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专题 运动与平衡功能研究

平衡评估训练系统对脑卒中后平衡功能的康复效果

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Effect of Balance Training with Balance Assessment Training System on Balance after Stroke

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Abstract

Objectives: The study aims to investigate the effects of the HUBER 360 proprioceptive muscle rehabilitation training system on the treatment of balance disorders in patients after stroke.

Methodology: Researchers adopted a double-blind, randomized controlled experiment. Sixteen patients that experienced stroke for the first time were divided evenly into the treatment group and the control group (eight patients each) based on the random number method. Both groups took the conventional motion function and balance function training for three weeks, while the treatment group was trained on the HUBER 360 proprioceptive muscle rehabilitation training system. Researchers evaluated the differences between the two groups using the Berg balance scale and Huber360's balance assessment results.

Results: After three weeks of training, the control group's Berg balance scale score was significantly higher than that of the control group (P<0.05). After the intervention, the two groups' motion track became more

stable, the peripheral area of the movement of patients' center of gravity shrank, and patients moved more quickly. The treatment group's results were significantly better than those of the control group (P<0.05).

Conclusions: Patients suffering balance disorders after stroke significantly improved their balance function after using the HUBER 360 proprioceptive muscle rehabilitation training system.

Keywords: Balance assessment and training system; stroke; balance disorders; rehabilitation training

A crucial rehabilitation goal for patients after stroke is to improve their daily living capacity where the standing balance function plays a determining role. The function can also indicate the degree of recovery of patients' limb function and walking ability[1, 2]. Insufficient standing balance function is also a vital risk factor that causes patients to fall[3]. Although most stroke patients can stand independently after recovery, they experience disorders such as asymmetric posture and reduced ability to move their center of gravity and cope with external disturbance[4]. The clinical diagnosis and treatment guideline suggests that patients suffering from balance disorders after stroke take balance training[5]. To improve patients' balance capacity through various rehabilitation methods is a critical goal in the patients' rehabilitation. HUBER 360 proprioceptive muscle rehabilitation training system can systematically evaluate the patients' balance function and treat patients accordingly[4], but so far, no findings regarding the device have been published. The study, therefore, investigates the rehabilitation effect of HUBER 360 proprioceptive muscle rehabilitation training system on patients with balance disorders after stroke.

1 Patients' Information and Methodology

1.1 Patients' Information

The sixteen patients were selected from patients that took rehabilitation protocols in the in-patient or out-patient departments during the period from July 2019 to January 202 at the Department of Rehabilitation Medicine in Beijing Tongren Hospital affiliated to Capital Medical University.

1.1.1 Inclusion Criteria:

1 The patient met the diagnostic criteria for cerebral hemorrhage and cerebral infarction enacted by the Fourth Cerebrovascular Disease Conference;

2 The focus of the patient's first stroke diagnosed by MRI or CT was located on one cerebral hemisphere, and the course of the disease was less than six months;

3 The patient aged between 30 to 70 and their vital signs were stable;

4 The patient had no other diseases in the central and peripheral nervous system before their stroke;

5 The patient had no unilateral neglect or hemianopia after the screening, and the patient could reach level 3 of standing balance.

6 The patient and their families had been informed of the treatment, agreed to cooperate with the check, and signed the informed consent letter.

1.1.2 Exclusion Criteria

1 The patient had impaired consciousness; cognitive dysfunction; obvious speech, visual, or hearing impairment, causing them unable to complete the clinical examinations as required;

2 The patient had lower limb joint or muscles disorders;

3 The patient had pathological changes in bilateral hemispheres, limb tremor, or ataxia, causing the patient unable to complete the treatment as required;

4 The function of the patient's heart, lung, liver, kidney, and other vital organs decreased or failed;

5 The patient refused to provide a written consent letter or could not complete the check as required due to unknown reasons.

1.1.3 Patient Overview

The sixteen patients were divided into two groups based on the random number method. There were no significant differences in age, course of the disease, disease diagnosis, side of the focus, and gender ($P>0.05$), as shown in Table 1.

表 1 两组患者一般资料比较

组别	例数	年龄	病程	病种		病灶侧		性别	
				脑梗死	脑出血	左	右	男	女
对照组	8	50.75±8.80	70.00±29.67	7	1	5	3	5	3
实验组	8	56.75±7.74	78.75±18.33	6	2	4	4	6	2
t值		1.448	0.710	0.385		0.238		0.273	
P		0.170	0.490	0.535		0.626		0.602	

Table 1 Comparison of Two Groups

Group Name	Number	Age	Course of Disease	Disease		Focus Side		Gender	
				Cerebral Infarction	Cerebral Hemorrhage	Left	Right	Male	Female
Control Group	8	50.75±8.80	70.00±29.67	7	1	5	3	5	3
Treatment Group	8	56.75±7.74	78.75±18.33	6	2	4	4	6	2
t value		1.448	0.710	0.385		0.238		0.273	
P		0.170	0.490	0.535		0.626		0.602	

1.2 Methodology

All patients took the conventional motion function training of the Department of Rehabilitation Medicine during the study. The same physiotherapist carried out the training for every patient. Each session took 40 minutes and was done twice per day, five days a week, for three weeks. The conventional motion function training included neuromuscular facilitation technologies (the PNF technology, Bobath technology, and proprioception facilitation technology), core muscles training, move of the center of gravity and balance training (during the training, the bearing surface was reduced and became softer, and the control scope was

enlarged; patients performed the training with eyes open and then gradually with their eyes closed; the training started from static balance to self-dynamic balance and then to balance with external disturbance).

Apart from the same treatment given to the control group, the treatment group took intensive training on the US-made Huber360 comprehensive assessment and training system. Researchers calibrated the device and designed six levels of intensive training. The higher the level, the higher the flexibility and the smaller the resistance. Each level has five degrees of difficulty, from one star to five stars. Patients started the training from one star. If their score reached 90/100 or above, they were allowed to advance to the next star level. After unlocking the device's static status, the platform can move in eight directions -- front, rear, left, right, front right, rear right, front left, and rear left. Researchers designed the training protocols based on the pre-treatment results of patients' body coordination function. Patients with a longer track and a larger area of the center of gravity movement shall choose training at higher levels and with higher flexibility requirements, while the patients with higher speed of the center of gravity movement shall choose training at lower levels and with larger resistance. Patients then took the intensive training and balance training on unstable platforms on the Huber360 platform following the device's training protocol. The training period was around five minutes, and the training protocol could also be changed based on the training progress of the patients. Each session lasted 30 minutes and was done twice a day, five days a week for three weeks.

1.3 Assessment Methodology

Two groups were assessed before treatment and three weeks after the treatment. All assessments were conducted by the same physiotherapist with rich experience.

1.3.1 Researchers adopted the Berg balance scale to assess the patient's recovery. The scale includes a total of 14 items, with the score of each item ranging from 0 to 4. A score of 4 indicated that the patient could complete the motions as required, while a score of 0 meant that the patient could not complete the motion or could only complete the motion with moderate or substantial assistance. The total score of the assessment was 56, with the lowest score being 0. A higher score indicated a better balance function.

1.3.2 Researchers adopted the US-made Huber 360 comprehensive assessment and training system to quantify patients' posture control ability at biped standing position with their eyes open and closed, respectively. The parameters included the center of the pressure movement (or the center of the movement

track), the length of the movement track (the total length of the patient's center of gravity movement), peripheral area (the area covered by the track of the patient's center of gravity movement), and movement speed (the average speed of the patient's center of gravity track).

Measurement methodology:

(1) Install the fixation bar on the balancing platform.

(2) The patient fit the inner side of their bare feet tightly to the inner edges of the fixation bar.

(3) Patients naturally hang down their upper limbs on both sides of their body.

(4) When the test starts, the patient shall chin up, look ahead, and follow the auditory cues to start and stop.

(5) After the test, the patient can get results of the center of gravity parameters, including the coordinates of the moving center of gravity, length of the track, peripheral area, and movement speed. Open-eye and closed-eye test lasted 50 seconds each. Before the assessment, the control group and treatment group would both be given adaptive training to Huber360.

1.4 Statistical Analysis

Researchers analyzed and processed the data using SPSSl9.0 statistical software. The quantitative data were expressed as X ±S; two independent samples t were adopted to compare two groups in different time points; two paired samples t were adopted to compare the same group's results at different time points. The condition of $P<0.05$ shows that the difference is statistically significant.

2. Results

2.1 Berg Score Comparison of Two Groups Before and After Treatment (see Table 2)

The two groups' Berg scores comparison before treatment did not show statistical significance ($P>0.05$). After three weeks of treatment, the two groups' BBS scores were dramatically higher than their own group's pre-treatment scores. The treatment group's performance was better than that of the control group, and the difference was statistically significant.

表 2 两组患者治疗前后 Berg 量表评分对比

组别	治疗前	治疗后	t 值	P
对照组	31.00±3.78	37.13±2.42	- 8.249	0.000
实验组	31.38±3.02	41.50±3.07	- 8.756	0.000
t 值	0.219	3.167		
P	0.830	0.007		

Table 2 Berg Score Comparison of Two Groups Before and After Treatment

Group Name	Before Treatment	After Treatment	t value	P
Control Group	31.00±3.78	37.13±2.42	-8.249	0.000
Treatment Group	31.38±3.02	41.50±3.07	-8.756	0.000
t value	0.219	3.167		
P	0.830	0.007		

2.1 Comparison of Two Groups' Posture Control with Eyes Open and Closed Before and After Treatment (see Table 2 and 3)

The difference between the two groups regarding the motion track length, peripheral area, and motion speed with eyes open and closed showed no statistical significance (P>0.05) before treatment; after three weeks of treatment, two groups' performance with eyes open and closed significantly improved compared with their own group's performance before treatment. The treatment group's improvement was apparently better than that of the control group, and the difference was statistically significant.

表 3 两组患者治疗前后睁眼双足站立下相关数据对比

	组别	治疗前	治疗后	t 值	P
长度	对照组	1236.26±247.10	988.41±138.82	2.441	0.045
	实验组	1249.85±309.57	790.69±66.70	3.548	0.009
	t 值	- 0.097	3.631		
	P	0.924	0.003		
面积	对照组	491.29±84.71	356.233±35.90	3.745	0.007
	实验组	478.29±109.28	300.27±39.87	3.495	0.010
	t 值	0.266	2.950		
	P	0.794	0.011		
速度	对照组	26.91±5.15	21.69±2.37	3.770	0.007
	实验组	25.83±4.26	15.94±1.88	8.168	0.000
	t 值	0.456	5.372		
	P	0.655	0.000		

Table 3 Comparison of Two Groups at Biped Standing Position Before and After Treatment with Eyes Open

	Group Name	Before Treatment	After Treatment	t value	P
Length	Control Group	1236.26±247.10	988.41±138.82	2.441	0.045
	Treatment Group	1249.85±309.57	790.69±66.70	3.548	0.009
	t value	-0.097	3.631		
	P	0.924	0.003		
Area	Control Group	491.29±84.71	356.233±35.90	3.745	0.007
	Treatment Group	478.29±109.28	300.27±39.87	3.495	0.010
	t value	0.266	2.95		
	P	0.794	0.011		
Speed	Control Group	26.91±5.15	21.69±2.37	3.770	0.007
	Treatment Group	25.83±4.26	15.94±1.88	8.168	0.000
	t value	0.456	5.372		
	P	0.655	0.000		

表 3 两组患者治疗前后闭眼双足站立下相关数据对比

	组别	治疗前	治疗后	t 值	P
长度	对照组	1839.69±334.53	1585.40±228.48	2.813	0.026
	实验组	1824.92±439.42	1341.97±127.52	3.174	0.016
	t 值	0.076	2.631		
	P	0.941	0.020		
面积	对照组	622.68±132.78	502.22±37.45	3.093	0.017
	实验组	676.26±120.62	459.44±39.26	5.072	0.001
	t 值	- 0.845	2.23		
	P	0.412	0.043		
速度	对照组	34.51±4.04	28.07±2.78	6.817	0.000
	实验组	32.91±2.26	22.31±2.65	16.181	0.000
	t 值	0.983	4.244		
	P	0.342	0.001		

Table 3 Comparison of Two Groups at Biped Standing Position Before and After Treatment with Eyes Closed

	Group Name	Before Treatment	After Treatment	t value	P
Length	Control Group	1839.69±334.53	1585.40±228.48	2.813	0.026
	Treatment Group	1824.92±439.42	1341.97±127.52	3.174	0.016
	t value	0.076	2.631		
	P	0.941	0.02		
Area	Control Group	622.68±132.78	502.22±37.45	3.093	0.017
	Treatment Group	676.26±120.62	459.44±39.26	5.072	0.001
	t value	-0.845	2.23		
	P	0.412	0.043		
Speed	Control Group	34.51±4.04	28.07±2.78	6.817	0.000
	Treatment Group	32.91±2.26	22.31±2.65	16.181	0.000
	t value	0.983	4.244		
	P	0.342	0.001		

3. Discussions

According to a study by the American Heart Position, in 2013, one out of twenty deaths was caused by stroke; someone in the US had a stroke every 40 seconds; someone died of a stroke every four minutes. Stroke is a commonly-seen serious disease with a high disability rate around the globe[7]. The onset could cause motion disorders, and varying degrees of limitations on patient's' neuromuscular control ability, daily living ability, and social participation abilities[8]. Balance function is a critical part of motion function[9]. Insufficient balance function could severely hinder the patient's daily living abilities, thus making it a key in today's rehabilitation training, but it remains a difficulty.

A number of studies have shown that kinetotherapy can improve patients' balance function. However, conventional training requires patients to take long-term, repeated training, and its effect may vary with the experience of the physiotherapists. If supported by the balance training system, the training may be much more effective[10, 11]. Researchers adopted HUBER 360 proprioceptive muscular rehabilitation system to train and assess the patients' balance. After three weeks of treatment, two groups both saw significant improvement in their Berg scores, and two groups' parameters about patients' posture control (with eyes open and closed) improved apparently; the improvement of the treatment group was much more significant than the control group. In conclusion, the balance improvement in the treatment group was more significant than in the control group.

Balance refers to the ability to maintain, achieve, or restore and maintain the position by adjusting the posture. Balance disorders after stroke can often affect patient's ability to move and walk, causing harm to patients' confidence about rehabilitation[12]. Today's conventional motion function training relies on physiotherapists' experience. Conventional training proactively adopts the neuromuscular development technologies to promote the neurosensory input; involves core muscles training, the center of gravity movement training, and gait training to strengthen the motion control, showing good rehabilitation effects[13, 14]. However, patients may involuntarily use the healthy side to compensate for the affected side in training, and there is no objective tool reminding patients of the mistake. Long-term, repeated training can also be boring. By contrast, when patients train under the biped training mode on the HUBER 360 proprioceptive muscular rehabilitation training system, the patient would stand at the center of the moving platform with both feet, and the screen in front of the patients can provide visual feedback by displaying the changing center of gravity. Therapists should first confirm that the patient has no contraindications and then set the training level based on the patient's performance during assessment. Patients can also take advanced training with their eyes closed. Therapists would closely monitor and protect the patient, making sure no accidents such as sprains or falls would happen. With the help of objective data showing the track length of the center of gravity, peripheral area, and motion speed, the training can facilitate the sensory input, motion control, and central nervous system to integrate the three elements engaged in the maintenance of balance, to improve the balance of the patient. The device also provides the closed-eye training protocol to train patients' somatic sensation in keeping their balance without visual input. The treatment group was better than the control group in terms of every parameter, indicating HUBER 360 proprioceptive muscular rehabilitation training system's significant effects in improving stroke patients' balance. Studies have found that the self-efficacy of balance is the main predictor of stroke patient's motion and participation's ability[15] and also an important variable that stroke patients should pay attention to. Bandura defines self-efficacy as the faith a person has in his ability to carry out plans, complete tasks, or gain results[16]. Patients who complete the balance assessment training on the device can gain better confidence and higher self-efficacy to maintain confidence and motivation in further training.

Limitations of the study:

1. The selected sample size is too small;

2. The study only investigated the rehabilitation effects after three weeks of treatment, but did not follow up to see the results in a longer term;

3. The study did not adopt parameters for observing patients' changes in walking abilities and activities of daily living (ADL) before and after treatment.

HUBER 360 proprioceptive muscle rehabilitation training system is mainly used for strength and balance functions training after motion damages. The study applied the training system in the balance function training for stroke patients, and the results showed that it could effectively improve the patients' balance, making the study clinically significant. Despite the limitations, the study preliminarily proved the feasibility of applying the HUBER 360 proprioceptive muscular rehabilitation training system to stroke patients, demonstrating statistical and clinical significance for the improvement of patients' balance. More comprehensive studies would be carried out in the future to resolve the aforementioned limitations.

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