICC 0.85-0.96 respectively. (Park et al., 2013).

Statistics Analysis

Data from this research was analyzed with SPSS version 20.0. The general properties of the subjects were analyzed through descriptive statistics. A paired t-test was employed to test the changes before and after the intervention within a group. An independent t-test was employed to test the change between the group. The statistical level of significance was set to α =0.05.

III. RESULT

In the changes of path length, there was a statistically significant difference between the eye tracking exercise group and the general exercise group($p<0.05$)(Table 2). In the changes of path velocity, there was a statistically significant difference between the eye tracking exercise group and the general exercise group ($p<0.05$)(Table 2). In the changes of the overall path area, there was a statistically significant difference between the eye tracking exercise group and the general exercise group (Table 2).

Table 2: Comparison of balance ability for intra group and between group.

		Pre	Post	Value difference	t	*p*
Path length (cm)	Eye tracking	54.92±7.33[a]	46.65±7.67	8.26±3.45	8.63	0.00*
	General	54.74±9.54	53.20±8.47	1.53±2.68	2.06	0.06
	t	0.06	-2.06			
	p	0.96	0.05			
Path velosity (sec)	Eye tracking	4.59±1.15	2.43±.49	2.16±1.19	6.51	0.00*
	General	4.90±.17	3.01±.80	1.89±1.06	6.45	0.00*
	t	-0.85	-2.20			
	p	0.40	0.04*			
Area95% (cm^2)	Eye tracking	5.73±.76 [a]	2.65±0.34	2.64±1.00	9.53	0.00*
	General	4.83±1.40	2.55±0.48	2.28±1.42	5.77	0.00*
	t	2.02	2.54			
	p	0.05	0.02*			

[a]mean±standard deviation, * $p<0.05$

IV. DISCUSSION

Most patients with stroke tend to employ strategies reliant on visual sense; they look down the ground to walk or maintain balance. The changes in this arrangement may influence the vestibular system (Bente, 2008). Although several patients tend to suffer from issues in deteriorating vestibular senses and sensory integration, most of the treatments are focusing on enhancing muscle strength and functional treatment of the limbs, and often overlook the relationship between the position the head, posture assessment, and adjustment of balance. Moreover, stroke patients tend to spend more time in a seated position (Michael et al., 2005), which leads to the development of forward head posture to compensate for relatively excessive bending of the upper torso (Persson et al., 2007). If the forward head posture intensifies, muscles on the neck charged with stabilizing the posture become tighter, pressuring the joints (Harrison et al., 2003). Therefore, the pattern to rely on the changes of head position and visual signals lead to changes in the motion of shoulder blades and muscle activities (Bente, 2008) and this asymmetry in muscle groups could lead to abnormal posture control. Silva et al. (2013) reported that proprioceptive afferent pressure plays a crucial role in controlling the posture. Hence, it is projected that changing perception of visual cognition related to posture control would improve balancing function by transforming body schema.

Morimoto et al. (2011) suggested that ocular movement exercise and gaze stability exercise on healthy adults may improve the stability of the posture. Even though Morimoto's findings were targeted to a different subject, they corroborate with this research to the point that target tracing exercise has a favorable effect on posture control. Koo et al., (2002) found that ocular exercise induces nervous contraction of antigravity muscle that leads to the activation of sensory nerve fibers which exert beneficial influence upon balancing function, According to Bae et al., (2019), in ocular exercise stimulation from diagonal direction in ocular exercise with the head in a fixed position, may have stronger learning effect over disarray of central nervous sonority integration compared to vertical and horizontal ocular movement because horizontal or vertical structure is dominant in most people's living environment. This finding supports the finding of this research that the rotation of the head towards multiple directions improves balancing function due to the learning effect over the fluctuation of the postures. Integration of Input signals from vestibular organs and visual information partake in controlling ocular movement and spatial cognitive ability by vestibular complex transmitting signals related to posture control through spinal cord to lower structures while reporting signals from lower echelon to higher structure (Cohen and Keshner, 1989), We could find that the subjects of this research experienced the improvement of balancing function and decrease in instability of posture after implementing the treatment program. We believe that various sensory inputs relayed through the vestibular system have influenced such changes.

A few limitations to this research could have been identified. Most of the subjects had a stroke more than 24 months prior to the time of the experiment, so it was difficult to prove the necessity of the research activity due to neuroplasticity. Also, we experienced considerable delays in the experimental process with some subjects as they had a hard time following the instruction that require rotation of their heads. Another limitation was that we could not effectively control the external environment except for the duration of training. Hence, further study may be required to complement this research by increasing the sample size and identify the appropriate length of intervention with target tracing exercise by recruiting subjects within 6 months since the onset of the stroke.

Based on the findings, we could conclude that employing various types of ocular exercise training for stroke patients helped improve patients' balancing function. Hence, we believe that developing and implementing ocular exercise programs with instruments accessible in our daily lives; it may be beneficial in enhancing balance ability of stroke patients.

REFERENCES

1. Badke MB, Duncan PW. Patterns of rapid motor responses during postural adjustments when standing in healthy subjects and hemiplegic patients. Phys Ther. 1983;63(1):13-20.
2. Bae JI, Cho HK, Mun BY, Yu DS, Kim SY. Change of Posture Stability according to Direction and Speed of Smooth persuit Eye Movement. J Kor Opht Opt Soc. 2019;24(2):153-159.

3. Basmajian JV, Gowland CA, Finlayson MA, Hall AL, Swanson LR, Stratford PW, Trotter JE, Brandstarter ME. Stroke treatment: comparison of integrated behavioral-physical therapy vs traditional physical therapy programs. Archives of physical medicine and rehabilitation. 1987;68(5 Pt 1):267-272.
4. Buntin MB, Colla CH, Deb P, Sood N, Escarce JJ. Medicare spending and outcomes after postacute care for stroke and hip fracture. Med Care. 2010;48(9):776-784.
5. Clark RA, Hunt M, Bryant AL, Pua YH. Author response to the letter: On "Validity and reliability of the Nintendo Wii Balance Board for assessment of standing balance": are the conclusions stated by the authors justified? Gait & posture. 2014;39(4):1151-1154; discussion 8-61.
6. Cohen H, Keshner EA. Current concepts of the vestibular system reviewed: 2. Visual/vestibular interaction and spatial orientation. Am J Occup Ther. 1989;43(5):331-338.
7. Fetter M. Vestibulo-ocular reflex. Developments in ophthalmology. 2007;40:35-51.
8. Goldie PA, Matyas TA, Evans OM, Galea M, Bach TM. Maximum voluntary weight-bearing by the affected and unaffected legs in standing following stroke. Clin Biomech (Bristol, Avon). 1996;11(6):333-342.
9. Harrison DE, Harrison DD, Betz JJ, Janik TJ, Holland B, Colloca CJ, Haas JW. Increasing the cervical lordosis with chiropractic biophysics seated combined extension-compression and transverse load cervical traction with cervical manipulation: nonrandomized clinical control trial. Journal of manipulative and physiological therapeutics. 2003;26(3):139-151.
10. Ikai T, Kamikubo T, Takehara I, Nishi M, Miyano S. Dynamic postural control in patients with hemiparesis. Am J Phys Med Rehabil. 2003;82(6):463-469; quiz 70-72, 84.
11. Ku BO, Bae SS, Kim HS, Lee DH. The Effect of Eye Movement on Balance Improvement by Plegia Side of Adult Hemiplegic Patient. J Kor Phys Ther 2002;14(4):1-19.
12. Michael KM, Allen JK, Macko RF. Reduced ambulatory activity after stroke: the role of balance, gait, and cardiovascular fitness. Archives of physical medicine and rehabilitation. 2005;86(8):1552-1556.
13. Morimoto H, Asai Y, Johnson EG, Lohman EB, Khoo K, Mizutani Y, Mizutani T. Effect of oculo-motor and gaze stability exercises on postural stability and dynamic visual acuity in healthy young adults. Gait & posture. 2011;33(4):600-603.
14. Petruseviciene D, Savickas R, Krisciunas A. NEvaluation of sensorimotor reactions during early rehabilitation for patients after cerebral stroke. Medicina Kaunas, Lithuania. 2007;43(12):942-946.
15. Park DS, Lee DY, Choi SJ, Shin WS. Reliability and Validity of the Balancia using Wii Balance Board for Assessment of Balance with Stroke Patients. Kor Aca-Ind coop Soc. 2013;14(6):2767-2772.
16. Silva AG, Johnson MI. Does forward head posture affect postural control in human healthy volunteers? Gait & posture. 2013;38(2):352-353.
17. Warren M. A hierarchical model for evaluation and treatment of visual perceptual dysfunction in adult acquired brain injury, Part 2. Am J Occup Ther. 1993;47(1):55-66.