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Current Application Status of Exercise Therapy in Lower Limb Dysfunction of Stroke Patients

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Abstract. The incidence of lower limb dysfunction after stroke is high, which seriously affects the quality of life of patients. Exercise therapy, based on the plasticity of the central nervous system, has become an important rehabilitation method for improving lower limb function due to its diversity, fun, and low-cost advantages. Suspension therapy utilizes unstable training to activate neuromuscular feedback, and studies have shown that its combination with repetitive transcranial magnetic stimulation can significantly improve lower limb motor function scores, walking speed, and walking grading. Aquatic exercise therapy utilizes the physical properties of water to improve balance, gait, and muscle tone through Halliwick, Ai Chi, and other methods. Aerobic exercise can also increase levels of brain-derived neurotrophic factor, promote neural plasticity, and improve rehabilitation motivation. The current clinical promotion of exercise therapy still faces challenges such as insufficient facilities and lack of individualized stratification of intervention plans. In the future, standardized research needs to be conducted for different populations to promote the establishment of precise rehabilitation strategies.

Keywords: Exercise Therapy, Lower Limb Dysfunction, Stroke

1. Introduction

Stroke is an acute cerebrovascular disease, which is caused by various reasons (blockage, rupture, or insufficient blood supply) that lead to hypoxia and necrosis of brain tissue and further develop into stroke. Its main form is ischemic stroke, also known as cerebral infarction, which accounts for almost 87% of stroke cases. Its characteristics are poor prognosis, rapid onset, and a large number of complications [1,2]. According to data, the standardized prevalence rate of middle-aged people (around 40 to 50 years old) in China reached about 2.6% in 2020, and the number of people who have suffered from stroke now and in the past is about 17 million [3].

Currently, the incidence of stroke in China is about 1250 per 100000 people, and among these survivors, nearly 70% have varying degrees of functional impairment [3]. The decline in walking ability and balance dysfunction caused by sensory and motor dysfunction are the main risk factors affecting the daily life of stroke patients.

Despite the increasingly mature treatment techniques for stroke, patients still face various complications and sequelae after discharge, seriously affecting their quality of life. Among them, lower limb dysfunction has the highest incidence and is one of the most significantly affected parts

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[4]. Although traditional rehabilitation therapies (such as medication therapy) have a certain improvement effect on post-stroke complications, such as relieving abnormal muscle tone to a certain extent, their training methods are often relatively single and the process is tedious. In contrast, exercise therapy, as a highly entertaining and cost-effective rehabilitation method, has demonstrated unique advantages.

There are various types of exercise therapies with their own characteristics, which help maintain patients' treatment compliance; Some of these methods, such as neurophysiological therapy, have unique and significant promoting effects on the functional redevelopment of nerves after disuse. As a cost-effective and effective rehabilitation method, exercise therapy deserves further in-depth research. This article aims to provide a theoretical basis for the application of exercise therapy in improving functional impairment in stroke patients.

2. The application of exercise therapy in lower limb dysfunction after stroke

Exercise therapy refers to the practice where doctors often use hands-on methods or equipment to select one or more types of exercise training according to the different needs of patients to treat injuries, illnesses, or disabilities, and to achieve cure or improve functional impairments in different parts of the patient's body, mainly based on mechanics in physics for treatment. The main types of exercise therapy are forced exercise therapy, high-intensity interval exercise, moderate-intensity continuous exercise (such as long-distance jogging at a constant speed), or other types of exercise therapy (exercise therapy conducted in water, exercise therapy using suspension systems, neurophysiological therapy).

Stroke is mainly caused by various reasons leading to cerebral vascular blockage (which can be from a cardiogenic embolus traveling to the cerebral vessels causing blockage, or blockage caused by atherosclerosis), resulting in normal brain tissue or neurons in the brain experiencing hypoxia or loss of necessary glucose, which in turn leads to reduced production of Adenosine Triphosphate (ATP) in neurons, causing Central Nervous System (CNS) necrosis and neurological dysfunction. Exercise therapy for the treatment of stroke mainly relies on the plasticity and regenerative capacity of the CNS [5,6].

2.1. Suspension therapy

The basic principle of suspension therapy is to use special suspension equipment or straps, based on neuromuscular activation techniques, through treatment methods such as joint mobility training and muscle strength training, to rebuild the feedback of the neuromuscular system, a special method of exercise rehabilitation therapy. The purpose is to provide lasting improvement for musculoskeletal system diseases, and it is a comprehensive training system that primarily trains motor sensations. This technique mainly requires the body to perform exercise training in an unbalanced state, using one's own weight as the load, emphasizing the standardization of treatment, and ultimately strengthening the nervous system's control over the muscles. Currently, the most common suspension equipment includes mesh suspension systems, mobile suspension systems, and suspension training systems.

Suspension therapy uses active training and rehabilitation treatment as key elements, mainly encompassing two systems: diagnosis and treatment. By conducting weak link tests to identify the weak links in movement, specialized training is carried out on them to achieve the main training goals such as muscle relaxation, increased joint mobility, stability muscle training, and sensory-motor function training.

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Stroke patients often have sequelae of sensory and motor function impairments, which make their routine rehabilitation training more difficult. At the same time, because the lower limbs are out of sight during training, patients may unconsciously feel unsafe and uncoordinated. Additionally, factors such as increased muscle tone and various abnormal movement patterns can interfere, resulting in less satisfactory rehabilitation outcomes. The suspension system provides patients with a safely suspended environment. By utilizing the specific characteristics and features of different suspension devices, it allows the body to train in an unstable state, which can exercise the contraction ability of deep trunk muscles and improve the body's balance, control, and stability during rehabilitation and daily life.

Sun Wenlin and others used a suspension system to improve balance and walking functions in stroke patients with hemiplegia and used the FMA-LE assessment form to illustrate this (Lower limb motor function assessment: The FMA-LE assessment scale is used to evaluate the patient's lower limb motor function [7]. The main contents include presence or absence of reflex activity, flexor synergy movement, extensor synergy movement, movements with associated reactions, movements out of synergy, hyperreflexia, coordination ability, and speed. The total score is 34 points, with higher scores indicating better motor function). A total of 72 patients were included and randomly divided into three groups on average. The control group received conventional medication combined with rehabilitation therapy, the suspension group received suspension exercise therapy in addition to the control group treatment, and the final combined group added inspiratory muscle strength training on top of the suspension group treatment. The results showed that the FMA-LE scale indicated a score of 20.44±3.11 for the control group before the trial, and 26.48±1.30 after completing the training. The suspension group had a score of 21.89±2.69 before treatment, and 27.84±2.60 after completing the training. And the suspension group obviously had higher final FMA-LE scores than the experimental group, indicating that suspension exercise therapy indeed has better effects on lower limb motor dysfunction.

Another randomized controlled study randomly assigned 82 post-stroke hemiplegic patients into a suspension exercise group and a combined group, with the latter receiving 1 Hz low-frequency repetitive Transcranial Magnetic Stimulation (rTMS) treatment for 2 weeks in addition to suspension training [8]. Regarding lower limb function, the results showed: in the combined group, the Fugl-Meyer Assessment for Lower Extremity (FMA-LE) score increased from (17.26±1.98) points before treatment to (28.95±3.82) points, significantly better than the suspension exercise group's increase from (17.29±2.62) points to (24.64±3.56) points; the 10-meter walk test (10MWT) time in the combined group decreased from (28.26±3.89) seconds to (12.06±3.49) seconds, with a greater improvement than the suspension exercise group, which decreased from (28.29±3.73) seconds to (16.75±3.82) seconds; the Holden walking function grade in the combined group rose from (1.66±0.21) to (3.05±0.42), also higher than the control group's increase from (1.69±0.18) to (2.92±0.35). Research shows that rTMS, by regulating the excitability balance of both cerebral hemispheres, forms a synergistic closed loop of 'top-down' and 'bottom-up' activation with peripheral core muscle activation caused by suspension training, more effectively improving lower limb motor function, walking ability, and balance control.

2.2. Aquatic exercise therapy

Aquatic exercise therapy refers to an exercise therapy in which the body is immersed in water and specialized exercises are developed and implemented according to the physiological needs of different patients, utilizing the temperature, mechanical, and chemical properties of water. They can be divided into three categories. The basis of Halliwick therapy is the application of the Ten-Point

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Program, which uses ten steps in therapy: mental adjustment, disengagement, sideways movement, sagittal movement, longitudinal and combined rotational control, mental inversion, static balance, turbulent gliding, simple forward movement, and basic swimming skills to help patients restore their motor and sensory functions. Ai Chi refers to patients standing in water up to shoulder depth, combining deep breathing with slow movements of the arms, legs, and trunk through various body shapes. These body movements include breathing, upper and lower limb movements, postural control, and coordinated movements. Bad Ragaz Ring therapy involves patients lying on the water surface, where they receive assistance and support to perform specific activities, promoting the recovery of limb sensation and motor perception. In addition, aerobic exercises in the water mainly include slow, steady swimming, walking in the water, water aerobics, and there can even be underwater treadmills.

Due to the severe neurological damage caused by a stroke, patients may experience bilateral or unilateral limb balance dysfunction and gait abnormalities caused by differences in strength between both sides, which greatly reduces their ability to perform daily activities.

Zeng Mingyu and others randomly divided 35 patients with cerebral infarction into an experimental group (n=17) and a control group (n=16) [9]. Both groups received sufficient aquatic exercise therapy, and the experimental group received additional aquatic walking and walking board training based on the treatment given to the control group. Therapy was conducted five times a week, 60 minutes each session, for a total of six weeks. After completion, they were tested using the Berg Balance Scale, the sit-to-stand test, and finally the two-minute walk test and gait analysis. In the final results, whether in the control group or the experimental group, the Berg Balance Scale scores were basically around 45, and the results of the sit-to-stand test and the 2-minute walk test greatly improved. This can prove that aquatic exercise therapy indeed has a significant effect on the improvement of lower limb dysfunction.

In addition, muscle spasms caused by abnormally increased lower limb muscle tone can greatly affect the patient's gait, and the combined therapy of aquatic exercise therapy and electroacupuncture stimulation can significantly improve abnormal movement patterns caused by increased abnormal muscle tone.

Aerobic exercises performed in water can also increase Brain-derived Neurotrophic Factor (BDNF), and the role of this neurotrophic factor is to increase the survival probability of neurons [10,11]. At the same time, it is an effective regulator of various neurotransmitters, capable of inhibiting neuronal stress responses, thereby reducing non-steady-state load, and affecting the activity of the nervous system and hypothalamic-pituitary-adrenal axis under non-steady-state load, increasing neuronal plasticity and stress responsiveness. At the same time, aerobic exercise can also increase the transmission of dopamine and raise the levels of dopamine in the brain, which can improve mood and other effects, enhancing the patient's motivation for recovery.

3. Conclusion

Exercise therapy, with its diverse technical system, is gradually becoming an important intervention in the field of stroke rehabilitation. As one of the most prominent sequelae after a stroke, lower limb dysfunction seriously restricts the quality of life of patients. With its diverse forms and low-cost advantages, exercise therapy has become an important means of rehabilitating lower limb dysfunction after a stroke. Suspension therapy activates neuromuscular feedback, and aquatic exercise therapy uses the physical properties of water to improve balance and gait. Both have shown significant improvements in lower limb motor function, walking ability, and muscle tone in clinical studies. However, current exercise therapies still face a dual dilemma in clinical promotion: on one

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hand, some therapies have high requirements for facilities, and uneven resource distribution limits their accessibility; On the other hand, existing intervention programs tend to be more standardized and uniform, neglecting the individual differences within patient populations and the heterogeneity of rehabilitation needs. An ideal rehabilitation strategy should not stop at the universal application of a 'standard program,' but should instead build a stratified and individualized treatment framework for different groups—for example, elderly patients focus on restoring daily living abilities, while athletes require higher-intensity functional reconstruction and return to competition. To achieve this goal, it is urgently necessary to rely on more systematic clinical research, accumulate stratified control data, verify the safety and effectiveness of differentiated interventions, and thereby maximize their clinical potential in stroke rehabilitation.

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