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Report

Study on the Efficacy of Hydrotherapy Exercise Prescription on Walking Ability of Patients with Spastic Cerebral Palsy

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Abstract: Objective: Spastic cerebral palsy is the most common type of cerebral palsy and is characterized by increased skeletal muscle tone throughout the body, especially in the lower extremities. Long-term muscle spasticity and muscle strength imbalance can cause different degrees of fixed deformities in the lower extremities of cerebral palsy patients, which can seriously affect their walking ability and even their daily life. In this study, we will conduct hydrotherapy exercise prescription rehabilitation training for patients with spastic cerebral palsy aged 20-40 years old and analyze the effect of hydrotherapy exercise prescription on patients' walking ability using gait analysis system to provide a new idea of treatment for improving walking ability of cerebral palsy patients. Methods: Thirty-two patients with spastic cerebral palsy admitted to our hospital from January 2017 to February 2018 were selected as the experimental group, and a walking tank manufactured by HYDRO PHYSIO, UK, was used to maintain the water temperature at 34-40°C. 32 patients were rehabilitated with hydrotherapy exercise prescription for 8 weeks, 1 time/day, 20-30 min/time. In the experimental group, gait data were collected in Vicon 3D gait analysis system after 8 weeks. The gait data of 32 normal subjects in the control group and the gait data of the experimental group before and after treatment were compared and analyzed to study the effect of hydrotherapy exercise prescription on the walking ability of patients with spastic cerebral palsy aged 20-40 years. Results: After 8 weeks of treatment, the patients' gait data in frequency, stride length, stride speed, single support and double support were significantly improved ($p < 0.05$). Conclusion Hydrotherapy exercise prescription is effective in the treatment of walking ability in patients with spastic cerebral palsy and helps patients' lower limb balance and stability, which is worthy of application and promotion.

Keywords: Hydrotherapy, Exercise Prescription, Spastic Cerebral Palsy, Walking Ability

1. Introduction

Cerebral palsy (CP) is a group of persistent central disorders of the motor and postural development and restricted movement syndromes that result from non-progressive brain damage in the developing fetus or infant [1]. The most common type of cerebral palsy is spastic cerebral palsy, in which increased skeletal muscle

tone in the lower extremities is particularly evident. Due to prolonged muscle spasticity and muscle imbalance, cerebral palsy is complicated by varying degrees of fixed deformities and, in severe cases, bony deformities. The principles of treatment for spastic cerebral palsy are to relieve muscle spasm, balance the muscle strength of the trunk and limbs, correct the contracture of the limbs, and reestablish the negative gravity line and biomechanical line of the body [2].

Walking ability is a fundamental and key element in determining the quality of daily survival of patients with cerebral palsy, and with age, there is an increasing risk of reduced walking function in patients with cerebral palsy, especially in adulthood between the ages of 20 and 40, when most patients with cerebral palsy will have significantly reduced walking function [3], and their own limited mobility will cause more serious consequences in their lives, as well as bring a heavy burden to their families and society. There are few studies on hydrotherapy rehabilitation for spastic cerebral palsy patients in the age group of 20 to 40 years old, and there are almost no studies on the efficacy of hydrotherapy exercise prescription in walking ability of spastic cerebral palsy patients. Therefore, this study uses hydrotherapy exercise prescription combined with Vicon gait analysis system to investigate the effect of hydrotherapy exercise prescription on walking efficacy of patients, aiming to reduce the social burden and promote the walking ability of middle-aged cerebral palsy patients The aim of this study is to reduce the social burden, improve the walking ability of middle-aged cerebral palsy patients, and provide better assistance to return to social life.

2. Materials and Methods

2.1. Participants

Table 1. *Baseline characteristics of study subjects.*

Variable	EG (n=32)	CG (n=32)	t	*p*
Gender (M/F)	24/8	26/6	1.44	0.16
Age	29±6.73	28±6.58	1.71	0.97

Thirty-two patients with spastic cerebral palsy aged 20-40 years which could walk independently for more than 3 m, including 24 males and eight females, who met the diagnostic criteria of spastic diplegia in the diagnostic and typing criteria developed by the National Symposium on Pediatric Cerebral Palsy from January 2017 to February 2018, were selected at the Bay Rehabilitation Hospital in Sichuan Province [4]. Inclusion criteria: 1. spastic cerebral palsy patients aged 20-40 years that could walk independently for more than three meters; 2. no cardiopulmonary disorders, no skin breaks, no acute inflammation and skin diseases, infectious diseases, etc. (patients had no other diseases affecting hydrotherapy and walking ability.); 3. no surgical treatment during the experiment; 4. informed consent of the patients' guardians. The experiment was divided into a control group and an experimental group, with 32 patients in each group; the control group was normal people with sound limbs, and the experimental group was patients with spastic cerebral palsy. The numbers of the two groups were the same, and there was no significant difference in age and sex ($P > 0.05$).

2.2. Treatment Method

The experimental group was rehabilitated with hydrotherapy exercise prescription using a walking tank manufactured by HYDRO PHYSIO, UK. As a hydroelectric physiotherapy product consists of an exercise room, control system and water tank and pump system. During the treatment, the room temperature was maintained at about 27°C; routine disinfection was performed, and the water temperature was maintained at 34-40°C (the optimum temperature for body sensation) [5], and the circulation insulation mode was turned on to monitor the water temperature changes in real time. Patients were not allowed to enter the walking tank until they had put on clean swimming trunks and necessary shoes. The therapist closes the door after the patient enters the walking tank and stands normally on the treadmill, starts the hydrotherapy physical therapy system after the exercise room is filled with water (approximately 1600 liters), manually or programmatically selects the patient's desired water depth, treadmill speed, and water jet resistance, and starts the hydrotherapy exercise prescription rehabilitation training after selecting the patient's training program.

Hydrotherapy exercise prescription design: the maximum load measurement and the maximum speed that the patient can walk in 6 meters before treatment, and then converted to the speed of the treadmill for separate treatment. 1. patient treatment time: once/day, 20 min-30min/time, for 8 weeks; 2. patient treatment speed: preset treadmill speed: 1-2 weeks 0.2km/h, 3-4 weeks 0.3-0.4km/h, 5-6 weeks 0.5km/h, 7-8 weeks 0.6-0.8km/h. Then according to the measured intensity corresponding to different treadmill speed; 3. patient treatment intensity The starting posture of treatment is normal standing force in the walking trough, and the purpose of treatment is to improve the mobility of limb joints, maintain muscle circumference, and prevent muscle atrophy and joint contracture.

The walking trough is equipped with an emergency stop button to ensure the safety of the patient's treatment, handrails on both sides to eliminate the psychological burden, and the buoyancy of the water to reduce the patient's gravity and increase the number of walking repetitions. The therapist will closely observe the patient's condition during the whole intervention treatment. If the patient has chest tightness, tightness of breath, dizziness and other discomfort, or monitors systolic blood pressure <60 mmHg or >140 mmHg, heart rate >120 beats/min, immediately terminate the intervention treatment, move the patient out of the walking trough, lie down to rest, do a good job of insulation measures, and actively treat symptomatically to ensure the patient's life safety.

The control group was the gait data collected by 32 normal people in Vicon gait analysis system for comparative analysis.

2.3. Efficacy Assessment Index

The Vicon 3D gait analysis system was used to guide the patients to complete 4 round trips of about 6 meters without aids in the collection area. The gait data were collected and processed after the rehabilitation training of hydrotherapy exercise prescription.

2.4. Statistical Analysis

The gait parameters used in this experiment were all measures, and the data were expressed as mean and standard deviation, and the data were analyzed using SPSS22.0 statistical software. A paired t-test was performed, and P<0.05 was considered statistically different.

3. Results

After the rehabilitation training with hydrotherapy exercise prescription, the walking parameters of the experimental group were significantly different from those of the control group (P < 0.01), and the gait parameters of the experimental group before and after the treatment were significantly improved, indicating that the rehabilitation training with hydrotherapy exercise prescription was effective in improving the walking efficacy of patients with spastic cerebral palsy.

Table 2. *Comparison of gait parameters between the control group and the experimental group before and after treatment.*

Parameters	Group	Pretest	Posttest	*t*	*P*
	CG	112.39±6.12			
Cadence (steps/min)					
	EG	80.67±13.03	88.69±19.33	-3.26	0.003
	CG	1.19±0.80	-	-	-
Walking velocity (m/s)					
	EG	0.56±0.24	0.59±0.25	-2.95	0.006
	CG	0.64±0.52	-	-	-
Step length (m)					
	EG	0.35±0.13	0.39±0.13	-2.94	0.006
	CG	34.39±0.55	-	-	-
Single support (%)					
	EG	0.40±0.10	0.46±0.10	-8.4	P<0.001
	CG	31.27±1.20	-	-	-
Double support (%)					
	EG	0.41±0.30	0.49±0.29	-7.30	P<0.001

4. Discussion

The onset of spastic cerebral palsy is dominated by damage to cortical motor areas and vertebral bodies. Motor commands from the brain are not well accomplished due to hyperactive detrusor reflexes in passive joint movements, which manifest as motor deficits and abnormal postures with symptoms such as internal rotation, inversion, and trunk forward flexion of the upper limbs, knee flexion and internal rotation, and inversion, internal rotation, crossover, and arch-back sitting of the lower limbs. The most common negative manifestations of dysfunction in patients with cerebral palsy are muscle weakness, loss of selective motor control, sensory deficits and muscle strength imbalance, and velocity-dependent increased muscle tone with hyperactive tendon reflexes, which are characteristic [6]. The spasticity and walking impairment of the lower extremities are even more serious to the survival quality of patients; therefore, reducing the walking dysfunction and improving the walking ability of patients are issues that rehabilitation workers must focus on. Spastic cerebral palsy has a higher chance of acquiring walking ability compared to other types of cerebral palsy, while the percentage of acrokinetic cerebral palsy acquiring walking is very low, and involuntary movement cerebral palsy can hardly acquire walking ability [7], and the overall motor functions such as walking of hemiplegia and diplegia are better than those of trigeminal and quadriplegia in spastic cerebral palsy [8], therefore, the types of cerebral palsy involved in this study are mainly spastic hemiplegia and spastic diplegia.

Exercise prescription is a purposeful and planned exercise method. The rehabilitation physician prescribes the type, intensity, duration, and frequency of exercise for the patient based on the health, physical, and cardiovascular status of the patient based on the examination results, and suggests precautions to be taken during exercise. For stroke patients, therapeutic exercise prescription can improve the excitatory or inhibitory function of the central nervous system, improve the regulation of the brain and neurohumoral function, and improve the function of the nervous system on the organs and systems. The neurological regulation of organs and systems can help accelerate the postoperative recovery of patients. Therefore, scientific and rational exercise using exercise prescription is an effective treatment modality [9].

The development of rehabilitation medicine is based on the fundamental goal of better recovery of patients' functions [10]. Hydrotherapy is widely used to prevent and treat diseases [11-13], and the Expert Consensus on Hydrotherapy Rehabilitation Techniques [14], which was jointly prepared by relevant experts, was developed with reference to the relevant standards at home and abroad to promote the better development of aquatic exercise therapy in stroke in China

[15]. Hydrokinesitherapy is a common rehabilitation method in hydrotherapy, which makes use of the physical properties of water to relieve the patient's symptoms and to improve and treat the disease. Hydrokinesitherapy can greatly alleviate various symptoms or improve motor functions for patients with neurological, muscular and skeletal injuries and burn rehabilitation [16-19]. People use the physical properties of water for exercise rehabilitation, which can improve muscle strength and endurance [20-23], increase the range of motion, restore the control of movement, balance and coordination, strongly improve the flexibility of the body and promote the recovery of the body injury [24-28]. In Europe, America and Japan, aquatic therapy plays an important role in the rehabilitation therapy system together with music therapy and recreational therapy and traditional physical therapy, occupational therapy, speech therapy and psychotherapy [29-30].

This study combined hydrotherapy and exercise prescription to develop postoperative rehabilitation training for stroke patients, an effective combination of an exercise program and postoperative rehabilitation, aiming to maximize the utility of both hydrotherapy and exercise prescription to provide directional guidance and efficacy enhancement for accelerating postoperative rehabilitation of patients with spastic cerebral palsy. Hydrotherapy exercise prescription for patients with spastic cerebral palsy can enhance the stability and coordination of the ankle, knee, and hip joints, increase proprioceptive input, and achieve improved balance and coordination [31-32]. Hydrotherapy with warm water baths can accelerate patients' blood circulation, relieve patients' muscle spasm, improve pulmonary function by stimulation of the thorax, and increase cardiac function by improving the nutritional effect of the myocardium, allowing recovery of brain function in patients with spastic cerebral palsy, improve the level of motor development and spasticity in patients with spastic central coordination disorders, prevent limb contractures and deformations, and induce correct posture.

First of all, the physical properties of water allow the patient to be buoyant in the water, so that the weight is reduced and the energy consumption of some muscles of the lower limbs is reduced, the load and the impact of the ground on the joints are slowed down, so that the treatment is relatively more energy-saving and relaxing. Secondly, the water temperature (different temperatures of sequential and alternating stimulation) also has a great impact on the therapeutic effect of patients. Thermal stimulation affects muscle tension and helps to relieve muscle spasm; it also relieves the pain associated with spasticity, which decreases as pain diminishes, and a series of neuroendocrine responses induced by thermal stress, thermal stimulation promotes the release of adrenocorticotropic hormone, cortisol, prolactin and growth hormone [33]. Collagen-rich tissues such as tendons, fascia, and joint capsule are more extensible with increased thermal stimulation, which improves the range of motion of joints [34]. Finally, hydrotherapy has anti-inflammatory and neuroprotective effects that have been demonstrated in studies of other diseases [35].

The experimental group underwent aquatic exercise rehabilitation in a walking tank manufactured by HYDRO PHYSIO, UK, and the results confirmed that the patients' walking ability improved with walking speed and lower limb motor function. Walking speed is a basic indicator of the level of walking function, which not only reflects walking stability and independence [36], but is also closely related to the kinematics and kinetics associated with walking [37]. From Table 2, it can be seen that although there is still a gap between the gait data of patients and normal people after treatment, the data after hydrotherapy shows that they are closer to normal gait; the comparison of gait data of the experimental group before and after treatment reveals that there is a significant change in gait data of patients who have done rehabilitation training with hydrotherapy exercise prescription, and the difference is significant ($P < 0.01$) walking ability can also be visually seen to improve, indicating that hydrotherapy exercise prescription also This indicates that the hydrotherapy exercise prescription also helps the balance and coordination of the lower limbs of patients with spastic cerebral palsy. The comfort of the hydrotherapy exercise prescription can also reduce the pain of spastic cerebral palsy patients, which is easily accepted by the patients.

5. Conclusion

In conclusion, the hydrotherapy exercise prescription has improved the gait of spastic cerebral palsy patients and is worth promoting and applying. However, at present, there is a lack of research on the mechanism of hydrotherapy exercise prescription to relieve spasticity, and the clinical evaluation of spasticity is easily influenced by subjective and other negative aspects, and there is a lack of unified standard. Due to the short rehabilitation time of hydrotherapy exercise prescription and the small sample size of patients with spastic cerebral palsy, later studies need to further increase the sample size, increase the clinical observation time of hydrotherapy exercise prescription, and conduct long-term observation and deeper research on the efficacy of walking ability in patients with spastic cerebral palsy aged 20-40 years.

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