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Research on the application of lower limb rehabilitation robots in rehabilitation nursing treatment

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Abstract: *The aging of the Chinese population has led to an increase in the proportion of elderly people with limited lower limb movement year by year. The continuous advancement of AI technology has made the efficacy of lower limb rehabilitation robots in clinical use continue to improve, and both the movement effect and quality of life of patients' lower limbs have been widely recognized. By introducing the application of lower limb rehabilitation robots in rehabilitation nursing, it will help the development trend of the next stage.*

Keywords: *Lower limb rehabilitation robot; rehabilitation*

1. Introduction

According to the National Bureau of Statistics, in 2023, the elderly population over 65 years old in the country will be about 216.76 million, accounting for 15.38% of the total population.[1]The main causes of lower limb dysfunction in the aging population are neurological injury, trauma and other factors.[2] With the continuous development of AI technology, lower limb rehabilitation robot technology is closer to ergonomics, which can not only prepare for lower limb rehabilitation, but also allow patients with lower limb disabilities to walk again through robots. The lower limb rehabilitation robot can accurately and repeatably control the complex rehabilitation process of muscle strength, muscle tone, balance and coordination, and continuously improve the quality of life of patients through individual rehabilitation training programs.[3]Foreign lower limb rehabilitation robots are mostly used for the later rehabilitation of orthopedic joint replacement of lower limbs.[4] It is mostly used in the rehabilitation of lower limbs of hemiplegic patients in China.[5]This paper reviews the application of lower limb rehabilitation robots to the field of rehabilitation nursing, and provides help for the next stage of development trends.

2. The development status of lower limb rehabilitation robots at home and abroad

The pioneer of lower limb rehabilitation robot is the human exoskeleton of military equipment, which is widely used in military marching operations and other fields, and then with the gradual improvement of patients' requirements for quality of life, rehabilitation professionals have continuously improved the military exoskeleton, forming a lower limb rehabilitation robot used at this stage. The Lokomat rehabilitation robot developed by Hocoma Company of Switzerland, which is the most widely developed abroad, drives the lower limbs to complete the walking action by suspending machinery.[6] The domestic research and development is the M300 anti-gravity treadmill developed by the University of Shanghai for Science and Technology in 2014, which mainly applies the principle of airbag weight reduction, and has limited activities during use and has not been used.[7]

2.1. Development status of lower limb rehabilitation robots abroad

The LokoHelp lower limb rehabilitation robot from WOODWAY, Germany, uses a suspended weight-loss system for rehabilitation training. The HAL exoskeleton robot of the University of Tsukuba, Japan, is trained with external direct support for space movement. Parker Hannifin's Indego lower limb exoskeleton robot is driven by central processing unit (CPU) to drive rehabilitation training. Erigo from

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Hocoma, Switzerland, can be used in patients with severe lower extremity dysfunction to be able to stand and complete walking training. The Swiss SWORTE company Motion Maker sit-down rehabilitation robot needs to complete the lower limb rehabilitation training in the sit-stand process. The MOTOmed rehabilitation trainer of the German RECK company carries out lower limb rehabilitation training through the principle of bicycle. Re Walk Robotics of Israel predicts the patient's next stage of action trajectory through the input and analysis of the patient's exercise habits, so as to make timely adjustments, and improve the patient's rehabilitation safety and exercise comfort. The Ekso GT from Ekso Bionics in the United States can more accurately improve personalized rehabilitation training by analyzing the patient's exercise habits and the computing function of the central processing unit. Harvard University's Soft Exosuit improves patient mobility through multi-faceted dynamic exoskeleton technology.

2.2. Development status of lower limb rehabilitation robots in China

The balance disorder rehabilitation robot of the General Hospital of the People's Liberation Army of Chinese combined with human biomechanics conducts all-round rehabilitation treatment program training. The CUHK-EXO lower limb exoskeleton robot of the Chinese University of Hong Kong uses electric drive plus crutch support for rehabilitation training. The Auto-Lee self-balancing exoskeleton robot of the Institute of Chinese Academy of Sciences can do all-round rehabilitation training. Shanghai Jinghe Robotics' Flexbot provides patients with individualized, high-frequency, and repetitive training programs through bariatric devices . Beijing Daai Robot Aikang uses early rehabilitation, Xiao Aikang uses mid-term rehabilitation, and Ai Dong uses post-rehabilitation to achieve the purpose of rehabilitation through personalized gait training. Shanghai Fourier Intelligence's ExoMotus provides stability for walking through self-developed motion control. Shenzhen Milebot Robot AR-H1 pioneered the global flexible drive technology, which improves the stability of walking movement through human-computer interaction control energy consumption. Hangzhou Chengtian Technology's Youxing UGO has further improved the effect of gait training for patients through personalized processing. Suzhou Yuanye Technology's muscle armor Relink-Ank combines ergonomics with biomimetic carbon fiber and uses machine algorithms to provide intelligent and personalized training strategies, which can effectively help patients improve their quality of life and quality of life.

3. Clinical application of lower limb rehabilitation robot in rehabilitation nursing

3.1. Clinical application of lower limb rehabilitation robot in patients with spinal cord injury

The number of patients with spinal cord injury and lower limb dysfunction is increasing, and the quality of life and quality of life of patients are facing serious challenges. Manns et al. interviewed 11 patients with spinal cord injuries who faced lower limb dysfunction and longed to live like a normal person, and longed for a lower limb rehabilitation robot that would allow the patient to perform daily activities like a healthy person and have a good experience when walking outside; Ehrlich-Jones et al. expressed the benefits of using rehabilitation robots for patients after spinal cord injury through 29 clinicians, and the need to provide personalized lower limb rehabilitation robots according to the needs of patients, and provide improvement directions for existing robots, so that lower limb rehabilitation robots can move towards a safer and lighter direction.

3.2. Clinical application of lower limb rehabilitation robot in postoperative rehabilitation of lower limb fractures

The ratio of hip fractures to systemic fractures in people over 70 years of age is about 1:4.2 , and surgical treatment is a common treatment method for people over 70 years of age. After surgery, the lower limbs can move like a normal person, which is the focus of the patient. SETOGUCHI et al. compared the use of HAL exoskeleton robots with conventional physical therapy and evaluated the gait cycle. The results showed that the use of HAL exoskeleton robots significantly improved the gait cycle compared to conventional physical therapy. FANG et al. reported that soft exoskeleton robots can reduce patients' exercise load and increase their exercise empowerment. Feng Yuning et al. compared the changes in the gait cycle of patients after hip surgery by using the balance disorder rehabilitation robot and conventional physical therapy clinically, and compared the Berg balance scale and the Fugl-Meyer scale, which are commonly used to evaluate the scales, showed that the effect of the balance disorder rehabilitation robot was significantly better than that of traditional rehabilitation

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treatment.

As the most important weight-bearing joint of the human body, the knee joint will be seriously affected by its own shape, structure, and activity with age, and the movement disorder of the knee joint will occur. Particular attention is paid to the rehabilitation of the knee joint. Li Jianhua et al. compared the knee function score and Berg balance scale score of patients with the functional recovery of patients after TKA, and showed that the recovery effect of the robot group was better. The Keeogo exoskeleton rehabilitation robot can provide patients with dynamic and adjustable assistance, and MCGIBBON et al. showed that the Keeogo exoskeleton rehabilitation robot can improve the user's function and safety. Cai et al. confirmed that the rehabilitation training of patients after TKA was significantly better than that of human-assisted rehabilitation training, and that the lower limb rehabilitation robot promoted the recovery of knee joint function and improved the rehabilitation effect.

The ankle joint also plays a crucial role in the lower limb function of the human body, and the application of lower limb rehabilitation robots in the ankle joint is becoming increasingly widespread. The ankle joint robot developed by GORDON et al.can assist in plantar and dorsiflexion training, but other functions still need to be developed. THAL-MAN et al. are specialized flexible ankle rehabilitation robots for patients with foot prolapse. THILE et al. showed that VACO ankle TM had a better effect on ankle rehabilitation training. RAFFALT et al. used rehabilitation robots to achieve good results on the ankle joint. PR and exoskeleton robots are suitable for patients with lower limb dysfunction to improve proprioception and joint activity, while dynamic AO is a brace mainly used to assist patients with residual function in restoring function. Due to the high cost of ankle joint robots, continuous improvement is needed at this stage to make them more convenient for clinical application.

3.3. Clinical application of lower limb rehabilitation robot in post-stroke rehabilitation

Stroke is a common and frequent disease in China, with a high disability rate. Sun et al. selected 60 patients with lower limb dysfunction after stroke into two groups, one group for rehabilitation nursing intervention, and the other group for training with lower limb rehabilitation robots. The gait analysis examination scale and the simplified Fugl-Meyer motor function assessment scale were used to evaluate the patient's gait and lower limb function recovery. Results: After 90 days of rehabilitation nursing intervention, the gait and lower limb function recovery effect of the observation group was significantly better than that of the control group ($P<0.05$). Conclusion: Lower limb robots play an important role in the rehabilitation of patients after stroke.

4. The development direction of lower limb rehabilitation robots in rehabilitation nursing

The lower limb rehabilitation robot has been recognized by a wide range of rehabilitation therapists, rehabilitation nurses, and rehabilitation doctors in clinical applications, and has been verified in Chang and Wang Kai and other studies. It can be widely used, indicating that the application effect of lower limb rehabilitation robots has been widely recognized. At the same time, the development direction of robots is thinking about the direction of human biomechanics, ergonomics, living environment science, and quality of life.

4.1. Elderly users are easy to accept

Elderly users have a certain degree of resistance and fear of emerging technologies, mainly due to the obscure technical terms of new technologies, the content of manuals is too complex, and the use price is high. Zhou et al. showed that the acceptance of emerging technologies is affected by many factors such as cognitive level and usage mode of elderly users. Through this study, producers need to consider the ease of operation, the applicability of the price, and eliminate the concerns of older users.

4.2. Safe for elderly users

Modern lower limb rehabilitation robots have been at a relatively high level after several generations of innovation. Due to the complexity of human movement, the lower limb rehabilitation robot needs to meet higher technical requirements. Elderly patients with lower limb dysfunction need to take into account the daily development from bed turning, lying position to sitting position, sitting position to standing position, standing position to walking and other multi-directional development, the elderly are prone to many risk factors such as pressure ulcers due to age skin laxity. By constantly summarizing the situation, we focus on the negative experience of elderly users, and solve the situation, so that the lower limb rehabilitation robot can be safer in use.

4.3. It is easy for elderly users to operate

Most of the lower limb rehabilitation robots developed first are mainly suspended, which are cumbersome in the process of wearing, and are prone to irritability and other emotions for elderly patients. In the process of research and development, the patient's physiological, psychological, social and other factors should be considered, and the materials should be light, the operation should be simple, and the occurrence of rehabilitation complications should be avoided.

4.4. Improve the allocation of resources for elderly users

Application of lower limb rehabilitation robots in China In hospitals and rehabilitation institutions, lower limb rehabilitation robots can seek professional help when they encounter some thorny problems such as operation. With the help of rehabilitation therapists, rehabilitation physicians, and rehabilitation nurses, it can relax the mood of elderly users, thereby increasing rehabilitation compliance and concentration. Comprehensive and systematic rehabilitation and nursing services enable elderly users to receive three-dimensional technical guidance and ensure that the problems of elderly users can be solved in a timely manner. Robots with excessive mass and cumbersome operation increase the physical load of elderly users, which increases the burden of self-care. Due to the high cost of lower limb rehabilitation robots and the lack of protection measures such as medical insurance, it is difficult to popularize the application of lower limb rehabilitation robots .

5. Conclusions

With the continuous maturity of AI technology, the clinical use of robots for rehabilitation will be an inevitable trend, rehabilitation robots can improve the dilemma of patients with mobility difficulties on a large scale, and through human mechanics and ergonomics, rehabilitation robots can get standardized treatment plans for patients, and with the maturity of technology, lower limb rehabilitation robots will be more reliable, simple, stable and efficient in rehabilitation care.

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