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ORIGINAL ARTICLE

Preliminary Trial of Postural Strategy Training Using a Personal Transport Assistance Robot for Patients With Central Nervous System Disorder

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Abstract

Objective: To examine the efficacy of postural strategy training using a personal transport assistance robot (PTAR) for patients with central nervous system disorders.

Design: Single-group intervention trial.

Setting: Rehabilitation center at a university hospital.

Participants: Outpatients (N=8; 5 men, 3 women; mean age, 50±13y) with a gait disturbance (mean time after onset, 34±29mo) as a result of central nervous system disorders were selected from a volunteer sample.

Interventions: Two methods of balance exercise using a PTAR were devised: exercise against perturbation and exercise moving the center of gravity. The exercises were performed twice a week for 4 weeks.

Main Outcome Measures: Preferred and tandem gait speeds, Functional Reach Test, functional base of support, center of pressure (COP), muscle strength of lower extremities, and grip strength were assessed before and after the completion of the exercise program. After the exercise program, enjoyment of exercise was investigated via a visual analog scale questionnaire.

Results: After the program, statistically significant improvements were noted for tandem gait speeds (P=.009), Functional Reach Test (P=.003), functional base of support (P=.014), and lower extremity muscle strength (P<.001−.042). On the other hand, preferred gait speeds (P=.151), COP (P=.446−.714), and grip power (P=.584) did not change. Finally, subjects rated that this exercise was more enjoyable than traditional balance exercises.

Conclusions: Dynamic balance and lower extremity muscle strength were significantly improved in response to postural strategy training with the PTAR. These results suggest that postural strategy training with the PTAR may contribute to fall prevention of patients with a balance disorder.

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Patients with cerebrovascular diseases and other central nervous system disorders often have impaired postural control and experience a high incidence of falls.[1,2] An increased risk of hip fractures and the psychological distress caused by a fear of falling result in a decrease in functional ability and quality of life. Weerdesteyn et al[3] suggested that balance and gait deficits were 2 major risk factors for falls. In response to an aging global population, a major focus of research has been the elucidation of exercise methods that improve patients' balance.

However, there exists a large variety of balance and fall prevention interventions, including flexibility exercises, strength

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training, sensory training or retraining, perceptual training, postural awareness training, task-specific training, vestibular rehabilitation, canalith repositioning treatments, multidimensional or multifactorial training, patient-related instruction education and safety, and injury prevention or reduction.[4] Specifically, postural awareness training focuses on attaining and regaining an upright posture and includes postural strategy training that may require some sort of ankle or hip strategies.[5] In postural strategy training, patients with balance deficits practice a task in a protected environment, but progress to more challenging environments or performing the task at faster speeds.

It has been assumed that postural awareness strategy training could be effective in improving the ability of patients to recover their body's center of gravity (COG) as it approaches the edge of their base of support (BOS). Although several studies[6,7] investigated postural strategy training as a part of a multidimensional or multifactorial study, not enough evidence is available to support the solitary use of this method. In addition, neither the difficulty of the environment nor the speed of the training was properly adjusted to the patient's ability. Indeed, the difficulty of the task was decided arbitrarily by the patient or the therapist and was rarely maintained at that level throughout the training session.

However, if the difficulty of the task could be properly adjusted and maintained until the patient became comfortable, motor learning would progress more efficiently. Also, we believe that from the perspective of motor learning, providing proper physical guidance is one of the key strategies used in rehabilitation settings. In the context of the current discussion, physical guidance entails the temporary assistance provided to the learner's body during the skill practice.

Schmidt and Wrisberg[8] suggested that there were 2 kinds of physical guidance: active and passive. While passive guidance involved passive movement of the learner, active guidance involved active movement by the performer, which tended to preserve the relative timing pattern and feel of the target skill. In active guidance, patients are able to manipulate the performance environment in a way that allows them to assume control of the movement. As a result, patients gain information regarding the requirements of the action via the feedback accompanying movement production. In a study that used a ski simulator to produce slalom-type movements, Wulf and Toole[9] suggested that active guidance gained by the self-controlled use of physical assistance devices provides a learning advantage when practicing complex motor skills.

We thought that applying novel robot technology is not only necessary for adjusting the task difficulty but also for providing active physical guidance for patients during postural strategy training. The recently designed personal transport assistance robot[a] (PTAR) (fig 1) is able to adjust the task difficulty by using information from the sensing device, including velocity and body gradient. The information from the robot is transmitted to a personal computer (PC) in order to control the robot and give an appropriate postural task to the patient. To help patients properly

Fig 1 The PTAR is a stand-up-and-ride transport robot and a personal mobility device with 2-wheel inverted balancing, which moves by transferring the rider's COG.

perform postural strategy training, we have designed exercise against perturbation and exercise for moving the COG programs by using a PTAR that is controlled by a PC system. In addition, we anticipated that the PTAR would provide proper active physical guidance during postural strategy training that would be more enjoyable to the patient. We also expected that the muscle strength of lower extremities would improve through active physical guidance. The aim of this research was to examine the effect of these programs, using the PTAR for postural strategy training, on muscle strength and training enjoyment among patients with central nervous system disorders.

List of abbreviations:

BOS	**base of support**
COG	**center of gravity**
COP	**center of pressure**
PC	**personal computer**
PTAR	**personal transport assistance robot**
VAS	**visual analog scale**

Methods

Design

The study was designed to test changes in the treatment group but did not include a comparison group. The Medical Ethics Committee of the Fujita Health University approved the design of this study.

Participants

From the patients referred to the rehabilitation department at our institute, 8 participants (5 men, 3 women; age range, 28–67y)