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THE EFFECT OF VESTIBULA STIMULATION TRAINING ON GAIT ABILITY FOR CHRONIC STROKE PATIENT

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ABSTRACT-- *Stroke patients have significantly reduced their functions of vestibular sensory and proprioception. thus, excessive reliance on vision is used as a strategy. The purpose of this study was to examine differences according to method of exercise in gait ability for stroke patient.The study subjects included 30 patients with stroke, who were divided into eyehead coordination vestibular training group (n1=15) and unstable base balance training(n2=15) groups. Groups underwent vestibula stimulus training five times per week, 20 min per session, for six weeks. To examine gait ability, Gait-checker was used. And experimental results were obtained by comparing Step length, step time, Timed up and go test were significantly increased in the vestibula stimulus training group (p<0.05). This study found that gait training with eyehead coordination exercise is effective for improving balance and gait ability of patients with stroke.*

Keywords--*Eyehead coordination, Gait, Stroke, Vestibular rehabilitation*

I. INTRODUCTION

When we observe the kinetic form of the gait process, stroke patients experience morphological and spatiotemporal changes such as the decrease in duration of lower limb support, angle of instep curve, walking speed and cadence, and endurance (Balasubramanian et al., 2007). Also, stroke patients tend to rely on visual senses when walking. Excessive reliance on visual stimulation is a reaction due to pathological disorder, and it can be seen as a strategy to compensate deteriorating vestibular senses and proprioceptive senses (Bonan et al., 2004).

The vestibular system is connected with numerous parts of the brain in terms of systemic embryology. It affects ocular movement and posture control related to the visual-vestibular system, spinal vestibular system and automatic nervous system. If an issue arises in the vestibular system, patients may suffer from loss of vision, disequilibrium, vertigo, and gait disorder (Jung et al., 2009). Stroke survivors tend to experience problems in vestibular functions, which lead to various neurological disorders (Slavik et al., 1984). The prevailing remedy to resolve the situation is aiding interaction between vestibular sensory system, visual sensors, and proprioceptive sensory systems (Bonan et al., 2006). In case of toddlers and children, training methods include unstable support surface such as trampoline, hammock, and balancing board (Park, 2009); in case of adults, training treatments may

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involve repeated training to move and maintain the focus of eyes, and stimulating vestibular system through movement of the head (Herdman, 1990).

Many rehabilitation procedures have been established to accelerate recovery of balancing and gait function of stork patients, and they mainly involve enhancing muscular strength, core strength, training of functional movements and stretching. However, there is clear limitation for the central nervous system to consolidate sensory signals from various sensory systems, including the vestibular system, only with muscular training. Vestibular training is required to enhance neuroplasticity from the central nervous system (Alfieri et al., 2010).

Vestibular training either include the method to overcome vertigo through reducing vestibulo-ocular reflex by fixing the line of sight when turning a patient's head (Tanguy et al., 2008) or Vestibular habituation method where a patient overcomes vertigo arising from the lymph fluid flow from vestibular organs, through consistent training during a predetermined period (Hall et al., 2009). Many precedent research on cats, monkeys, and humans have reported the decrease in correlation coefficient to vertigo by habituation through repeated stimulation of vestibular organs (Clement et al., 2008). However, it is still controversial whether habituation through vestibular stimulation leads to improvement in gait function of stroke patients. Hence, we aim to identify the effect on the development of repeated eye-head coordination vestibula stimulation exercise, compared to vestibula stimulation exercise from the unstable support surface. Also, through the findings, we aim to discover the importance of vestibular stimulation training in designing a rehabilitation program.

II. METHOD

Subjects

We researched 30 subjects who provided consent after understanding the purpose of this study. The subjects are patients who are suffering from partial paralysis due to cerebral infarction or cerebral hemorrhage for 6 months or longer, patients able to understand and execute therapist's instructions with Mini-Mental State Examination-Korean score of 23 or higher, persons who can stand independently 10 minutes or longer in upright position, and walk 10 metre or more, using supplementary equipment, and persons without visual or auditory disorders such as amblyopia, and benign paroxysmal positional vertigo. The general characteristics of the research subjects are presented in Table 1.

Table 1: General characteristic of the subjects.

	Eyeheadcoordination Vestibula stimulus group	Unstable base Vestibula stimulus 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
Weight(kg)	61.40±10.01	62.40±12.76	0.81

Gender	Male	7	9
	Female	8	6
Stroke type			
Hemorrhage		5	7
Infarction		10	8

procedure

For the eye head coordination vestibula stimulation program, we proceeded with the research process by modifying and supplementing the methods employed in experiments by Ku (2002). A subject fixes the eye focus on a thumb and rapidly shake the head from left to right until the focus becomes weaker, then stop. Repeat the process 15 times, then repeat it again after closing the eyes.

The subject fixes the eye focus on a thumb and rapidly nods the head up and down until the focus becomes weaker, then stop. Repeat the process 15 times, then repeat it again after closing the eyes.

The subject fixes the eye focus on a thumb. Nod the head 15 times after turning the head leftward for 45 degrees, then 15 times after turning the head rightward 45 degrees.

The subject fixes the eye focus on the fixed object on parallel bars. Then the subject walks forward to the end of the bars, then backward. One hand should hold a bar to prevent falling.

The subject walks 20 steps while slowly nodding the head up and down, then walk another 20 steps while shaking the head left and right. A therapist shall position nearby to respond in case of the patient falling. The subject takes one step while closing the eye, simultaneously turning the head leftward. The subject takes another step, turning the head rightward. Each step shall be taken carefully and very slowly. Take 20 steps with this method, and repeat the process while nodding the head up and down. A therapist shall be positioned nearby to respond in case of the patient falling.

Figure 1: Fixing the sight and directional head rotation.

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Figure 2: Head rotation while walking, and walk forward and backward, fixing the sight focus.

In case of unstable base vestibula stimulus exercise group, On the balancing cushion, start from upright position holding the armrest. Let the pelvis lean forward and bend the knee for 40 degrees. Repeat the process 20 times. Repeat it again on the stable base for 20 times. Standing on togu, adjust to the base, and relocate the center of body mass, extending the shoulder to the farthest position from the pelvis. Then, repeat the process 20 times with the same method.

Equipment

Gait analysis Device

In order to analyze spatiotemporal variables of the subject, we conducted gait analysis using gait-checker by Ghiwell, Co. Ltd. Korea. Subjects were instructed to start walking from the left foot and finish with the left foot, on the mat with the dimension of 1320mm X 650mm, then repeat the process after turning around. We evaluated the average of 3 trials and admitted it as the experiment data. Collected information was processed through dedicated computation software (Gait-checker ITS system Ghiwell, Co. Ltd. Korea).

Table 2: Comparison of gait ability

	Group	Pre	Post	Value difference	t	*p*
Step length (cm)	Eyehead	17.79±2.59	26.48±1.72	-8.68±2.81	-11.128	0.00*
	Unstable	20.20±3.52	24.67±2.52	-4.47±2.39	-6.72	0.00*
	t	-1.987	2.129			
	p	0.06	0.04*			
Step time (sec)	Eyehead	2.93±.58	2.38±.58	0.54±.45	4.314	0.00*
	Unstable	3.16±.29	2.86±.48	0.29±.38	2.82	0.02*
	t	-1.273	-2.278			
	p	0.22	0.03*			
Timed up and go	Eyehead	24.60±2.57	21.59±2.15	3.0±2.27	5.12	0.00*
	Unstable	24.12±1.56	22.86±2.86	1.25±2.25	2.15	0.05

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(sec)	t	-.61	-1.75
	p	0.54	0.03*

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

Timed up and go

We asked the subject to stand up and walk in order to measure gait performance and balance. We measured the time elapsed while a subject walks 3 meters and return to the seat, starting from sitting on a chair with an armrest. The digitized watch was employed for the measurement. The average time measured in 3 trials were admitted to experimenting data. The confidence level within a single measurer is r=0.99, and the confidence level between multiple measurers is r=0.98 (Podisadlo & Richardson, 1991).

Statistics Analysis

We utilized SPSS software (ver 22.0; SPSS Inc, Chicago, IL, USA)., the normality of collected data was tested through the Shapiro-Wilk test to process the observations measured through the experiments. Parametric estimation was performed after verifying the data were normally distributed. We used paired t-test to compare before and after the experiment within a group, then employed an independent t-test to compare the effect of the experiment between different groups. Each test was performed with a significance level (p-value) of 0.05.

III. RESULTS

An Intra-group average of the Eyeheadcoordination vestibula stimulus group on the length of the single-step increased significantly (p<0.05) after an intervention. The result also indicated that the increase in the eyeheadcoordination vestibula stimulus group was significantly different compared to the vestibula stimulus on the unstable base group (Table 2). An intra-group average on the duration of each step for the eyeheadcoordination vestibula stimulus group significantly increased after an intervention (p<0.05) and is significantly different compared to the vestibula stimulus on the unstable base group (Table 2).

In timed up and go test, the intra-group average of the eyeheadcoordination vestibula stimulus group significantly increased after an intervention (p<0.05). Also, it is significantly different compared to the vestibula stimulus on the unstable base group (p<0.05)(Table 2).

IV. DISCUSSION

The purpose of this research was to identify the effect of vestibular stimulation exercise coupled with eye-head coordination on the gait performance of chronic stroke patients. To this end, we applied “Eye-Head Coordinated Vestibula Stimulation Exercise” for the experimental group, and Usual Exercise Treatments and Balancing Training” for the control group. According to our findings, the experimental group exhibited a significant difference between the duration and length of support with a single foot. The experimental group also showed a significant difference from the control group, in the timed up and walk test designed to measure the gait performance.

The core function of the vestibular function lies in adjusting posture balance through harmonizing proprioceptive and visual signals. Exterior vestibular spinal cord enables coordination between motor functions of arms and legs; the interior vestibular spinal cord is charged with adjusting the head position which commensurate the status of the body. Such features of vestibular function are known to be facilitated by the motion of the neck and the head (Brodal, 2004). Ocular and posture adjustments are processed simultaneously by the constitution of the nervous network between nerve nuclei for ocular controls and in vestibular nerve system (Bear et al., 2007; Kligyte, 2003). They are the neurological background that corroborates the hypothesis that Eye-Head coordinated vestibula stimulation exercise may improve balancing performance through controlling the posture. Meesen et al. (2003) presented that since rotation and diagonal movement of the head affected coordination between upper and lower limbs, people tend to produce various periodical coordination patterns based on the degree of stability of the head. Hence, we believe that the motion of the head affects the balance of posture. According to Lim et al., (2013) a 6-week vestibular stimulation training regimen using horseback-riding equipment leads to a significant decrease in vertical and horizontal electrooculography, with a favorable impact on vestibular function. Heine (1997) stated that the reason for such phenomena is that the movement of the horse provides consistent vestibular senses to the rider to adapt to vibrating motion. Such findings corroborate the findings of this research as the constant stimulation of vestibular senses provided in this research is the same type of stimulus to vestibular senses in the 6-week intervention period designed for Lim's research.

The research by Badke et al. (2005) reported that a training regimen that stimulated vestibular senses with 32 subjects who are suffering from vertigo and balancing disorder led to a significant difference in sensory orientation and Dizziness Handicap Inventory scores. The researchers suggested that the reason is the body's tendency to compensate for the damages to neural pathways in central nerve vestibular with other sensory pathways such as visual or proprioception senses. Therefore, Badke et al.; concluded that it is more helpful to help out the compensation with appropriate intervention rather than restraining such a mechanism. Also, Smania (2008) conducted vestibula stimulation training for 26 stroke patients on different surfaces to achieve sensory integration. The research suggested that the training regimen improved the duration of posture maintenance as sensory organization enhanced; then it led to significant improvement in gait function. Smania asserted that gait is a succession of movements of the center of the body, and sensory integration is required to maintain them. We believe that the improved gait function from this experimental process is the result of sensory integration efforts through multidirectional rotation and ocular movements.

V. CONCLUSION

Compiling the findings of the research, we believe that vestibular stimulation training should be integrated with general physical therapy in organizing exercise treatment to improve the effect on enhancing gait function in terms of sensory integration. We believe that vestibular stimulation within the training regimen helps correct inappropriate sensory input and lower the threshold for disarrangement through habituation resulting from repeated exposure.

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