

# Effects of Mechanical Horseback Riding Exercise on Static Balance of Patient with Chronic Stroke

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## 승마기구 운동이 만성 뇌졸중 환자의 정적 균형능력에 미치는 영향

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**Abstract** The purpose of this study is to evaluate the effect of horse-riding simulator exercise on the static balance of chronic stroke patients. The study's sample included 30 stroke patients who were randomly classified into an experiment group and a control group. Both the experiment and control groups received therapeutic exercise one time per day, but the experiment group also received twenty minutes of horse-riding simulator exercise three times per week for six weeks. To compare the groups, an independent t-test was performed, and to compare each period, a paired t-test was conducted and its result was analyzed. The result of this study, moving distance under standing position with eyes closed, showed significant difference in horse-riding simulator exercise group after exercise. But, there was no significant difference between horse-riding simulator exercise group and control group. Further, various clinical studies focusing on effects of horseback riding exercise on function of stroke patients are needed.

**요약** 본 연구의 목적은 승마기구 운동이 만성 뇌졸중 환자의 정적균형 능력에 어떠한 영향을 미치는지 알아보는 것이다. 연구대상자는 뇌졸중 진단을 받은 환자 30명으로서 승마기구 운동군과 대조군으로 무작위 분류하였다. 대조군은 운동치료를 하루에 1회씩 받았으며, 실험군은 하루 1회의 운동치료 외에 별도의 시간에 승마기구 운동을 받았다. 승마기구 운동은 6주 동안 주 3회, 회당 20분씩 실시하였다. 집단 간 비교를 위해 independent t-test를 실시하였고, 집단 내 기간별 비교를 위해 paired t-test를 실시하여 분석하였다. 본 연구의 결과, 운동 후 승마기구 운동군의 눈 감고 선 자세에서는 균형에 유의한 차이가 있었으나, 승마기구 운동군과 대조군의 그룹간 비교에서는 유의한 차이가 나타나지 않았다. 앞으로 승마기구 운동이 뇌졸중 환자의 기능에 어떠한 영향을 미치는지 알아보는 다양한 임상적 연구가 필요할 것으로 생각된다.

**Key Words** : Mechanical horseback riding, Stroke, Static balance

## 1. Introduction

Stroke is a dysfunction of upper motion neuron that creates hemiplegia or paralysis symptom of one side of body due to cerebrovascular damage[1]. Most general symptom of stroke is sudden weakening of face, hand

or leg or numbness in any certain part of body[2]. In addition, motor dysfunction including difficulty and instability in trunk control, declined walking ability, loss of motor capacity of being able to perform a delicate function and difficulty in activity of daily living due to weakened muscle and sensory change is taken

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place[3].

One of the most serious problems of patient with hemiplegia due to stroke is declined balance ability due to physical asymmetry[4]. Balance means an ability of controlling posture based on interaction of sense, motor and cognitive system under the diversified environment[5]. Ability of maintaining body balance in order to perform a task under a given environment is one of exercise controlling elements that value highly in daily life. Patients with stroke feel considerable difficulty in keeping balance under standing posture as an ability of moving body weight to paralyzed side is reduced[6].

A method of using an animal that induce interest of the patients and help them participate in long-term rehabilitation program among therapeutic intervention methods for enhancing balance is highlighted and one of such methods is hippotherapy. Hippotherapy is a training method of enhancing functional ability of the patients whose motor function is damaged or body activity is limited through walking method of horse[7], and it is a kind of integrated therapeutic program of providing horse riders with an opportunity of postural training or muscle strengthening exercise by using horse movement[8].

Rhythmical and repeated movement of horse through horseback riding is helpful for enhancing sensory stimulation, balance ability and coordination capability required for walking by providing an information similar to movement pattern of repeated forward, backward and lateral inclinations being taken place in pelvis during walking[9-12].

Kim et al [13] reported that as a result of exploring balance ability after performing horseback riding exercise by targeting a child with autism, an enhanced result was represented in sway period, sway area, maximal sway velocity of COP as a whole. Lee [14] reported that as a result of exploring balance ability based on COP moving distance after performing horseback riding exercise therapy for total 8 weeks based on 40 minutes per time and 2 times per week by

targeting a child with mental retardation, in experiment group rather than control group, a positive result could be observed in balance ability. In addition, Benda et al [15] compared the level of symmetry of trunk muscle of 15 children with spastic cerebral palsy and reported that the level of symmetry of trunk muscle of a horse-riding exercise therapy group was significantly higher than a control group.

However, horse-riding is too dynamic for patients and requires a large outdoor space[16]. Therefore, many studies have explored horse riding equipment that offers horse-like movements, which is used to treat various diseases[17-23]. But so far, a study on change of static balance ability by targeting patient with stroke is not sufficient in reality. Therefore, this study intended to explore an effect on static balance of patient with stroke by using horse-riding simulator.

Although a balanced standing position is needed to recover a symmetrical gait ability of stroke patients, studies on changes in static balancing using horse-riding equipment has not been often conducted. Therefore, this study was conducted to investigate the effect of horse-riding equipment on static balancing of stroke patients.

## 2. Methods

### 2.1 Subjects

This study targeted 30 patients who were hospitalized for treatment 6 months after onset of disease being diagnosed as stroke by a neurosurgeon of A hospital located at G metropolitan city. Targets were limited to patients who can stand up alone without any help from others and walk independently over 10m indoors and in addition, persons who do not have lower motor neuron lesion or orthopedic disease in upper, lower extremities. And they were able to understand and comply with the study method, scored at least 24 points on the Korean version of the mini-mental state examination (MMSE-K). They were grade 2 or lower

on the Modified Ashworth Scale (MAS), which measures spasticity. We sorted under MAS 2 stage that usually feel resistance in the range of passive movement, but able to move. We selected a group of people who are possible for weight support in sitting posture. And, the subjects should have no deficit for pain and noxious stimulation.

This study was progressed after having persons who wish to participate in the study after having fully heard an explanation for the study sign the informed consent. General characteristics of the study subjects are as shown on Table 1.

## 2.2 Procedure of Study

Both horse-riding simulator exercise group and control group performed therapeutic exercise for 30 minutes everyday. Horse-riding simulator exercise group performed horse-riding simulator exercise for 6 weeks based on 3 times/week, 20 minutes/time at a separate time. All the study subjects underwent pre-test before an experiment and after 6 weeks, post-test was performed in the same way.

Height-adjustable table was used for the patients in order to have them ride on horse-riding simulator. Height of table was adjusted so that the patient could stand on table and ride on simulator without difficulty under support of therapist. Patients were guided to ride on horse-riding simulator by using one of the two methods. A method of sitting down on saddle with spreading both legs under standing position under

assistance of therapist or aides or another method of stably sitting down with spreading both legs after turning the body followed by placing hip on saddle.

Before starting the exercise, a few steps were taken for a safe preparation. First, patients were instructed to hold the support fixture located at both ends of the equipment. It was fixed with a string to allow them to hold the fixture with the affected hand if necessary. Second, they placed their both feet on the foot support fixture that was raised or lowered depending on the length of their feet.

During their exercise, two therapists were watching them closely by their both sides to prevent an accident. Also, one week preliminary experiment was conducted in advance to get them familiar with the equipment and reduce their fear.

## 2.3 Study Tool

### 2.3.1 Mechanical horseback riding

A FORTIS-101 model of Daewon Fortis was selected as horse-riding simulator and used. A course having the biggest up/down, forward/backward movement among 100 kinds of program courses built in horse-riding simulator being furnished with size and weight similar to actual horse was selected and used. In order to prevent sensitivity to simulator from being decreased as the patients adapt themselves to speed of horse-riding simulator during exercise, exercise was progressed based on start speed of 50 at 1st week, 60 at 3rd week and 70 at 5th week[24](Fig. 1).

[Table 1] General characteristics of subjects

(N=30)

	MHREG (n=15)	CG (n=15)	<i>t</i>	<i>p</i>
Age(year)	54.20±9.21	54.00±8.79	.061	.952
Height(cm)	163.67±10.17	165.23±8.48	-.456	.652
Weight(kg)	62.21±7.88	62.31±7.22	-.039	.969
BMI(kg/m <sup>2</sup> )	23.20±1.82	22.80±1.80	.599	.554
Time since stroke (month)	13.87±5.77	13.93±5.64	-.032	.975
Paretic side (Right/Left)	6/9	7/8		

M±SD : mean±standard deviation

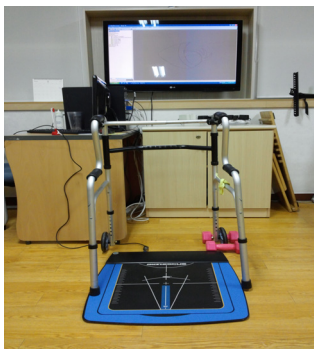
MHREG: mechanical horseback riding exercise group, CG: control group



[Fig. 1] Horse-riding simulator

### 2.3.2 Balance measuring equipment

In order to measure balance ability under standing position, balance measuring equipment (Biorescue, RM INGENIERIE, France) was used figure 2. This equipment comprises platform that may sense moving distance of COP(center of pressure), computer analysis program and screen. The equipment was aimed at measuring the balancing ability of patients, non-patients, and athletes[25-27].



[Fig. 2] Balance measuring equipment

As a test of static balance, Romberg test was performed under standing position with eyes opened and that with closed eyes, respectively. Static balance was evaluated by measuring moving distance of COP after having test subjects look forward under maximal static, comfortable position for 1 minute followed by standing on top of platform in barefoot and spreading both legs in 30 degrees. Under standing stance with eyes opened, a mark was indicated at eye level of test

subjects and test subjects were directed to look at it motionlessly and under standing stance with eyes closed, 1 therapist was made to observe patient at its side in order to ensure safety of the patient[28]. In order to explain measuring method and procedure to test subject, measurement was performed after showing demonstration for 1 time. During measurement, respite of 1 minute was given to those test subjects.

## 2.4 Data Processing

All the test data for comparing an effect of horse-riding simulator exercise on static balance of patient with stroke was analyzed by using SPSS 18.0 version. For analyzing general features of test subjects, technical statistics was used and as a result of performing Kolmogorov-Smirnov test and Shapiro-Wilk test in order to verify normality of two groups, normality and equal variance were satisfied. In order to compare difference of two groups as a result of exercise, independent t-test was used and in order to compare hourly change before and after exercise, it was analyzed by using paired t-test. Statistical significance level of all the data was set at .05.

## 3. Result of Study

### 3.1 Comparison of moving distance of COP within group depending on passing time

In comparison by each period, moving distance under standing position with eyes significant difference in MHREG( $p < .05$ )(Table 2).

### 3.2 Comparison of Moving distance of COP between Groups

In moving distance under standing position with eyes opened and that with eyes closed, a significant difference was not represented between two groups before and after exercise.( $p > .05$ )(Table 3).

**[Table 2]** Comparison of moving distance of COP depending on passing time (unit : cm)

		pre	post	<i>t</i>	<i>p</i>
MHREG	EO	65.13±23.36	57.95±20.50	1.780	.096
	EC	72.66±23.64	58.80±19.94	6.470	.000*
CG	EO	66.71±23.83	59.76±22.59	1.224	.241
	EC	71.59±30.61	65.57±27.15	.892	.387

\**p*<.05, M±SD : mean±standard deviation

MHREG: mechanical horseback riding exercise group, CG: control group

EO : eye open, EC : eye closed

**[Table 3]** Comparison of moving distance of COP between groups (unit : cm)

		MHREG	CG	<i>t</i>	<i>p</i>
EO	pre	65.13±23.36	66.71±23.83	-.183	.856
	post	57.95±20.50	59.76±22.59	-.229	.820
	difference	7.17±15.58	6.95±21.98	.033	.974
EC	pre	72.66±23.64	71.59±30.61	.107	.916
	post	58.80±19.94	65.57±27.15	-.779	.443
	difference	13.86±8.29	6.02±26.14	1.107	.278

M±SD : mean±standard deviation

#### 4. Discussion

Ability of maintaining body balance on floor is one of the most important motor control elements in daily life[29]. If balance under standing position is unstable, body becomes asymmetrical as more body weight is loaded on non-paralyzed leg and an ability of being able to move under the posture of body weight being supported without losing balance is reduced[4]. Therefore, recovery of balance ability in patient with stroke is one of the functional tasks that is required to be achieved most precedently.

Horseback riding exercise is frequently applied to patient who has inferior motor ability as it is helpful for postural correction and balance enhancement but as it has many restrictions in its clinical application, studies of identifying same effect based on horse-riding simulator exercise that shows similar pattern and walking method as that of actual horse have been presented. In particular, horse-riding simulator exercise that is greatly helpful for enhancing balance with trunk applies to diversified diseases but so far, a study of

exploring change of static balance ability by targeting patient with stroke is not sufficient in reality. Therefore, this study intended to compare an effect of horse-riding simulator exercise on static balance of patient with stroke.

In this study, as a result of measuring moving distance of COP in order to explore static standing balance of patient with stroke, under standing position with eyes closed in horse-riding simulator exercise group, a significant decrease of static balance was presented after exercise rather than before exercise but under that with eyes opened, any significant difference was not observed.

In a standing posture with open eyes, the visual sense, proprioceptive sense and vestibular sense are all used to keep the balance whereas in a standing posture with close eyes, the proprioceptive sense and vestibular sense without the visual sense are used to keep the balance. In the study by Kim [30], in the result of measuring postural sway in a standing posture after using horse riding exercise equipment, sway was more decreased when closing eyes compared to opening

eyes. It suggests that the proprioceptor and vestibular organ, except the visual sense, among balance controlling sensory organs were improved. In our study, continuous movement of horse-riding equipment also improved the proprioceptive sense and vestibular sense to show the significant difference in a posture with close eyes.

However, it is considered that the reason why any significant difference was not represented in standing position with eyes opened is that as static balance ability of the test subjects reached ceiling effect already, no more effect could be achieved. Because this study only targeted those with high balancing ability who can stand on their own and walk at least 10m indoors, there were no statistically significant differences. Sung et al [31] presented that as a result of measuring trunk balance ability of patient with stroke after horse-riding simulation, as static balance ability of the test subjects had already been provided, significantly enhanced result was not represented. In the same way as the result of this study, it is considered that this result was derived as static balance ability of the patients reached ceiling effect already.

In addition, in the result of investigating a difference of a migration distance between a standing posture with open eyes and a standing posture with close eyes, there was no significant difference after training. A migration distance of a test group was shorter than that of a control group in both a standing posture with open eyes and a standing posture with close eyes. However, it is thought that a test period (6 weeks) was not long enough to consider this result as a significant difference between groups. In the study by Kim et al [16], a balancing ability was measured before using indoor horse riding exercise equipment, at 2, 4 and 6 weeks after exercising. In the result, the sway area, sway distance and maximum sway rate were significantly different after four-week exercise, but there was no significant difference between groups. If comparing a balancing ability of two groups for six

weeks or longer, there would be a more difference between groups.

The limitations of the study include a short period of time (6 weeks) for the study and a difficulty of accurate measurement due to the ceiling effect of subjects. Thus, further long-term studies on horse riding exercise equipment are required. In the future, it is considered that studies target not only chronic but also acute and subacute stroke patients, or target who has low balance ability. And, study of investigating visual characteristics, asymmetry for paralyzed side and non-paralyzed side of the patient with stroke would be also required.

## 5. Conclusion

This study compared how much effect horse-riding simulator exercise exerts on static balance ability by targeting 30 patients with chronic stroke. It was confirmed that the proprioceptive sense and vestibular sense enhanced by horse riding exercise equipment affect balance improvement. It is expected that horse riding exercise equipment will be effective in enhancement of sensory function in patients with chronic stroke or in improvement of static balance in patients with acute and subacute stroke who has a lower static balancing ability than patients with chronic stroke.

The result showed that there were no statistically significant differences on static balance in stroke patients. In the study, a static balancing ability of patients included in the selection criteria has already been secured in some degree and the test period was somewhat short. Thus, additional studies need to be conducted.

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