ORIGINAL RESEARCH

Effect of Water Exercise Therapy on Lower Limb Function Rehabilitation in Hemiplegic Patients with the First Stroke

Ning Bei, PhD; Dengyi Long, PhD; Zheng Bei, PhD; Yi Chen, PhD; Zeng Chen, PhD; Zengluan Xing, PhD

ABSTRACT

Objective • To investigate water exercise therapy's effect on lower limb function rehabilitation in patients with the first stroke.

Method • 160 patients with the first stroke and lower limb dysfunction who received rehabilitation treatment in the Geriatric Hospital of Hainan, China, from May 2020 to June 2021 were randomly divided into two groups, the control group, and the hydrotherapy group. Each group comprises 80 cases in each group. The control group received conventional drug therapy and traditional rehabilitation training, while the hydrotherapy group received underwater exercise training in combination with the routine group treatment plan. The National Health Center Stroke Scale (NIHSS), the modified Rankin scale (MRS), the limb motor function score table (Fugl-Meyer assessment, FMA), Functional Walking Scale (functional ambulation category scale, FAC), Berg Balance Scale (BBS) and the modified Barthel index (MBI) were respectively used to evaluate the neurological function, lower limb motor function, walking function, balance function and daily living ability before and after treatment.

Result • There was no significant difference in NIHSS, MRS, FMA, FAC, BBS, and MBI scores between the two groups before treatment ($P > .05$). However, after 8 weeks of treatment, there was a significant difference in FMA, FAC, BBS, and MBI scores between the two groups ($P = .00035$). The FMA scores in control group was 16.60 ± 4.49, while 21.45 ± 2.96 after treatment. The FAC scores in control group was 1.45 ± 0.68, while 1.95 ± 0.783 after treatment.

Conclusion • Early water exercise training in hemiplegic patients with the first stroke can significantly enhance the balance ability, walking ability as well as limb coordination of patients. (*Altern Ther Health Med.* 2023;29(7):429-433).

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INTRODUCTION

Stroke is one of the major diseases with high global morbidity, disability, and mortality, and it is also the most common and serious cardiovascular and cerebrovascular disease in China. Current epidemiological data shows that 16.9 million people worldwide suffer from stroke each year, with an annual global incidence of 258 / 10000. The number of stroke survivors will increase to about 77 million by 2030.[1] Post-stroke rehabilitation has also become a social problem. Walking function recovery is the primary goal of rehabilitation in hemiplegic patients after stroke.[2] The efficacy of early rehabilitation therapy on the recovery of daily activities in stroke patients has been verified[3]. In recent years, water exercise therapy, as a new form of physical therapy, is widely spread among patients.[4,5]

Due to the limitation of walking function, stroke patients still rely on others for life after treatment in acute and subacute stages of stroke.[6] At present, the intervention measures for motor function recovery after stroke all emphasize the treatment strategy of early active and repetitive training, whose focus is to realize the utilization of residual motor function and the stimulation of potential motor ability under the meaningful incentive.

It has been reported that the fluidity of water, combined with its density, buoyancy, hydrostatic pressure, resistance, and thermodynamic properties can affect human physiology and activity.[7] Hydrotherapy plays an important role in motor function recovery of stroke patients. Different hydrotherapy

Table 1. Comparison of the basic information between the two groups

Group	Case	Age (year) ($\bar{x} \pm s$)	Disease time (days) ($\bar{x} \pm s$)	Gender (example)		Paraparesis (side)		Stroke type (Example)	
				male	female	left	right	hematencephalon	cerebral infarction
Hydrotherapy group	80	62.63 ± 6.79	21.75 ± 3.11	60	20	32	48	40	40
Control group	80	62.68 ± 6.56	22.38 ± 3.01	52	28	50	30	40	40

Table 2. Comparison of NIHSS scores and MRS scores between the two groups

Group	NIHSS	MRS	FMA	FAC	BBS	MBI
Hydrotherapy group	12.43 ± 2.438[a]	2.48 ± 0.56[b]	9.82 ± 4.11[c]	0.80 ± 0.85[d]	7.93 ± 3.94[e]	30.88 ± 7.80[f]
Control group	11.85 ± 2.438	2.50 ± 0.60	9.32 ± 3.51	0.57 ± 0.81	7.65 ± 4.22	30.20 ± 7.87

[a]Compared with the control group, $t = 0.973$, $P = .334$
[b]Compared with the control group, $t = 0.194$, $P = .847$
[c]Compared with the control group, $t = 0.585$, $P = .560$
[d]Control group comparison, $t = 1.297$, $P = .231$
[e]Control group comparison, $t = 0.301$, $P = .764$
[f]Control group comparison, $t = 0.385$, $P = .701$.

programs should be selected for stroke patients with different functional states. In stroke patients, early hydrotherapy serves to prevent complications and prepare for active training.[8] This includes predicting muscle spasms and taking measures to inhibit abnormal posture, particularly in the shoulder. In water resistance or passive movement, it is necessary to pay attention to swollen parts prone to contracture to prevent joint deformation. For patients with stroke stabilization period, limb function training in water, walking bath, or butterfly bath, such as trunk movement in the water, hip extension, hip flexion training, sitting balance training, standing balance training and sitting up training, walking training, etc can be carried out. However, there is no unified operating procedure standard and evaluation standard for spa rehabilitation training and nursing measures at present, which needs to be further improved.

Due to their stages of recovery and degrees of dysfunction, stroke patients need to be given corresponding, different treatment plans, nursing measures, treatment complementary, and rehabilitation therapists.[9] For many years, rehabilitation nursing at the Geriatric Hospital of Hainan is groping forward, gradually improving. Rehabilitation nursing is patient-centered, there are no medical accidents or disputes in the work of rehabilitation therapists. Rehabilitation nursing refers to escorting patients to rehabilitation treatment, monitoring patients' physical signs, providing psychological counseling for patients, and conducting effective communication with patients and their family members.[10] The effective publicity and education of rehabilitation spas is to ensure the safety of treatment, effectively improve the treatment effect on patients, and gain the trust of patients and their families.

This study investigates the role of underwater exercise therapy in the rehabilitation of lower limb function in patients with first-episode stroke, and spot a new light on clinical practice.

DATA AND METHODS

Object of study

Patients with the first stroke who underwent rehabilitation treatment in Geriatric Hospital of Hainan, China, from May 2020 to June 2021 were selected as the study subjects. 160 patients with stroke were divided into routine group and hydrotherapy group, randomly, with 80 cases in each group, and all of them signed the informed consent form. The basic information of the two groups, including age, disease time, gender, hemiplegia site, and stroke type, are shown in Table 1.

The National Health Center Stroke Scale (National Institute of Health Stroke Scale, NIHSS), the modified Rankin scale (Modified Rankin Scale, MRS), the limb motor function score table (Fugl-Meyer assessment, FMA), the Functional Walking Scale (functional ambulation category scale, FAC), Berg Balance Scale (Berg balance scale, BBS) and the modified Barthel index (Modified Barthel Index, MBI) were respectively used to evaluate the neurological function, lower limb motor function, walking function, balance function, and daily living ability before and after treatment. There was no significant difference in NIHSS, MRS, FMA, FAC, BBS, and MBI scores between the two groups before treatment ($P > .05$), as shown in Table 2.

Inclusion and exclusion criteria

Inclusion criteria.(1) Inclusion criteria met the diagnostic criteria of *Guidelines for the Diagnosis and Treatment of Acute Ischemic Stroke in China 2018* and *Guidelines for the Diagnosis and Treatment of Cerebral Hemorrhage in China (2019).*[11,12] Verified by skull CT or MRI imaging scans; (2) The disease time less than 1 month with no severe pain in the lower limb or limitation of motion in the affected side; (3) stable vital signs; (4) Sign informed consent to follow guidance and consistent treatment.

Exclusion criteria. (1) Patients with major diseases such as heart, liver, kidney dysfunction, poor glycemic control of

diabetes, etc; (2) Patients with severe lower limb joint disease, with ataxia symptoms caused by walking dysfunction; (3) Patients with hydrotherapy contraindications.

Rehabilitation training

Two groups underwent limb function training, which included exercises to reduce muscle spasms while sitting and lying down, standing training, neuromuscular promotion techniques, joint motion training, bridge exercises, lower limb weight-bearing training, and daily life activity training. Each session lasted for 40 minutes, one session per day, six days a week, for a total of 48 sessions. The control group received the treatment of freehand-assisted walking ability training with the help of rehabilitation therapists. According to literature[7], the hydrotherapy group underwent a treatment method that included water exercise training in addition to the routine group's treatment. The training was divided into two stages: the first stage involved water hemiplegia exercise training, while the second stage involved water walking training. Each training session lasted for 30 to 40 minutes, once a day, six days a week, for a total of 48 times.[13]

Evaluation indicator

To assess the progress of patients, their neurological and motor functions, ability to walk and balance, and daily living skills were evaluated before and 8 weeks after treatment. The evaluation involved the following scales (1) NIHSS, which has 15 items and a point range of 0-42. (2) MRS, divided into 0-6 grades based on clinical symptoms, with corresponding scores of 0-6 points. (3) The lower extremity motor function score scale (FMA), which has 17 items and a point range of 0-34. (4) The Functional Walking Scale (FAC), which is divided into 0-5 grades based on walking performance, with corresponding scores of 0-5 points. (5) BBS, which has 14 items and a point range of 0-56. (6) MBI, which has 10 items and a point range of 0-95.

Rehabilitation nursing of stroke patients with hydrotherapy training

As part of hydrotherapy training, patients participated in (1) a Butterfly bath rehabilitation exercise.[14] They were informed of their treatment the day before and instructed to arrive at the spa room 15 minutes early to gradually adjust to the temperature difference between indoors and outdoors. Upon arrival, the medical staff conducted necessary psychological counseling to establish a good doctor-patient relationship, strengthen trust in the medical staff, and monitor the patient's blood pressure, pulse, heart rate, and respiratory rate. Patients were required to have stable blood pressure and no abnormal signs, and should neither have an empty stomach nor be too full before the rehabilitation session. During the water exercise, attention was paid to the patient's respiratory rate and complexion. After the treatment, the staff assisted patients in measuring and recording their blood pressure for future reference.

(2) Limbs bath rehabilitation nursing where a direct current electric (DC) stimulation water bath therapy was applied to the patient's limbs in the water. At the same time, drug ion import can be carried out to enhance the patient's proprioception and stimulate muscle contraction at the affected limb. In water treatment, the hydrothermal effect and uniform pressure therapy were used to eliminate limb swelling.

(3) Rehabilitation nursing of walking bath (gait training): Gait training is crucial for stroke patients. By standing and performing weight-bearing exercises while walking in the water, patients can benefit from sensory stimulation provided by the bubble-generating device. The water's thermal effect and uniform pressure distribution can also help reduce lower limb edema. Parameters related to the water gait cycle can be obtained by marking the walking groove directly. Through the observation window of the bath, their progress can be easily monitored. Additionally, weight loss belts can be implemented for patients who are unable to fully load early on, helping them achieve their weight loss goals.

Statistic analysis

SPSS 20.0 software was used for analysis. The measurement data were expressed as ($\bar{x} \pm s$). Levene test and independent-sample t test were used. The enumeration data were analyzed by the χ^2 test. $P < .05$ indicated that the difference was statistically significant.

RESULTS

The motor function and walking function in the lower limbs

There was no significant difference in the FMA scale and FAC between the two groups before treatment ($P > .05$). After

Table 3. Comparison of FMA and FAC scores after treatment in both groups

Group	FMA	FAC
Hydrotherapy group	21.45 ± 2.96[a]	1.95 ± 0.783[b]
Control group	16.60 ± 4.49	1.45 ± 0.68

[a]Compared with the control group, $t = 5.700$, $P < .05$
[b]Comparison with the control group, $t = 3.055$, $P < .01$

Table 4. Comparison of BBS and MBI scores before and after treatment in both groups

Group	Time	BBS	MBI
Hydrotherapy group	post-treatment	27.40 ± 5.34[a]	64.90 ± 8.61[a]
Control group	post-treatment	21.38 ± 5.82	43.75 ± 8.22

[a]Compared with the control group, $t = 4.824$, $P < .05$.

Table 5. Comparison of NIHSS scores and MRS scores between the two groups

Group	NIHSS	MRS
Hydrotherapy group	9.15 ± 1.85[a]	1.00 ± 0.68[b]
Control group	9.85 ± 2.48	1.40 ± 0.87

[a]Compared with the conventional group, $t = 3.480$, $P < .01$
[b]Compared with the conventional group, $t = 2.290$, $P < .05$

8 weeks of treatment, the difference in efficacy between the two groups was statistically significant ($P < .01$), as shown in Table 3.

Balance ability and activity of daily living in the Lower limb

There was no significant difference in balance ability and activity of daily living between the two groups before treatment ($P > .05$). After 8 weeks of treatment, the efficacy of the hydrotherapy group was significantly higher than that of the control group ($P < .001$), as shown in Table 4.

Comparison of NIHSS score and MRS score after treatment

After treatment, there were significant differences in NIHSS score and MRS score between the two groups ($P < .001$), as shown in Table 5.

DISCUSSION

Stroke causes damage and death of brain nerve cells, with various dysfunctions including motor dysfunction.[15,16] Motor dysfunction, which can limit or even cause a loss of muscle control in the patient's daily life, can affect the upper and/or lower limbs on one or both sides of the body, with dysfunction in the lower limbs being particularly common and difficult to treat. Although in China, hydrotherapy technology has become increasingly popular in the field of rehabilitation medicine. However, there is still a lack of understanding about the role and effectiveness of hydrotherapy in stroke rehabilitation. Hydrotherapy uses mechanical, temperature, and chemical stimulation from water to produce physiological effects on the body, which can have a wide range of benefits for stroke patients.[17,18] Stroke is a common cerebrovascular accident, mostly caused by lack of blood or hemorrhage in brain tissue, which will lead to acute local, temporary, or lasting brain injury, among which hemiplegia is the most common. Some studies have pointed out that walk reconstruction was the key to fast recovery of walking function in stroke patients with hemiplegia. Electrical stimulation is a kind of treatment method that stimulates human muscle with low and medium-frequency electric currents to induce neuromuscular activity and improve muscle group function.[19] Some studies have found that functional electrical stimulation can promote the recovery of limb motor function in stroke patients.[19] However, the motor dysfunction of stroke patients with hemiplegia is more serious, among which abnormal gait is the most common. Single electrical stimulation therapy may not achieve the ideal therapeutic effect, given the patient's age and severe hemiplegia.

In recent years, it has been pointed out that hydrotherapy has achieved remarkable results in limb function rehabilitation after various orthopedic diseases.[8] With the rapid development of the concept of water therapy, the spa has gradually matured in the rehabilitation of hemiplegic limb movement function, which can improve the rehabilitation effect of patients and improve limb movement function. Water therapy through hydrostatic pressure and water buoyancy, supports patients in water movement with a symmetrical distribution of standing, and walking generated by gravity, combined with electrical stimulation therapy can improve the treatment effect of stroke patients with hemiplegia, and promote the recovery of limb function. Stroke patients with hemiplegia need to receive walking training as early as possible to recover lower limb function and improve impaired nerve function. The reason is that during water therapy, the warm water can effectively relieve muscle tension, reduce compensation and improve walking stability. However, there are still controversies about the clinical effects of hydrotherapy combined with electrical stimulation on gait reconstruction and cognitive function of stroke patients with hemiplegia.

This study showed that an early combination of water exercise training in hemiplegic patients with first stroke can significantly enhance the control of the lower limb, and improve the balance ability, walking ability, and limb coordination of patients.

This study analyzed the effectiveness of combining hydrotherapy with electrical stimulation to promote early gait reconstruction. The patients were observed before and after 8 weeks of treatment to track changes in gait number. The results showed that the observation group had a higher step speed and lower step width than the control group, indicating that spa joint electrical stimulation can promote early gait reconstruction. The combination of hydrotherapy and electrical stimulation can activate the motor control core-neural regulation system, which stimulates the motor cortex and regulates the skeletal and muscle activities of the lower limbs. This process relies on motor patterns learned in the brain and stored in memory. By using this therapy, patients' limb muscle groups are stimulated to obtain comprehensive input of motion, proprioception, and cognition. This strengthens the information input of muscles and joints and motor visual feedback, improves the functional connection of the motor cortex, helps rebuild nerve function, and enhances patients' cognitive function. The lower limb motor dysfunction in stroke patients in the recovery period is manifested as abnormal gait, slow speed, and difficulty in motor initiation (or transformation). Water exercise therapy can use water buoyancy to achieve uniform weight loss, which will help patients carry out walking training as soon as possible, and reduce muscle spasms, and other adverse factors, such as lower limb weight-bearing. When the water height reaches the level of the anterior superior iliac spine, the human lower extremities bear 43% of the body weight. The reduction of load in the lower limb can reduce the load of muscle contraction, energy consumption, and impact on joints from the ground, which will promote standing and walking earlier on land and obtain favorable physiological responses.[20,21] Moreover, the effect of warm water can relieve muscle tension, while the fluid viscosity force of water can slow down the movement speed to relieve the speed-dependent tension reflex hyperactivity,[18] thus training the patient's posture adjustment ability. With the support of water buoyancy and hydrostatic pressure, the center of gravity distribution of patients during standing and walking can be more symmetrical, the compensation can be reduced,

and the walking stability can be improved. At the same time, the proprioception and posture control ability can be enhanced, and the body balance and coordination function can be improved.[22-25] Since weight-bearing can be reduced in water, patients can control limb movement completely and significantly improve their enthusiasm for training.

CONCLUSION

To summarize, incorporating water sports training in the regular rehabilitation treatment of first-time stroke patients can greatly enhance their lower limb motor function, improve their walking ability, and establish a strong foundation for their reintegration into society. As a part of a comprehensive rehabilitation program, water exercise therapy is a relatively safe and effective physical therapy option with minimal adverse reactions.

DATA AVAILABILITY

The data could be obtained by contacting the corresponding author.

AUTHOR CONTRIBUTIONS

Ning Bei and Dengyi Long contributed equally to this work

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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