Chapter 13
Design of and Experimentation with a Walking Assistance Robot

Zhang Lixun
Harbin Engineering University, China

Bai Dapeng
Harbin Engineering University, China

Yi Lei
Harbin Engineering University, China

ABSTRACT

To help patients with lower limb disabilities walk, a robot was designed to help train patients to stand up. An experimental prototype was developed, and experiments to train patients stand up and walk were performed using this robot. The results show that the robot can help patients to stand from a sitting position, which is the purpose of standing-up training. At the same time, the standing-up mechanism can coordinate with the walking assistance mechanism in the walking training mode, allowing the robot to help patients to perform rehabilitation walking training. The justification of the mechanism design was demonstrated, and thus, the robot can be used for stranding-up training and walking training.

INTRODUCTION

The number of patients with lower limb movement disorders has increased for various reasons in recent years thus the demand for rehabilitation will increase and rehabilitation robots will have good market potential (Lv Guang-ming, 2004). Rehabilitation robotics is an important branch of medical robotics and involves bio-mechanics, mechanics, electronics, materials science, computer science and robotics. This field has become an internationally popular research field (Xu Guozheng, 2009).

In recent years, lower limb rehabilitation robots have become a research focus in China and abroad. Many research institutions have contributed to development in the field. Scientists in Switzerland developed the Lokomat walking rehabilitation robot with the help of a body weight support system and treadmill, the screw mechanism of this robot can drive thigh and shank swing to complete the walking motion, which assists in exercise train-

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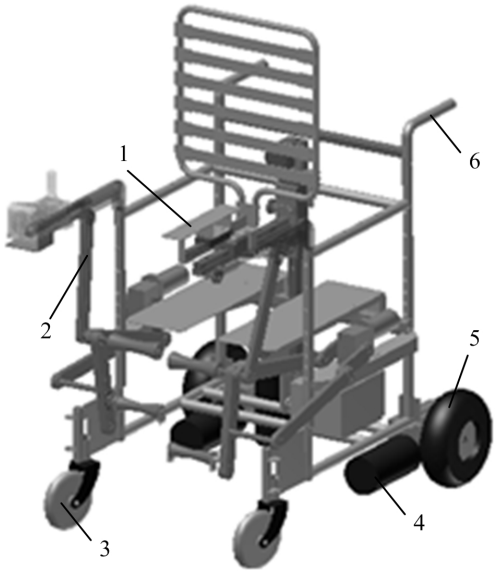
ing of the lower limb joints (Valentina Magagnin, 2009; Ingo Borggraefe, 2010). Tsinghua University is in the national "863" program support and has conducted research on robot-assisted neurological rehabilitation since 2000. This research has led to the development of a horizontal limb rehabilitation robot and a walking rehabilitation robot (Fang Cheng, 2008). Scientists at the University of Split developed a standing-assist robot that is actuated by the electronic control hydraulic servo system. The robot can train patients to stand so that the joints, nerves and muscles of the lower limbs can be trained (Josip Music, 2008). The Mechatronics Laboratory of Harbin Engineering University has been committed to the field of rehabilitation robotics research and has developed a horizontal limb rehabilitation robot that can lie flat while training the patient's gait (Hongying Sun, 2009; Zhang Li-xun 2010). The lower limb rehabilitation robot can be controlld remotely to imulate normal walking on an oval track and can also control the movement of the ankle, which leads to alking leg movements. The mechanical structures of the lower limb rehabilitation robot mentioned above are complex, and the robot's function is to signal to the patient. However, the patient cannot rehabilitate independently using this tobot.

In this paper, we present a new kind of walking assistance robot that has four operating modes. The robot is easy to operate and is safe and comfortable during use.

THE STRUCTURE OF THE WALKING ASSISTANCE ROBOT

The rehabilitation wheelchair, shown Figure 1, mainly contains a wheelchair frame, divining wheels, universal wheels, drive motors, and a walking assistance mechanism The robot designed in this paper has four operating models wheelchair model, rehabilitation model, standing-up model and walking training model.

Figure 1. Three-dimensional image of the walking assistance robot: 1. standing-up mechanism, 2. walking assistance mechanism, 3. universal wheels, 4. motors, 5. divining wheels, 6.wheelchair frame



Standing-Up Mechanism

The body weight is supported by a weight vest in the rope supported method, which gives a strong sense of restriction and can be dangerous for some patients. Partial excessive pressure will lead to pressure sores, and the weight vest can lead to brachial plexus injury to the arm. The seated standing-up mechanism can support patients' body weight in the seated position, which is a benefit of the mechanism. It is suitable for patients with waist and arm weakness such as the elderly and paraplegic patients. We present a new kind of the seated standing-up mechanism in this paper.

The design of the standing-up mechanism is shown in Figure 2. This design has coupling between vertical and horizontal movements. When the motor drives the lift sea in the vertical direction, it can also move in the horizontal direction for the pull force provided by the wire. The patient's center of gravity can move up and down under