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Effect of exercise program using mirrors for stroke patients

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ABSTRACT

This study was performed for two of specific reasons, one is for exercise development for improving stroke patient's muscle power, balance and gait and, after verifying the effect of the exercise, the other is for showing that the appling this exercise was more effective on hemi-plegic stroke patients into the clinical trial. The subjects of this study were hemi-plegic patients by stroke, 51 patients were picked up, who were agreed with this research. Close kinetic chain leg exercise using mirrors was applied to study group Ⅰ, Close kinetic chain leg exercise without mirrors was applied to study group Ⅱ and general physical therapy was applied to comparison group. The results of this study are as follows. The difference of the groups, study group Ⅰ showed more effective than study group Ⅱ on checking rectus femoris, vastus lateralis, biceps femoris, Korean version of Berg Balance Scale, Center of pressure, Functional gait assessment. In this study, Close kinetic chain leg exercise showed more effective and significant on improving for muscle power, balance and gait on stroke patients. Especially, doing exercise using mirrors is considered as more effective method than without mirrors.

Keywords*: Stroke, Mirror, Close kinetic chain exercise, Muscle strength, Balance, Gait.*

1. INTRODUCTION

As mortality has decreased and senior population has increased due to the development of medical technology in recent years, various diseases such as cancer and cardio-cerebrovascular disease are on the rise. In particular, stroke is a leading cause of death in the circulatory system for the population after 50 years of age in Korea. It is reported that the mortality of stroke is currently 56.5 deaths per 100,000 population, the second highest following cancer, and stroke is the highest cause of death as a single disease [1].

Various studies have been conducted on the exercise methods for stroke patients, focusing especially on improving muscle strength, balance and walking ability, which are essential for daily routine. Ng and Shepherd [2] reported that muscle strengthening exercise improved both muscle strength and function without increasing abnormal muscle activities. In recent years, a number of study have reported a significant correlation between muscle strength and function [3],[4]. Balance and gait have been studied as clinically important factors for a long time [5]. Due to the reduced balance of hemiplegic patients, postural sway increases, center of the body moves to the unaffected leg for stability, asymmetry is created in the production of force in lower limbs [6], and the balance ability maintaining the stability of hip joints against external sway is reduced due to lack of symmetric weight bearing [7]. As a consequence, stroke patients have big obstacles to recovery due to postural sway in standing position, asymmetric body balance, and disruption of controlling weight bearing and walking ability [8]. Therefore, balance retaining is one of the most important elements in the treatment of neurological impairment, such as the one in stroke patients [9].

Another treatment to improve symmetric posture, which is a difficult posture typically experienced by stroke patients, is a method to correct posture using visual and auditory sensory feedbacks [10]. The learning with the sensory-feedbacks is a method to correct the errors of task performance by obtaining information on the outcome of patients' performance or the cause of the outcome as the feedback of visual, auditory and somatosensory, and used to help them learn accurate movement [11]. Since visual sense, among other senses, can receive information more accurately than other senses, the motor learning method using visual feedback has been widely used for balance training of stroke patients. In a study carried out on balance disorder patients, De Haart [12] reported that visual feedback training improved posture controlling function.

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Patients trained with visual feedback can perform tasks with interest in the treatment process, and their motivational effect is maximized through the entire treatment process. In addition, patients can perform continuous and repeated training and learning with this method, and immediately check the outcome of task performance. Therefore, this seems to be an appropriate evaluation and training method for hemiplegic patients [13]. Mirror therapy, another exercise method using visual information, was first introduced by Ramachandran and Roger-Ramachandran [14] as a therapy using visual stimuli to reduce the phantom pain of amputees. It was reported that mirror therapy can reduce pain, as well as induce smooth movement by easing tension on the amputated area. In addition, Altschuler, Sidney, Wisdom, Lance Stone and Chris Foster [15] revealed that mirror therapy is effective for the range of motion (ROM), velocity of motion and accuracy of upper limbs for stroke patients. Sathian, Arlene, Greenspan, Steven and Wolf [16] found that the motion and grip strength of the paralyzed arm have improved after a 2 week mirror therapy. Stevens et al. [17] also applied a mirror therapy to stroke patients for 3-4 weeks and reported increased Fugl-Meyer Assessment scores and active range of motion, velocity of motion and hand dexterity. Similarly, studies reported that when applying a mirror therapy to recover the function of hemiplegic stroke patients, better recovery effect was found than the group with only rehabilitation therapy [18].

As seen above, previous studies on the therapy using mirror dealt mostly with ROM, velocity of motion and accuracy through the upper and lower limbs exercise in the open kinetic chain or static postural alignment exercise. This study thus aims to develop a new closed kinetic chain exercise using a mirror and apply it to stroke patients, and then test its effectiveness.

2. MATERIALS AND METHODS

2.1 Participants of the study

The subjects of this study included patients who were diagnosed as hemiplegia from stroke and under treatment in hospital, and consented to the study. More specifically, the subjects included those who had at least 6 months of disease duration, had a score of 20 or above on the MMSE-K, could walk more than 10 meters, had a score of 2 or less in the stiffness from the Modified Ashworth Scale, were measured as above fair on lower limbs from the manual muscle testing, and did not have any other diseases on lower limbs. General characteristics of the subjects are as follows [Table 1].

2.2 Research tools

2.2.1 Strength measurement tools: The surface electromyogram Myosystem 1400A unit (Noraxon, Inc, U.S.A) was used to measure each electromyographic activity of rectus femoris, vastus lateralis, biceps femoris, and semitendinosus.

2.2.2 Balance measurement tools: For balance, the BBS (Berg Balance Scale), which had high interrater reliability (r=0.98) and high retest reliability (r^2=0.99) [18], was measured for stroke patients, and the moving area of the center of pressure (COP), which considerably affects balance, was measured using the Gait view AFA-50.

2.2.3 Walking ability measurement tools: Walking ability was measured with the Functional Gait Assessment (FGA), which reduced the ceiling effect that could affect the discrimination effect of measuring tools, by Wrisley et al. [19], and the Fugl-Meyer Assessment (FMA), which was designed to measure motor function, balance, sense, ROM and pain after the onset of stroke [20].

Table 1. General characteristics of subjects

Factors	Study group Ⅰ (N=15)	Study group Ⅱ (N=15)	Control group (N=15)	F	P
Age(year)	57.46±8.61	58.06±13.32	57.93±13.43	.01	.990
Sex, Male(%)	10(66.7%)	11(73.3%)	12(80.0%)	2.16	.128
Height(cm)	163.47±9.36	164.60±8.80	164.46±8.61	.07	.930
Weight(kg)	63.19±12.08	64.22±10.39	64.89±10.11	.09	.912
Time since stroke(month)	24.33±19.32	25.13±19.58	25.87±22.03	.02	.979
Stroke side, right(%)	3(20%)	8(53%)	6(30.4%)	1.82	.174
MMSE-K(point)	26.00±3.89	25.67±5.96	25.53±2.33	.05	.955
AFO, yes(%)	3(20%)	2(13%)	3(20%)	.14	.867
Diagnose, Inf(%)	12(80%)	12(80%)	13(86.7%)	.14	.867

Values are N (%) or Mean ± standard deviation
inf.: Infarction
MMSE-K : Korean version Mini-Mental State Examination
AFO : Ankle Foot Orthosis
Inf : Infarction
Control group: Physical therapy generally

2.3 Method of study

The study was conducted for the period between October 10 and December 10, 2011. Before applying a therapeutic intervention to the subjects, general characteristics, muscle activity of lower limbs, K-BBS, COP, FGA, and FMA of the subjects were measured. Fifty one stroke patients were randomly assigned to 3 different groups: closed kinetic chain lower limb resistance exercise group using a mirror, closed kinetic chain lower limb resistance exercise group without using a mirror, and general physical therapy group. The 3 groups had basic physical therapy, occupational therapy and speech therapy, and added closed kinetic chain lower limb exercise using a mirror [Figure 1], closed kinetic chain lower limb exercise without using a mirror [Figure 2], and general physical therapy once a day, 5 times a week. General physical therapy consisted of a 5 minute passive ROM exercise and a 15 minute exercise using manual resistance within a range of maximum 10 times with isotonic exercise within ROM with hip abductor muscles, knee flexors, knee extensors, ankle flexors, and ankle extensors.

Fig 1. Closed-chain exercises with mirror

Fig 2. Closed-chain exercise did not use a mirror

2.4 Method of analysis

For statistical analysis of data, SPSS (Ver.12.0) was used. Normality was tested with the Kolmogorov-Smimov test, and the paired t-test was used to test significance before and after the experiment of each group. For significance test on the data of change in each group, a one-way ANOVA was performed and, a LSD (least significant difference) post hoc test was conducted. The significance level was set at .05.

3. RESULTS

In a comparison before and after experiment, the experimental group Ⅰ showed improvement in the measurements of muscle activity, K-BBS, COP, FGA, and FMA of lower limbs compared to before the experiment. The experimental group Ⅱ showed improvement after the experiment in the measurements of FGA and FMA.

In a before and after comparison, the control group demonstrated improvement in the measurements of vastus lateralis activity, K-BBS, COP, FGA, and FMA after the experiment. In a comparison among experimental groups, the experimental group Ⅰ showed improvement in rectus femoris, vastus lateralis, biceps femoris, K-BBS, COP and FGA compared to the experimental group Ⅱ after the experiment [Table 2].

Table 2. Instead of results

		Study group Ⅰ (N=15)	Study group Ⅱ (N=15)	Control group (N=15)	*F*	*P*
Rectus Femoris strength	Pre	33.84±5.17	33.71±3.93	33.79±5.17	2.583	.088
	Post	36.63±5.99	33.45±5.99	34.98±5.88		
	P	.014	.815	.118		
Vastus Lateralis strength	Pre	34.34±5.69	34.03±3.95	34.01±4.55	7.392	.002
	Post	38.34±4.76	33.96±2.85	35.36±5.35		
	P	.000	.929	.028		
Biceps Femoris strength	Pre	34.34±5.69	34.03±3.95	34.01±4.55	7.392	.002
	Post	38.34±4.76	33.96±2.85	35.36±5.35		
	P	.000	.929	.028		
SemiTendinosus strength	Pre	34.34±5.69	34.03±3.95	34.01±4.55	7.392	.002
	Post	38.34±4.76	33.96±2.85	35.36±5.35		
	P	.000	.929	.028		
K-BBS	Pre	33.80±12.70	33.27±9.12	33.20±10.36	18.083	.000
	Post	38.27±12.51	34.20±8.50	34.66±10.19		
	P	.000	.063	.000		
COP	Pre	5.62±6.14	5.57±4.60	5.63±3.61	6.006	.005
	Post	4.63±5.42	5.55±4.31	5.26±3.39		
	P	.006	.891	.001		
FGA	Pre	19.07±6.80	18.87±5.11	19.27±5.48	5.143	.010
	Post	20.87±6.20	19.60±5.21	20.07±5.38		
	P	.000	.003	.005		
FMA	Pre	19.87±5.84	20.27±6.18	20.07±10.69	.724	.491
	Post	22.13±5.64	22.27±5.90	21.80±10.59		
	P	.000	.000	.000		

Data=Mean ± SD
K-BBS: Korean version of Berg Balance Scale
FMA: Fugl meyer assessment
FGA: Functional gait assessment
COP: Center of pressure
EMG: electromyography (RVC% = reference voluntary contraction)

4. DISCUSSION

For the purpose of improving muscle strength, balance and walking ability of hemiplegic stroke patients, this study was conducted to investigate the effect of stroke on the lower limb muscle strength, balance and walking ability of the patients by dividing the subjects into experiment group I and experiment group II, and apply the results to a clinical practice. Previous studies showed that the application of exercise using a mirror to the rehabilitation exercise of hemiplegic stroke patients is more efficient in enhancing physical function than other exercise methods [13]. Also, sensory-feedback using visual sense has been widely used for the exercise of stroke patients because information can be more accurately received through this method. In this study, there was difference in vastus lateralis, biceps femoris, semitendinosus, K-BBS, COP moving distance, and FGA among the experiment group Ⅰ, experiment group Ⅱ and control group before and after the experiment, while no difference was found in rectus femoris and FMA. In addition, the experiment group Ⅰ, experiment group Ⅱ, and control group all showed increased scores, but no significant difference was found among the groups. In this study, surface electromyogram was used to measure the degree of muscle strength increase. The findings indicated that the muscle activity of the experiment group Ⅰ significantly increased,

compared to the experiment group Ⅱ and control group. In a study conducted on 14 hemiplegic stroke patients, Ji [21] revealed that a combination of isotonic technique in proprioceptive neuromuscular facilitation (PNF) with weight bearing significantly increased muscle activity of vastus medialis, vastus lateralis, and rectus femoris. Kim [22] conducted closed kinetic chain exercise for patients with anterior cruciate ligament reconstruction for 6 weeks and investigated muscle activities of vastus medialis, vastus lateralis, semitendinosus, and semimembranosus by exercise period. The findings showed that muscle activities significantly increased depending on the exercise period, especially most significantly increased before the exercise and 6 weeks after the exercise. The K-BBS was employed to measure balance ability. It was revealed that a minimum of potential muscle activation occurred as the visual feedback training for maintaining balance generally affected the activation of the nervous system, such as proprioceptive sense [23], indicating that the impairment of proprioceptive sense led to lack of perception on the location change of body in a given environment, making it difficult to maintain balance and control posture. In this study, the experiment group Ⅰ, experiment group Ⅱ and control group all showed significant improvement compared to before the exercise, and in a comparison among the groups, significant increase was found in the experiment group Ⅰ. Cheng, Wang, Chung and Chen [24] conducted a symmetric standing posture training in a visual feedback training on 30 stroke patients, and reported that the standing posture training with visual feedback training strengthens the ability of symmetric weight distribution, indicating that visual feedback training affects the improvement of balance. As seen from the result of this study, it is therefore considered that a mirror therapy using visual sense can help patients recover their balance. The Gait view was employed to measure the moving area of the center of pressure. To quantitatively measure body sway, the movement between the center of pressure and center of the body is generally measured [25]. The finding showed that both experimental group Ⅰ and control group showed significant increase, while the experiment group Ⅱ did not show significant difference. In the change of COP among the groups, the experiment group Ⅰ showed a marked increase. Ji et al. [26] measured body sway, that is, center of the body, to investigate the postural stability of hemiplegic patients by employing the visual feedback training using a mirror, and reported that significant decrease was found in the mirror therapy group.

In this study, the FGA was employed to measure walking ability. The experiment group Ⅰ, experiment group Ⅱ and control group all showed increased score. As for the change of FGA among the groups, the experiment group Ⅰ showed a considerable increase. This is similar with the result of a study by Serap et al. [27]. In the study, they used mirror therapy to investigate the motor recovery and motor function of lower limbs after stroke and found that the mirror therapy group showed an increase of 1.7 points in the Functional Ambulation Categories compared to the control group. In the present study, the FMA was employed to measure the recovery of lower limbs. The experiment group Ⅰ, experiment group Ⅱ and control group all showed increased score. It was reported that when applying the mirror therapy that included the traditional rehabilitation program of Serap et al. (2007), it provided additional long-term support for the motor recovery and motor function of lower limbs. However, no difference was found among the groups, which is similar with the result of a study by Dunsky, Dickstein, Marcovitz, and Levy [28]. In the study, they performed a visual feedback training for normal gait for chronic stroke patients and found that the lower limb motor function on the Fugl-Myer scale decreased from 13.9 before the experiment to 13.8 after the experiment, which is similar with the finding of the present study. This is attributable to the fact that since only the ability to perform certain tasks was improved, it did not affect other functions. In a comparison among the groups, as we have seen, the experiment group I showed significant difference in the volume of change, compared to the experiment group II and control group. These findings indicate that an exercise using a mirror is very effective for hemiplegic stroke patients, and it is expected, in particular, that the application of closed kinetic chain exercise will be very helpful in improving muscle strength, balance and walking ability of the patients. This study has some limitations: it is difficult to generalize the result of the study because it was conducted only on 45 stroke patients who met the participation condition. Also, the external environment of the patients such as daily lives, except the time of experiment, and the will of the patients were not controlled.

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