The Effects of Realignment at Paretic Lower Extremity on Balance and Gait in Hemiplegic Patients

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Purpose This study was to investigate the realignment program is effect on rehabilitation of the weight bearing in the standing position, balance and gait for hemiplegic patients. ***Methods*** Twenty subjects (mean age 45.15±18.33) were randomly recruited and the subjects were divided into a realignment group and a control group. The subjects for the realignment group were participated in the realignment exercise program for 8 weeks, and the control group were treated general exercise program. They were assessed weight bearing(Messen Trairuieren Dokumentieren System), dynamic balance(Berg balance scale, Timed Up & Go) and gait velocity pre and post-treatment. ***Results*** 1. For the weight bearing in the standing position using MTD System, the affected sides was improved from 46.78±4.74 % to 50±5.5 %, the unaffected sides was decreased from 53.22±4.74 % to 50±5.5 %, there was a significance in both sides(p<.05). 2. The BBS was decreased from 44.33±6.02 points before the treatment to 51±4.15 points after it, which had a significant meaning(p<.05) in the realignment group. 3. The TUG test was decreased from 46.15±34.52 seconds before the treatment to 39.95±34.42 seconds after it, which had a significant meaning(p<.05) in the realignment group. 5. The 10mWT was improved from 0.45±0.32 m/sec before the treatment to 0.61±0.55m/sec after it, there was a significance in the realignment group(p<.05). ***Conclusion*** These finding suggest that symmetrical alignment at lower extremity can serve as an effective means of improving the weight bearing in the standing position, balance and gait ability of hemiplegic patients.

Key words Realignment, Balance, Gait, Hemiplegic patients

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I. Introduction

In brain damaged patients, 80% of their entire weight at a standing posture is supported by non-paralyzed lower extremity.[1)] Such asymmetry of two legs causes abnormality during dynamic posture and movement.[2)] Dickstein et al stated that an ideal goal of functional rehabilitation for hemiplegic patients lied in reducing asymmetry and the ultimate goal was to recover symmetric gait by taking a balanced standing position with balanced weight bearing.[1)] Such asymmetry appears by the changes in physical alignment, which means an alignment of physical location with respect to weight bearing surface and gravity as well as that of physical segment, etc.[3)] The alignment of physical segment in weight bearing surface determines distributing the exercise strategies that may be effective in adjusting the degree of force and posture necessary for supporting a body against the gravity. Lynch proposed that for an effective activity of antigravity muscle when adjusting a posture or during functional movement, a normal alignment between pelvis and femoral region and between femoral region and foot should be preceded.[4)] Also, Raine et al. stated that an appropriate alignment of lower extremities had an important impact on timing and pattern of muscular activation and also on mobilization characteristics of motor units or distribution of muscular activity.[5,6)] In addition, Sahrmann suggested that a correct physical alignment would make the neuromuscular activity efficient and highly adaptable and improve the muscular balance.[7)]

Changes in initial posture and alignment is one of the characteristics of patients with upper motor neuron lesion and in case of bodily misalignment, the neuromuscular mobilization pattern of the applicable parts will become inefficient, thus preventing patients from reacting effectively to the surrounding circumstances.[3] Abnormal alignment reflects changes in alignment of one physical part against the other parts. In patients who sit or stand with rear pelvis inclined, for example, such an asymmetric alignment when abnormally curving backward, when head bending forward, in a sitting posture, or at a standing position is a major characteristic in hemiplegic patients.[8]

In particular, asymmetric standing balance causes changes in stability limit of hemiplegic patients. Geiger et al. stated that when hemiplegic patients are standing, their center of a body is situated forward because the degree of standing stability is situated forward in paralyzed foot compared to the normal one, that the range of stability is narrow,[9] and that physical unrest is about twice higher.[10] The stability limit and the alignment of the center of gravity are changed by abnormal muscular skeletal system. If the ankle plantarflexor is paralyzed in the joint of foot, the stability limit is reduced because the center of a body is not brought forward the joint of foot in order to prevent joint of foot from being collapsed suddenly.[11] In addition, such a reduction in stability limit shows a high correlation with gait, an important goal of physical therapy for hemiplegic patients and also has an impact on the recovery of gait.[12,13] Bohannon and Leary reported that gait ability was highly correlated with sense of balance and that standing balance was significantly correlated with gait ability, and Perry et al suggested that imbalance between paralyzed lower extremity and non-paralyzed lower extremity reduces gait ability in hemiplegic patients significantly and the symmetry of gait elements is an important indicator to measure whether treatment is successful or not.[14-16] As seen above, many researches have been conducted on the symmetry of weight bearing in hemiplegic patients, in other words, enhancement of weight bearing rate into paralyzed lower extremity, but little researches have been conducted on the fundamental approaches to the re-education of physical alignment in transformed lower extremity of hemiplegic patients, which was caused by stroke. Therefore, this study aims to understand the impact of the realignment of paralyzed lower extremities on the balance and gait of hemiplegic patients which was caused by stroke.

II. Materials and Methods

1. Subjects

Patients who had suffered for over six months after onset of the disease and whose MMSE-K was found to be over 24 scores, among the patients who were diagnosed with hemiparalysis caused by stroke, from the entire patients who were hospitalized or treated as outpatient at Bobath Memorial Hospital located at Bundang-gu, Seongnam-si, Gyeonggido were selected as research subjects in this study. The patients who agreed to submit a written consent form for this study among the subjects who showed no internal disease like diabetes and orthopedic problems that might affect remedial value and could walk up to 14m independently regardless of walking aid were selected.

2. Treatment Methods

The lower extremity realignment and therapeutic exercise program used in this study was modified and supplemented by referring to the proposals made by Lynch and Grisgono and Rohlfs. The single session took 30 min. and it was performed three times a week: for eight weeks in total. Research participants were in a sitting posture on a treatment table where one can adjust the height of a chair with basal surface about 1/2 of the femoral region and both knees heading forward. First, in a sitting posture on the treatment table, they optimized the location of paralyzed foot and ankle and then adjusted the alignment of pelvis and lower extremity. Patients were induced to be in a standing posture and at this time, their alignment of lower extremities was made to be maintained. At a standing posture, first, their paralyzed foot were made to be located at the position of one step forward and then moved forward and backward little by little when a therapist caught the abductor muscle and external portion of extensor of hip joint. When weight movement was sufficient, the foot on the unaffected side was made to be put on the foot of therapist and then the efferent contraction of hip abduction and ankle plantar flexor muscles in the paralyzed lower extremities depending on the movement of non-paralyzed lower extremities was induced with a therapist's foot movement. At this time, it was induced not to cause associative reaction in paralyzed side. Finally, they were made to walk, catching both abductor muscle of hip joint and external portion of extensor so that the treatment contents can achieve carryover effect as much as possible. At this time, the therapist who caught the hip joint added proprioception to mobilize the muscular contraction according to the gait cycle as much as possible.

3. Measurements

1) Bilateral weight distribution test at a standing position

Messen Trairuieren Dokumentieren (MTD) System

Research participants put their foots on force plate and measured bilateral weight distribution at a standing posture, among the measurement items in MTD system. At this time, they were asked to maintain a standing position at the point of time when they felt that they kept their balance and to make them not to recognize any graphs in monitor, the monitor was covered and they were instructed to keep eyes forward. The scale of balance was analyzed with MTD-balance physiofeedback ver. 4.0.

2) Dynamic Balance Test

(1) Berg balance scale

This scale is widely used to evaluate the balance ability at a moving or standing posture in hemiplegic patients caused by senile disorder and stroke. This test, which consists of 14 items has the lowest score of 0 and the highest score of 4 for each item, and the total score is 56. This test is known to be highly correlated with walking speed, and the validity, test-retest, and inter-examiner reliability was 0.99.

(2) Timed up & go test

Participants were instructed to sit on a chair with arms and height adjustable by 46 ㎝ and adjust the height to be 90° flexuosity of knee joint and then rise from the chair simultaneously with the word of "start" and go at a comfortable speed and turn at the point of 3 ｍ and back to the original position and sit on the chair. The total time consumed was measured with stop watch. Inter-rater reliability (r=.98) and intra-rater reliability (r=.99) were high and thus it's an appropriate instrument for evaluation of balance, movement capability, and functional mobility.

3) Ambulatory ability (speed) test

While walking a total distance of 14m at a usual speed, acceleration and deceleration section of 2m, respectively was set at a starting point and a point of arrival and the time consumed to walk the rest 10m except the two sections was measured with stopwatch. The distance was divided by measured time (s) to obtain speed (㎧), which was used as a variable to measure gait speed. Intra-rater reliability and inter-rater reliability appeared highly at r=.96 and r=.97, respectively.

3. Data Analysis

The data obtained through this study were treated statistically using SPSS for windows ver. 18.0. The general characteristics of research subjects were observed by obtaining mean and standard deviation through descriptive statistics. The test of significance before and after treatment of each group used Wilcoxon rank sum test and after treatment, used Mann-Whitney U test to compare differences between groups. After treatment, bivariate correlation analysis (Pearson correlation) between measurement items were performed to identify the relevance and the statistical level of significance was set at α=.05.

Table 1. General characteristics of subjects (Mean±SD)

Descriptions		Experimental group	Control group
Sex	Male	6	9
	Female	4	1
Paretic side	Left	5	9
	Right	5	1
Age(yrs)		44.89±17.55	45.4±19.96
MMSE-K(score)		26.77±2.68	27.75±2.86
Height(cm)		165.67±10.95	167.9±7.5
Weight(kg)		63.33±12.34	66.8±4.85
Time since stroke(month)		16.22±5.21	22.1±7.39

MMSE-K : Mini-Mental State Examination-Korean version

Table 2. Changes in bilateral weight distribution at a standing position

(Unit: %)

	Experimental group		z	Contorl group		z	p
	Before	After		Before	After		
PS	46.78±4.74	50±5.5	.049*	45.5±9.88	48.5±9.35	.239	.774
NPS	53.22±4.74	50±5.5	.049*	54.5±9.88	51.5±9.35	.239	.774

*p<.05
PS: Paretic side, NPS: Non paretic side

III. Results

1. General characteristics of subjects

In general characteristics, the number of research subjects among the hemiplegic patients caused by stroke was 20: research group included 10 individuals (6 males, 4 females) and control group 10 (9 males, 1 female) and the general characteristics of subjects are shown in (Table 1).

2. Effects of Realignment Exercise Treatment Program on lower extremity paralyzed

1) Changes in bilateral weight distribution at a standing position

To look at the items that measured changes in bilateral weight distribution at a standing posture in MTD test, research group showed an increase from 46.78±4.74% to 50±5.5% in affected side and showed a decrease from 53.22±4.74% to 50±5.5% in unaffected side. There was a significant difference (p<.05)(Table 2).

2) Changes in dynamic balance

In BBS test, research group showed an increase from 44.33±6.02 point before treatment to 51±4.15 point after treatment and there was a significant difference (p<.05). In TUG test in which patients rose from a chair and travelled 3m back and forth, research group showed a decrease in time from 46.15±34.52s before treatment to 39.95±34.42s after treatment. There was a significant difference (p<.05)(Table 3)(Figure 1).

3) Changes in walking speed

In 10 meter walking test that evaluated the subjects' walking speed, research group showed an improvement at a comfortable gait speed from 0.45±0.32m/sec before treatment to 0.61±0.55m/sec after treatment. There was a statistically significant difference (p<.05) (Table 4) (Figure 1).

Table 3. Changes in dynamic balance

	Experimental group		z	Contorl group		z	p
	Before	After		Before	After		
BBS(sore)	44.33±6.02	51±4.15	.008**	44.2±5.47	44.9±6.87	.475	.060
TUG(sec)	46.15±34.52	39.95±34.42	.038*	27.57±8.31	25.98±8.18	.047*	.369

*p<.05 **p<.01
BBS: Berg balance scale, TUG: Timed up & go test

Table 4. Changes in walking speed

	Experimental group		z	Contorl group		z	p
	Before	After		Before	After		
10mWT	.45±.32	.61±.55	.024*	.54±.16	.56±.18	.026*	.513

*p<.05
10mWT: 10-Meter walk test

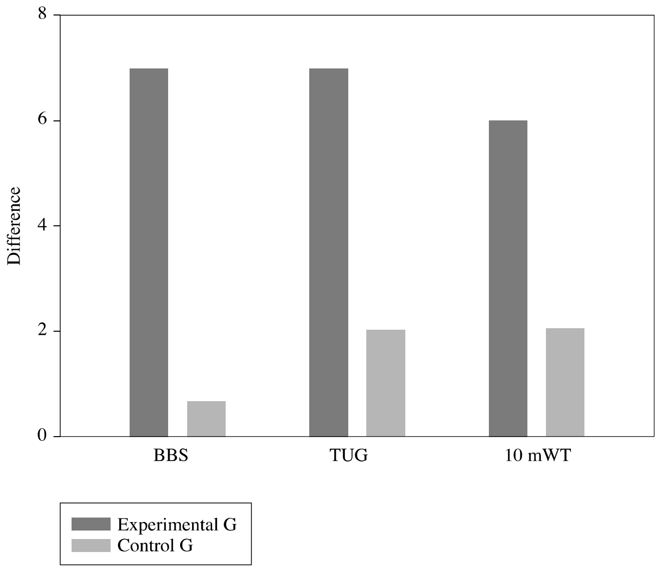

Figure 1. Difference in dynamic balance and walking speed

IV. Discussion

There was an improvement in balance and gait ability despite the fact that the mean prevalence of research participants in this study was 19.32±6.96 months. This is consistent with previous researchers[17,18] who stated that the degree of recovery in patients depended on the quality and type of exercise program and thus proves the necessity of conducting active and efficient exercise program from the onset of disease, given that the central nervous system can be reorganized by therapist's hands.

As a result, the proportion of weight distribution in affected side at a standing posture increased from 46.78±4.74% before treatment to 50±5.5% after treatment and that in unaffected side decreased from 53.22±4.74% before treatment to 50±5.5% after treatment in research group, and there was a significant difference (p<.05). In light of this, it is found that exercise program is effective for the recovery from the asymmetry in affected and unaffected side at a standing posture and that realignment program is considered to have moved weight toward the important paralyzed side and increased symmetry in both lower extremities when walking by promoting the action of antigravity muscle in paralyzed side, and thus it's helpful for identifying the purpose of this study. This is also consistent with the previous researchers: Hwang who said that proprioceptive motor control is effective for recovering bodily asymmetry when moving and Kim who indicated that realignment program through proprioceptive motor control has a consistent treatment effect for enhancing the balance of hemiplegic patients.[12,19)]

In BBS test, research group showed an increase from 44.33±6.02 point before treatment to 51±4.15 point after treatment, and there was a significant difference (p<.05).

In normal men aged in their 60ties, the mean of TUG is known to be 8∼13.1s and in normal men without neurologic damage, found to be less than 10s.[20-22)] In this study, research group showed a decrease from 46.15±34.52s after treatment to 39.95±34.42s after treatment in TUG test, and there was a significant difference (p<.05). This is consistent with previous researchers: Kim who indicated that after lower extremity realignment and therapeutic exercise program, it showed a decrease from 35.15s to 23.40s and Gu who suggested that realignment group showed an increase from 23.43s to 21.15s and there was a statistically significant difference (p<.01).[12,23] Such results are considered to be due to the effect of enhanced joint alignment and level of tension in antigravity muscle on the improvement of TUG.

The gait speed of men aged in their 60ties is reported to be about 0.60∼1.59m/sec at a comfortable speed.[21] Goldie et al.[24] told that in 42 acute stroke patients, the gait speed appeared at 0.45m/sec at a comfortable walking and Walker et al. indicated that it was initially at 0.42m/sec, but improved to 0.79m/sec after 3 months.[25] In 10m walking that evaluated subjects' gait speed, group research showed an increase from 0.45±0.32m/sec before treatment to 0.61±0.55m/sec after treatment at a comfortable speed, and there was a statistically significant difference (p<.05). This is consistent with the previous researchers who indicated that before and after treatment, comfortable walking increased at 0.34∼0.45m/sec and who indicated that realignment group showed an improved comfortable walking at 0.43∼0.47m/sec.[12] Therefore, the alignment program for the affected side through proprioceptive motor control at a standing posture and when walking is found to be more significant in enhancing balance and gait ability in hemiplegic patients. In light of these findings, it is found that changes in bilateral weight distribution at a standing posture after lower extremity realignment and therapeutic treatment program can enhance balance and gait speed and if therapeutic exercise is performed in a similar form to the actual and dynamic life when realignment is fundamentally solved with other general exercise treatments in order to recover the asymmetry between affected side and unaffected side, it would become a more effective balance recovery exercise.

When bilateral weight distribution was changed at a standing posture, research group showed an increase from 46.78±4.74% to 50±5.5% in affected side and showed a decrease from 53.22±4.74% to 50±5.5% in unaffected side, and both showed a significant difference (p<.05). In BBS test, research group showed an improvement from 44.33±6.02 point before treatment to 51±4.15 point after treatment and there was a significant difference (p<.05). In TUG test in which one moves 3m back and forth after rising from a chair, research group showed a decrease in time from 46.15±34.52s before treatment to 39.95±34.42s after treatment and there was a significant difference (P<.05). In 10m walking in which subjects' gait ability is evaluated, research group showed an improvement in speed from 0.45±0.32m/sec before treatment to 0.61±0.55m/sec after treatment at a comfortable walking, and there was a significant difference(p<.05). In conclusion, it is found that the realignment of lower extremity in affected side for 8 weeks is effective for balance and gait ability in hemiplegic patients caused by stroke. So, it seems to be necessary to make more efforts to develop effective exercise programs to improve balance and gait ability in hemiplegic patients.

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