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Intervention Effect of Lower Limb Rehabilitation Robot with Task-Oriented Training on Stroke Patients and Its Influence on KFAROM Score

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Abstract

Objective: To explore the effect of lower limb rehabilitation robot combined with task-oriented training on stroke patients and its influence on KFAROM score. **Methods:** 100 stroke patients with hemiplegia admitted to our hospital from January 2023 to December 2023 were randomly divided into two groups, the control group (50 cases) was given task-oriented training assisted by nurses, and the observation group (50 cases) was given lower limb rehabilitation robot with task-oriented training. Lower limb balance, lower limb muscle strength, motor function, ankle function, knee flexion range of motion and walking ability were observed. **Results:** After treatment, the scores of BBS, quadriceps femoris and hamstrings in the observation group were significantly higher than those in the control group ($P < 0.05$). FMA and AOFAS scores were significantly better than those in the control group ($P < 0.05$). The scores of KFAROM and 6-minute walking distance were significantly higher than those in the control group ($P < 0.05$). **Conclusion:** In the clinical treatment of stroke patients, the combination of task-oriented training and lower limb rehabilitation robot can effectively improve the lower limb muscle strength, facilitate the recovery of balance function, and have a significant effect on the recovery of motor function, which can improve the walking ability of stroke patients and the range of motion of knee flexion, and achieve more ideal therapeutic effectiveness.

Keywords

Lower Limb Rehabilitation Robot, Task-Oriented Training, Stroke, KFAROM

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1. Introduction

Stroke is a common and multiple disease with the characteristics of high disability rate and high incidence [1]. Studies have shown that blood pressure medications, obstructive sleep apnea, electronic cigarettes, and elevated lipoprotein (a) are all factors that increase the risk of stroke [2]. In addition, urinary tract infections after acute stroke are a potential factor in making strokes more severe [3]. Most patients with stroke present with hemiplegia, aphasia, and dysphagia, which manifest as vocal tract disease [4]. In stroke patients, about 79% of patients will have different degrees of lower limb motor dysfunction [5]. Hemiplegia is a common and serious sequela, which seriously affects the daily life and health of patients. Appropriate and scientific rehabilitation training for stroke patients with hemiplegia can effectively promote the recovery of motor function, improve the curative effect and improve the prognosis [6]. There are also Soft Robotic Exosuit (SRE) that can effectively improve the walking ability of stroke patients [7]. Task-oriented training theory holds that setting non-abstract tasks and goals for patients can fully mobilize the vision and touch of patients, so that the nervous system of patients can effectively promote the normal play of their motor system, but the traditional training method is mainly one-to-one guidance by nurses to patients. In the training process, it is difficult to combine weight bearing, walking and balance organically, and the recovery of patients mainly depends on the subjective judgment of nurses. It is easy to cause the formation of abnormal gait, so the rehabilitation effect is not good [8]. Lower limb rehabilitation robot is a new type of rehabilitation treatment technology, which can develop individualized gait training programs for patients through intelligent feedback and other systems, and effectively improve their lower limb motor function, thereby enhancing the effect of rehabilitation treatment and promoting functional recovery [9]. In order to further analyze the therapeutic effect of lower limb rehabilitation robot, in this study, the lower limb rehabilitation robot with task-oriented training program was used in the rehabilitation treatment of stroke patients, and its impact on the KFAROM score of patients was discussed. The following report is made.

2. Data and Method

2.1. General Information

A total of 100 stroke patients with hemiplegia admitted to our hospital from January 2023 to December 2023 were selected as the research objects and randomly divided into groups. The control group consisted of 50 cases, including 22 males and 28 females; 35 - 70 years old, mean (45.71 ± 4.59) years old; course of disease: 1 - 6 months, mean (3.18 ± 0.23) months; types of diseases: 27 cases of cerebral infarction and 23 cases of cerebral hemorrhage; location of hemiplegia: right side 30 cases, left side 20 cases. There were 50 cases in the observation group, including 23 males and 27 females; 35 - 69 years old, mean (45.24 ± 4.28) years old; course of disease: 1 - 5 months, mean (3.34 ± 0.15) months; types of diseases: 26 cases of cerebral infarction and 24 cases of cerebral hemorrhage; location of hemiplegia:

right side 29 cases, left side 21 cases. There was no significant difference in gender, course of disease, age and other demographic data between the two groups ($P > 0.05$). This study has been reviewed and approved by the hospital ethics committee, and the patients and their families have signed the informed consent.

2.2. Inclusion and Exclusion Criteria

Inclusion criteria: 1) Meet the clinical diagnostic criteria for hemiplegia after stroke [10]; 2) Those who have walking dysfunction, but can walk for more than 6 minutes with the help of a walker; 3) No history of heart failure, serious lung infection and other serious complications that affect rehabilitation treatment; 4) Patients with the first onset of the disease and receiving rehabilitation training for the first time; 5) Those with stable vital signs; 6) All of them belong to unilateral limb hemiplegia; 7) The neurological function score of stroke patients in China is 0 - 15 points.

Exclusion criteria: 1) Patients with malignant tumor disease; 2) Those with severe dysfunction of important organs; 3) Patients with unstable fractures; 4) Those with neurological diseases, cognitive impairments, and psychiatric diseases, and poor treatment compliance; 5) Patients with severe lower limb spasm, osteoporosis, neuromuscular and lower limb bone and joint diseases; 6) Severe contracture of the lower limbs and affecting the joint movement of the lower limbs; 7) Hemiplegia caused by head injury.

2.3. Method

The control group received task-oriented training assisted by nurses. The target tasks of sitting, standing and walking were formulated, and rehabilitation training was carried out according to the motor function and walking disorder of patients, mainly including lower limb balance control, strength, weight-bearing ability, ability to clear obstacles in the lower limb of the affected side and walking endurance. 1) Sitting position training: The nurse first helped the patient to practice sitting position by using the back support, and gradually pulled the back support away to guide the patient to sit alone; when the sitting alone was stable, then they were instructed to sit on their sides, and then they were trained by changing direction every 5 minutes. 2) Standing exercise: When the patient was in a sitting position, the nurse instructed the patient to use arm poles and crutches for standing training; if necessary, the nurse should assist the patient to stand. The patient was instructed to stand with the help of external forces such as handrails, and repeated contact was made in this way. The standing time was about 10 minutes each time. The actual condition of the patient was considered. Gradually instruct the patient to stand free of external forces and perform a twist-in-place exercise. 3) Walking exercise: With the help of the nurse, they were instructed to lift their feet and move forward slowly. The walking distance could be gradually increased from 5 m to 20 m, and the walking time could be increased from 10 min to 30 min. The training was repeated until they walked independently. 4) Trunk muscle training: The main purpose is to train the ability of trunk balance control. Instruct the patient to take the supine position, hold the head with both hands, keep the head and feet lifted off the bed at the same time, move the body focus to the trunk, hold for 10 minutes, then slowly put down the feet and head, repeat the training. 5) Lower limb muscle strength training: The patient was instructed to take the supine position for straight foot raising and abduction exercise; the nurse set the lifting point in the void. Instruct the patient to repeatedly lift the foot to the designated point and stay for 5 s after touching the obstacle; also instruct the patient to perform bicycle posture exercises. 10 minutes for each exercise. They were instructed to take the lateral and prone positions and perform knee flexion exercises. In the standing position, instruct the patient to lift his heels off the ground and stand with both feet on the inclined board; instruct the patient to go up and down the steps and can also guide that patient to carry out transfer train. For example, stand up from the chair and walk for 10 m, and then return to the chair again. Treatment 2 times/d, 20 min/time.

On the basis of the above treatment, the observation group was given lower limb rehabilitation robot treatment. Lower limb rehabilitation robot treatment uses Lokomat automatic robot produced by Hocoma Company in Switzerland, and nurses who have been certified by the company's rehabilitation robot trainers are responsible for the whole operation. Before the training, the patient's lower limbs were measured by the nurse and the data were input into the computer system. Then, according to the specific condition of the patient, the Lokomat system parameters are set, that is, the initial weight loss of the patient is set to 50% of the body mass, during which the tolerance of weight loss should be adjusted appropriately in combination with the patient's training process. The adjustment of weight loss should be based on the fact that the knee joint of the patient's legs does not bend during walking training, but the weight loss should be kept above 20% of the body mass. The walking speed should be set according to the actual situation of the patient, and the principle to be followed is to keep the speed of the exoskeleton lower limb gait correction driving device consistent with the speed of the medical treadmill. In addition, the nurse also needs to adjust the guiding force of the exoskeletal lower limb gait correction driving device according to the patient's condition. The initial setting is 100%, and then the patient's tolerance to the guiding force during training is used to gradually reduce the guiding force, increase the difficulty of training, and enhance the patient's active walking strength and endurance, but it is necessary to ensure that the guiding force is more than 30%. When the patient is in walking training, the nurse should instruct the patient to touch the nurse's palm with his toe and stretch the affected leg to induce the deceleration period of the stride phase in the normal gait cycle, so as to enhance the patient's proprioception and brain plasticity for the heel load of the affected side. Treatment once a day, 30 min/time.

The two groups of patients were treated with the above treatment methods for 3 months, and then the relevant indicators were evaluated.

2.4. Observation Index

Lower limb balance and lower limb muscle strength. Balance ability of lower limbs: The balance ability of lower limbs was assessed with Berg Balance Scale (BBS) [11] before and after treatment. The scale included 14 items, and each item had 5 items. The scale was scored by 0 - 4 points and 5 grades, and the total score was 56 points. The lower the score was, the worse the balance ability of lower limbs was. Muscle strength of lower limbs: The quadriceps femoris and hamstring muscles of the patients were evaluated by Manual Muscle Testing (MMT) before and after treatment respectively. Kendall percentage method was used to evaluate the muscle strength. The lowest score was 0 and the highest score was 100. The muscle strength increased with the increase of the score.

Motor function and ankle function: The motor function of upper and lower limbs of the patients before and after treatment was scored with Fugl-Meyer Assessment (FMA) [12], in which the total score of upper limb motor function was 66 points, the total score of lower limb motor function was 34 points, the total score was 100 points, and the higher the score, the higher the motor function of the patients. Ankle joint function: Before and after the treatment, the recovery of ankle joint function of the patients was evaluated with the American Orthopedic Foot and Ankle Society (AOFAS) [13]. The evaluation items included 10 items such as pain and function, with a total score of 100 points. The higher the score, the better the ankle joint function.

Knee Flexion Active Range of Motion (KFAROM) and walking ability. KFAROM was measured with a special angle ruler for joint range of motion evaluation before and after treatment to evaluate the recovery of knee range of motion. Walking ability: The walking ability of the patients was evaluated by 6-minute walking test before and after treatment. That is to say, the patient repeatedly walked in a distance of 50 cm within 6 minutes, and the distance of walking in 6 minutes was recorded. The longer the distance, the better the walking ability.

2.5. Statistical Methods

SPSS 22.0 software was used to complete the statistical analysis of the data, and the difference was statistically significant ($P < 0.05$). Counting data were described as percentage, χ^2 test was used for comparison, and measurement data were described as standard deviation "$\bar{x} \pm s$", *t*-test for comparison.

3. Result

3.1. Comparison of Lower Limb Balance and Muscle Strength between the Two Groups

Before treatment, there was no significant difference in lower limb balance and lower limb muscle strength scores between the two groups ($P > 0.05$). After treatment, the scores of BBS, quadriceps femoris and hamstrings increased significantly in both groups, and the increase in the observation group was significantly greater than that in the control group ($P < 0.05$), as shown in **Table 1**.

Table 1. Comparison of lower limb balance and muscle strength between the two groups (points, $\bar{x} \pm s$).

Group	n	BBS		Quadriceps femoris muscle		Hamstring muscle	
		Before treatment	After treatment	Before treatment	After treatment	Before treatment	After treatment
Control group	50	21.04 ± 3.21	42.11 ± 3.14*	41.20 ± 2.35	78.01 ± 2.17*	48.40 ± 4.13	74.38 ± 5.34*
Observation group	50	21.06 ± 3.18	50.10 ± 3.23*	41.22 ± 2.30	92.02 ± 2.10*	48.38 ± 4.24	96.37 ± 5.30*
T-value	-	0.031	12.541	0.043	32.805	0.023	20.667
P-value	-	0.975	0.000	0.965	0.000	0.981	0.000

Note: * refers to the comparison between this group and before treatment, $P < 0.05$.

3.2. Comparison of Motor Function and Ankle Function between the Two Groups

There was no significant difference in the scores of motor function and ankle function between the two groups before treatment ($P > 0.05$). The FMA and AOFAS scores in the control group were significantly higher than those before treatment, while the FMA and AOFAS scores in the observation group were significantly higher than those before treatment and significantly higher than those in the control group ($P < 0.05$), as shown in Table 2.

Table 2. Comparison of motor function and ankle function scores between the two groups (score, $\bar{x} \pm s$).

Group	n	FMA		AOFAS	
		Before treatment	After treatment	Before treatment	After treatment
Control group	50	54.92 ± 5.26	85.35 ± 5.52*	42.59 ± 5.31	81.80 ± 5.10*
Observation group	50	54.91 ± 5.39	93.36 ± 5.46*	42.48 ± 5.42	95.91 ± 5.12*
T-value	-	0.009	7.294	0.102	13.806
P-value	-	0.992	0.000	0.918	0.000

Note: * refers to the comparison between this group and before treatment, $P < 0.05$.

3.3. Comparison of Knee Flexion Range of Motion and Walking Ability between the Two Groups

There was no significant difference in knee joint activity and walking ability between the two groups before treatment ($P > 0.05$). The scores of KFAROM and 6-minute walking distance in both groups were significantly higher than those before treatment, and those in the observation group were significantly higher than those in the control group ($P < 0.05$), as shown in Table 3.

Table 3. Comparison of knee range of motion and 6-minute walking distance between the two groups ($\overline{x} \pm s$).

Group	n	KFAROM (˚)		6 min walking distance (m)	
		Before treatment	After treatment	Before treatment	After treatment
Control group	50	55.82 ± 5.87	70.14 ± 5.71*	195.14 ± 10.42	270.75 ± 10.48*
Observation group	50	55.77 ± 5.58	85.17 ± 5.58*	195.18 ± 10.25	320.14 ± 10.36*
T-value	-	0.043	13.311	0.019	23.699
P-value	-	0.965	0.000	0.984	0.000

Note: * refers to the comparison between this group and before treatment, $P < 0.05$.

4. Discussion

Hemiplegia after stroke is one of the common sequelae of stroke patients. It may lead to disuse atrophy of motor center and corresponding muscles, and then lose the ability of daily living [14]. Task-oriented training is to combine clinical rehabilitation training with purposeful functional movements, and repeatedly carry out task-oriented training, so as to achieve the purpose of functional training [15]. In the process of stroke rehabilitation training, task-oriented training can achieve certain curative effect, but the traditional clinical rehabilitation training mode is guided by manual work. Long-term use of this kind of guidance model is difficult to obtain ideal treatment and training needs, and it is difficult to obtain significant curative effect.

The lower limb rehabilitation robot has a plurality of systems such as a virtual training mode, intelligent feedback, weight reduction and the like, can provide long-term, stable, scientific and reasonable quantitative motion input and real-time feedback information for a patient, can ensure the consistency, scientificity and continuity during the training of the patient, can realize the parameterization of a training scheme and rehabilitation evaluation and the like, and can effectively improve the rehabilitation effect of patients. After stroke, the patient's motor or sensory conduction pathway is impaired, which leads to abnormal muscle tension and muscle strength, motor control disorders, and ultimately affects the balance function. BBS scale can not only effectively reflect the balance disorder of patients, but also distinguish their static and dynamic balance ability [16]. The results of this study showed that the scores of BBS, quadriceps femoris and hamstrings in the observation group were significantly better than those in the control group after treatment, indicating that the lower limb rehabilitation robot combined with task-oriented training can promote the recovery of muscle strength and balance function in stroke patients. The reason may be that the lower limb rehabilitation robot system has the function of adjusting the balance bar. It can make patients imitate normal walking by adjusting the width of the balance bar, which can not only stabilize the body of patients, but also reduce the twisting movement between feet and the ground, thus improving the balance and improving the BBS score. The lower limb rehabilitation robot carries out corresponding weight reduction according to the actual situation of the patient in the process of guiding the patient to train; and in the weight reduction state, the motor drives the patient to carry out training in a mode close to a normal gait. Based on this, the patient is instructed to simulate the healthy walking rule, which can stimulate the proprioceptor of the tendon and muscle of the lower limb joint, and gradually help the patient recover his proprioception after continuous and repeated training. It can effectively exercise the lower limb muscle strength of patients, and then improve the recovery effect of the nervous system and the improvement effect of the lower limb muscles. Ankle joint is the fine-tuning hub of human walking posture and stability. Whether ankle joint can be dorsiflexed or not is of great significance to lower limb motor function and gait. Some studies have pointed out that the recovery of ankle function on the hemiplegic side of stroke and the compensation of ankle function on the healthy side can improve the balance and lower limb motor function of patients to a certain extent, while foot varus usually causes ankle instability [17] [18]. The results of this study showed that the FMA and AOFAS scores of the observation group were significantly improved after treatment, indicating that the combined task-oriented training of lower limb rehabilitation robots can effectively improve the motor and ankle function of patients. The reason may be that the repeated weight-bearing training of lower limb rehabilitation robots can increase the density while promoting muscle creep and improving the connective tissue muscle spindle. It can also effectively improve the muscle strength and balance adaptation function of patients and their corresponding walking level, thus effectively improving the limb motor function of patients and improving the FMA score. Lower limb rehabilitation robot training can improve the contraction load of lower limb muscles under walking, promote the cooperative movement of antagonistic muscles and active muscles, expand the range of motion of joints, regulate muscle tension, and then promote the improvement of lower limb motor function and enhance the level of FMA. At the same time, it can also promote the compensation and reorganization of the structure and function of the human nervous system, improve the control ability of the central nervous system, and make the weight-bearing thigh, non-weight-bearing or suspension thigh muscles out of cortical control, so as to control rhythmic walking and improve motor function. When the multifunctional foot lifter in the lower limb rehabilitation robot swings, the multifunctional foot lifter can promote the ankle joint to carry out active dorsiflexion, thereby inhibiting toe plantar flexion and stretching the toes, and the training is repeated continuously. It can effectively stimulate the required dorsiflexion muscle response and improve the dorsiflexion ability of the ankle joint; the lower limb rehabilitation robot can also carry out quantitative training on the ankle joint and stimulate the separation movement of the ankle joint, thereby forming the active dorsiflexion movement of the ankle joint and improving the function of the ankle joint. The recovery of walking ability in stroke patients with hemiplegia focuses on the improvement of abnormal gait. However, because of the loss or low function of the affected limb, patients often use the voluntary movement of the healthy side to achieve the goal of functional recovery. Even with the correct guidance and assistance of nurses, the functional impairment caused by the body compensation still exists and affects the recovery of the patient's gait [19] [20]. This study showed that after treatment, the KFAROM and 6-minute walking distance scores of the patients in the observation group were significantly improved, indicating that the joint task-oriented training program of lower limb rehabilitation can effectively improve the knee flexion range of motion of the patients and promote their walking ability. According to the rehabilitation situation of patients, the parameters such as the range of motion of the knee joint and its (flexion and extension) deviation range can be constantly revised and adjusted, which can make the index of knee flexion more accurate. And that continuity and the consistency of the rehabilitation train are ensured, so that the rehabilitation effect of a patient is further improved, and the improvement of the knee joint flexion range of motion and the walking ability is facilitated; and meanwhile, the intelligent feedback training system can detect the occurrence of leg muscle spasm through an electronic circuit. It can cut off the motor energy supply in time, and automatically reduce the preset walking speed to adapt to the actual physical condition of the patient after the spasm is relieved, thus effectively promoting the improvement of the walking ability of the patient. Lower limb rehabilitation robot training can also simulate the walking gait of healthy people, and can implement intelligent, stable, long-term and systematic motion output, thus ensuring the consistency with physiological gait as far as possible, so as to improve walking ability.

To sum up, the combined treatment of lower limb rehabilitation robot and task-oriented program for stroke patients can significantly improve the correction effect of gait, better improve the balance and muscle strength of lower limbs, and better improve their movement and joint function.

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Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declaration

This study has been reviewed and approved by the Medical Ethics Committee of Qujing First People's Hospital ([2019] No. (68)). Informed consent was obtained from all subjects involved in the study.

Consent for Publication

All the authors agreed on the publication of this manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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