Supported Treadmill Training for Gait and Balance in a Patient With Progressive Supranuclear Palsy

Background and Purpose. Impaired balance, gait disturbances, and frequent falls are common problems in people with progressive supranuclear palsy (PSP). This case report describes the use of a modified body weight support treadmill training program to reduce falls and improve the balance and gait of a patient with PSP. Case Description. The patient was a 62-year-old man diagnosed with PSP. His major problems were impaired balance and frequent, abrupt falls. Methods. Physical therapy included walk training, balance perturbation, and step training using body weight support with a treadmill. Training sessions lasted 1 1/2 hours and occurred 3 days a week for 8 weeks. Fall incidence, balance, and gait were assessed before, during, and after the program. Outcomes. The patient reported fewer falls during and after training. Balance and gait improved after training. Discussion. This case report is the first to report fall reduction, improved gait, and improved balance following physical therapy for a person with PSP. [Suteerawattananon M, MacNeill B, Protas EJ. Supported treadmill training for gait and balance in a patient with progressive supranuclear palsy. Phys Ther. 2002;82:485–495.]

Key Words: Balance, Falls, Gait, Mobility, Progressive supranuclear palsy, Treadmill training.

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After idiopathic Parkinson disease (PD), progressive supranuclear palsy (PSP) is the most common degenerative form of parkinsonism, although it is still a relatively rare neurologic disorder. Pathologically, PSP is characterized by severe degeneration of the brain stem (eg, red nuclei, substantia nigra), diencephalon (eg, thalamic nuclei, subthalamic nuclei), cerebellum (eg, dentate nuclei), and other cortical areas. The incidence of PSP has been reported to be about 3 to 4 per million per year. Most patients have difficulty with balance, turning, getting up, and sitting down as well as facial hypomimia, hypophonia, slowness of movement, gait disturbance, sleep disturbances, unexplained falls, visual and ocular disturbances, slurred speech, dysphagia, and changes in personality. Unlike the shuffling, festinating gait seen with PD, patients with PSP display a cavalier gait (described as a swaggering gait) with usual stride lengths and arm swing.

In advanced stages, patients frequently have postural instability, a downward gaze, a frozen appearance with a worried stare, and reduced neck extension. Patients tend to lean and fall backward. The frequent and unexplained falls are a result of akinesia associated with axial rigidity, vertical supranuclear gaze palsy, and impaired postural reflexes. Eventually, patients develop anarthria and become immobile and helpless. Dementia is often present, but is mostly mild. Forgetfulness, an apathetic appearance, and slow thinking are frequently seen in clients with PSP.

Management of PSP by antiparkinsonian medications has remained disappointing. Dopaminergic medications reduce the bradykinesia and rigidity in about one third of the patients, but the benefit diminishes after a few years. Partial therapeutic responses also have been obtained by using dopamine agonists such as bromocriptine or pergolide. Combinations of other antiparkinsonian medications have been of slight and unsustained benefit in patients with PSP.

In the initial stages, PSP is difficult to differentiate from PD. Certain histopathological findings (eg, decrease in striatal dopamine [D2] receptors, neurofibrillary tangles, change in the striatal iron level) may contribute to the differential diagnosis. About 4% of patients initially diagnosed with parkinsonism are later found to have PSP. Progressive supranuclear palsy is an uncommon but increasingly recognized condition. Gait disturbances, postural instability, and falls are the common problems that cause patients to seek rehabilitation; however, few reports of effective rehabilitation for PSP have appeared in the literature. Izzo et al reported a program for a patient with PSP. Treatments included limb coordination activities, fine motor activities, tilt board balancing, and ambulation training to incorporate trunk flexion and rotation. At the end of the program, the patient’s standing balance improved, and she became independent in transfers and most activities of daily living (ADL). Despite intensive training, the patient’s gait continued to show lack of trunk and head rotation. Although the training helped the patient to ambulate independently and she felt safer ambulating with a straight cane, her gait characteristics improved little. The family reported more frequent falls and increased difficulties in ambulation after discharge from an 8-week rehabilitation program.

Another report concerned the rehabilitation of 2 patients with PSP. These patients were given an individualized exercise program to strengthen limb muscles, improve range of motion of the trunk and extremities, facilitate coordination of movements, and improve static and dynamic standing balance. Although the patients’ gait and muscle strength improved, sudden loss of balance and potential falls remained the primary problems.

Treadmill training has been reported to be a beneficial tool for gait training in many patients with neurological disorders. By using a supporting harness system, a person’s body weight is partially supported to facilitate a more normal gait pattern. Studies have shown the effi-

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cacy of continuous training on a treadmill on gait improvement in patients with spinal cord injury.\textsuperscript{23–25} Finch and Barbeau\textsuperscript{26} proposed that the postural stability and balance required for gait in humans may be regained by using a strategy of partial to full weight bearing in combination with training on the treadmill aimed at recovery of stepping mechanisms.

Recently, the application of treadmill training in patients with PD was reported. Miyai et al\textsuperscript{27} used a partial body weight support system and a treadmill to train 10 patients with PD. Using a crossover design, they studied the functional changes after body weight support treadmill training for 4 weeks, compared with conventional physical therapy for 4 weeks. Patients received 20\%, 10\%, and 0\% support sequentially during each training session. The treadmill speed increased as training progressed. The results showed that treadmill training with body weight support produced greater improvement in the ADL and motor performance scales of the Unified Parkinson’s Disease Rating Scale (UPDRS), increased gait speed, and reduced the number of steps in 10 m compared with conventional physical therapy.

People with PD show reduced leg extensor muscle activation\textsuperscript{28} and reduced electromyographic (EMG) amplitudes of the gastrocnemius muscle.\textsuperscript{29} These deficits may interfere with the ability of people with PD to maintain body equilibrium during stance and gait. Body weight support might compensate for these reductions, thus permitting the development of balance and stability. Furthermore, postural reflexes were improved in 4 out of 10 patients after body weight support treadmill training.\textsuperscript{27} Extraneous muscular contractions are also reduced with a body weight support system.\textsuperscript{30} Evidence from EMG and kinematic recordings suggested that body weight unloading on the treadmill reduced gait asymmetry and induced the acquisition of a more normal gait.\textsuperscript{16,18}

The purpose of this case report is to report an 8-week rehabilitation program for a patient with PSP. We used treadmill training with body weight support to attempt to improve gait and balance for the purpose of reducing falls.

**Case Description**

**Patient and History**

The patient was a 62-year-old man who was diagnosed with PSP. He had slight truncal sway; a slightly stooped posture of the head, neck, and shoulders; and a fixed, staring gaze. He could walk without an assistive device but sometimes carried a cane for better balance. His wife reported frequent, backward falls at home but no episodes of freezing (a transient episode in which initiation or continuation of walking is halted). Getting up from a chair was difficult due to an inability to weight shift anteriorly and inappropriate placement of the lower extremities. His movement from standing to sitting was characterized by abrupt falling into a chair. The patient had some difficulty in judging distances and frequently walked into objects. His speech was slurred and soft. He could comprehend and respond to any command, but he rarely started a conversation. Generally, his facial expression and emotions appeared normal.

The patient’s wife reported that as early as 6 years before his referral for physical therapy, some vague, unusual behaviors began to occur. The patient would stand very still behind his wife and stare over her shoulder while she performed her chores. He had difficulty making financial decisions, would not pay bills on time, and had difficulty writing a check. He became depressed as a result of reduced responsibilities and lower pay in his employment. He was easily irritated and depressed when something went wrong at home; however, his family noticed no significant physical changes.

Five years previously, the patient started losing his balance and developed very slow movements. He experienced falls while getting in and out of a car. The patient took early retirement 3 years before his referral for physical therapy, when he lost his teaching job because of micrographia and slurred, quiet speech. Several months after losing his job, his wife first consulted a physician about his lack of motivation and initiative and his reduced talking. He was referred to a neurologist and underwent diagnostic tests, including magnetic resonance imaging of his brain, blood tests, and psychological tests. His wife noted that all tests were reported to be normal.

According to his wife, approximately 2 years before referral for physical therapy, the patient demonstrated reduced facial expression and a kyphotic posture when he was walking. He was diagnosed as having a neuropsychiatric disorder and was referred to another neurologist. The neurologist prescribed levodopa/carbidopa (Sinemet\textsuperscript{*}), but did not diagnose PD. Amantadine was added to his drug regimen shortly afterward. Vitamin E and an anti-inflammatory drug also were prescribed for his symptoms, but his falling became serious and more frequent.

His wife continued to seek medical advice because his symptoms were not improved by the medications. A neurologist diagnosed him as having PSP just prior to his referral for physical therapy. Written informed consent was obtained from the patient before the training. The

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\* DuPont Pharma, PO Box 80723, Wilmington, DE 19880.
protocol was approved by the Institutional Review Board of Texas Woman’s University–Houston Center.

Examination

Cognitive Function
The Mini-Mental State Examination (MMSE) was administered. The MMSE is a questionnaire designed to measure cognitive performance. The test consists of 11 questions administered orally by the tester. The points for each question are summed for a total score, with a maximum score of 30. A score below 27 is considered indicative of a mild cognitive deficit, and a score less than 21 is considered indicative of a moderate deficit. The patient had an MMSE score of 27, suggesting no cognitive deficit. Cognitive dysfunction has been found to be associated with a poor rehabilitation outcome.

Impairment Rating
The UPDRS was used to rate the patient’s impairment. The UPDRS consists of both interview and observational tests and has subscales on mentation, ADL, motor behavior, and complications of drug therapy, with higher scores indicating greater impairment. The patient had a total score of 47 out of 176 on the UPDRS while taking antiparkinsonian medications. He had a score of 4 out of a maximum of 16 on the subscales for mentation, behavior, and mood. The patient’s score on the ADL subscale was 19 out of a maximum of 52, suggesting mild to moderate impairment reported by the patient in speech, swallowing, handwriting, cutting food and handling utensils, hygiene, turning in bed, falling, freezing, walking, tremor, and sensory complaints. The motor subscale comprised 14 items observed by the examiner and included activities such as finger taps, rapid alternating movements, and rigidity. His motor behavior subscale score was 24 out of a maximum of 52, also indicating mild to moderate motor involvement. The complications of drug therapy subscale assesses dyskinesias, dystonias, and clinical fluctuations, among other complications. The patient experienced almost no drug complications, as indicated by his subscale score of 1 out of 23. The patient’s score on the Hoehn and Yahr Disability Scale was 3.0 (out of 5.0), indicating bilateral disease with balance deficits. From 11 descriptors of ADL on the Schwab and England Activities of Daily Living Scale, ranging from 0% to 100%, the patient was asked to select the item that best fit his function. He selected 30%, which is described in the scale as “with effort, now and then does a few chores alone or begins alone. Much help needed.” Reliability and validity for the UPDRS are reported elsewhere.

Fall Report
The patient’s wife was asked to complete a questionnaire concerning fall incidences for 2 weeks prior to the training, during the 8 weeks of training, and for 2 weeks after completing the training. The questionnaire consisted of 5 open-ended questions related to the number of falls, time of falls, activity while falling, and characteristics of falls. A fall was operationally defined as an unexpected event that resulted in the patient inadvertently resting on the floor, ground, or an object below knee level, but that was not a result of a blow, loss of consciousness, sudden onset of paralysis, or epileptic seizure. We have no reliability values for fall report.

Mobility Tests
We used a timed 15.2-m (50-ft) walk, 360-degree turns, the Get Up & Go Test, and a 5-step test for mobility performance. The 15.2-m walk was taken from the Physical Performance Test (PPT). The reliability of data obtained with the PPT in patients with PD (ICC = .92) and the validity of data obtained with the PPT in elderly people have been reported. The patient was timed while walking at his fastest speed for 7.6 m (25 ft), turning, and walking back 7.6 m. For 360-degree turns, the patient was asked to turn 360 degrees as fast as possible. The time (in seconds) was recorded. Timed 15.2-m walks (r = .99) and timed turns (r = .90) have been reported to yield reliable measurements in subjects with PD. The Get Up & Go Test is a timed test of rising from a chair and walking a distance of 3 m, turning, walking back to the same chair, and completely sitting down. In a previous study, the test demonstrated high test-retest reliability (r = .73–.99) and interrater reliability (intraclass correlation coefficients [ICC] = .87–.99) in subjects with PD. For the 5-step test, the patient was timed while stepping up and back down a 10.2-cm (4-in) step continuously for 5 times. The step test has been reported to have high test-retest reliability (r = .95) and interrater reliability (r = .99) in elderly subjects with no known neuromuscular disorders. There are no reliability values for this test in people with PSP. The patient performed 3 trials of each test, and the average for each test was used as definitive data.

Balance Measures
The Functional Reach Test (FRT) was used to evaluate the patient’s forward stability. The patient stood behind a line and was asked to reach as far forward as possible while maintaining his balance. The distance of the forward reach was measured along a yardstick fixed to a wall that was placed at the level of the patient’s acromion. The FRT has been used as a balance assessment tool to evaluate the effectiveness of many interventions, as a practical functional assessment of elderly people, and as a predictor of falls, and it had good test-retest reliability in individuals with PD (ICC = .84). To assess his balance on an unstable surface, the patient stood without shoes on a square, medium-density, 12.7-cm-width (5-in-width) foam pad, with his arms folded.
walkway (GAITRite system preferred speed in the middle of a 3-m instrumented test were performed, and the average for each gait characteristic was recorded.51 The GAITRite system was stored on the computer by the system. Two trials of the test were performed, and the average for each gait characteristic was recorded. 51 The GAITRite system was reported to have reliability and validity for measuring spatial and temporal characteristics of gait. Reliability for selected spatial and temporal parameters (ICC >.94) and validity (ICC >.93) of data obtained with the GAITRite system have been reported.52,53 There are no reliability data for individuals with PSP. Pretraining gait characteristics for this patient are reported in Table 2.

This battery of tests was used to provide a thorough understanding of the patient’s problems. They provided detailed information about his balance and gait deficits, and they provided measurements of his responses.

**Equipment**

**Treadmill**

A Pacer Treadmill8 was used for the training. The treadmill belt is about 335 cm (132 in) long and 46 cm (18 in) wide. The unit is adjustable for inclination of the walking surface and has variable speeds from 1.5 to 10 mph. Parallel handrails are attached to a front vertical beam, on which a digital control panel is located. Inclination, distance, speed, and time were displayed on the digital control panel in front of the patient. Start and stop buttons were easily controlled either by the therapist or by the patient. An emergency stopping cord also was attached to the control panel and could be easily pulled by the patient for an emergency stop.

**Unloading System**

The unloading system (SOMA Incremental Weightbearing System1) was used to support the body weight of the patient. The system is an electronically controlled body weight support system. The system allows unweighting vertically either according to pounds or by percentage of body weight. The harness, consisting of a wide thoracic pad with 3 buckles, was aligned horizontally in front of the patient. All horizontal attachment straps have Velcro fasteners8 that can be detached and adjusted easily and quickly. Two vertical straps are attached to the harness to connect to a steel bar that descends from the unloading system. This harness can easily be applied to the patient in either a sitting or standing position.

**Intervention**

The patient’s initial resting blood pressure and heart rate were recorded at the beginning of each training session. The patient’s body weight was obtained from a scale to provide accurate support. The harness was then securely applied to the patient and adjusted for his comfort. The 2 vertical straps of the harness were

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1 Neurocom International Inc, 9570 SE Lawsonfield Rd, Clackamas, OR 97015.
2 CIR Systems Inc, PO Box 4402, Clifton, NJ 07012.
3 SOMA Inc, 10711 Burnet Rd, Ste 210, Austin, TX 78758.
4 Velcro USA Inc, PO Box 5218, 406 Brown Ave, Manchester, NH 03103.
5 Healthcare Biomedical Services Inc, 7003 Woodway Dr, Ste 315, Waco, TX 76712.
connected to the descending steel bar of the unloading system. A gait belt was also tightened on the harness after the patient was completely secured on the unloading system for safety purposes.

Each body weight support treadmill training session was conducted for 1½ hours and occurred 3 days a week for 8 weeks. The patient was trained using 2 strategies: walking in different directions on the treadmill and balance-perturbation step training on the treadmill. Pretraining, midtraining, and posttraining assessments were administered 1 day before the training, 1 day after 12 sessions (at the 4th week), and 1 day after 24 sessions (at the 8th week), respectively.

**Walking Strategy Training**

Once the patient was on the treadmill, the harness was adjusted snugly, but comfortably, and 15% of the patient’s body weight was supported with the harness system. Miyai et al reported that the patients with PD in their study felt most comfortable when walking with 20% body weight support. Our subject reported, however, that he was most comfortable at 15% body weight support; therefore, 15% body weight support was selected. To ensure the patient’s safety, he was guarded by the therapist and given verbal cueing while walking. He was asked to walk at his comfortable, self-selected fastest speed in 4 directions: forward, backward, and sideways both left and right. The most comfortable treadmill speed was different in each direction. The treadmill surface was level. The walking time for each direction varied based on the therapist’s judgment and the patient’s ability. The walking speed was started at 1.5 mph and increased up to 3 mph by increments of 0.1 mph until the patient’s fastest speed was determined. The patient was able to walk at a speed of 3.0 mph while walking forward, and at a speed of 1.5 mph while walking backward and sideways. Each training session consisted of walking forward at 3 mph for 5 to 7 minutes, walking backward at 1.5 mph for 5 to 7 minutes, and walking sideways with the left and right side leading at 1.5 mph for 2 minutes each. A mirror was used to provide feedback to the patient regarding his upright posture. The patient sat down to rest between changing walking directions, if needed. Figure 1 shows the patient walking on a treadmill with the body weight support system. For each training session, the patient stopped holding the support as the session progressed.

**Balance Perturbation and Step Training**

For balance perturbation and step training, the patient was given 0% unloading but was placed in the harness system for safety and the prevention of falls. He was asked to stand on the treadmill belt and hold the handrails. When he was ready, the therapist disturbed his balance by suddenly turning the treadmill on (speed=1.5 mph) and letting him walk either 5 to 6 steps or until he recovered from swaying and regained his balance in an erect posture. The treadmill was then turned off (speed=0 mph). After a few times holding the handrail, the patient was asked to fold his arms across his chest to provide more challenge to his balance. These perturbation activities occurred while the patient stood facing forward, backward, and both right and left sideways on the treadmill. The number of trials in each position per session varied based on the patient’s ability and the therapist’s judgment. Consequently, most training consisted of about 15 to 20 perturbations in the forward and backward directions and 10 to 15 perturbations for both left and right sideways positions.

**Outcomes**

The patient was followed for 12 weeks (2 weeks prior to training, 8 weeks of training, and 2 weeks after training). He fell 8 times during the 2 weeks prior to training. During the 8 weeks of treadmill training, the patient fell 2 times, and he fell 3 times during the 2 weeks after training ended. Usually, the patient fell while reaching out for something when standing and leaning diagonally with his feet together. His wife reported, however, that after he started the training, he could take a few steps backward to prevent himself from falling backward. In addition, she reported that he became more active during the training. The patient also reported that he had become more confident in walking through a doorway. He could walk through without having to stop and hold the doorframe, as he did before training.

The mobility and balance results are presented in Table 1. After 4 weeks of training, the timed 15.2-m walk, turning 360 degrees, and 5 step tests decreased to 2.78 s, 0.29 s, and 1.44 s, respectively. These improvements continued until the end of the 8-week program. His performance on the Get Up & Go Test did not change after 8 weeks.

Static balance in reaching forward, which was measured by the FRT, increased 3.63 cm (1.43 in) after the patient completed the program. While standing on foam, the patient was able to remain balanced 7 seconds longer after he completed the training. The Berg Balance Scale score increased from 45 at the beginning of the training to 49 at midpoint, but it decreased to 47 by the end of the program.

For the LOS balance test, reaction time decreased after the program in 7 out of 8 directions: forward, right forward, right, right backward, left backward, left, and left forward (Fig. 2). Backward reaction time did improve compared with that measured before the training. The decreased reaction times were accompanied by more target acquisitions.
Gait characteristics were measured only at the beginning and at the end of the 8-week program. Temporal and spatial measurements are presented in Table 2. Gait speed increased from $73.40 \pm 10.47$ cm/s to $100.05 \pm 0.78$ cm/s after 8 weeks of treadmill training. The number of steps changed from $5.50 \pm 2.12$ steps to $6.00 \pm 1.41$ steps, while the cadence increased from $93.75 \pm 3.04$ steps/min to $109.85 \pm 0.50$ steps/min. Step length of the left and right legs improved from $43.76 \pm 5.52$ cm and $49.66 \pm 4.32$ cm to $51.27 \pm 0.44$ cm and $58.74 \pm 3.80$ cm, respectively. These gait measurements were comparable to the norms of men with no known neuromuscular disorders of a similar age. Gait speed, cadence, and step length in men with no known neuromuscular disorders, aged 60 to 69 years, ranged from $87.9 \pm 13.3$ to $127.7 \pm 12.4$ cm/s, from $93 \pm 11.4$ to $117 \pm 8.4$ step/min, and from $56 \pm 3.5$ to $65 \pm 3.6$ cm, respectively, for slow to normal walking. Step time of the left leg and the right leg decreased from $0.66 \pm 0.03$ and $0.62 \pm 0.01$ seconds to $0.56$ and $0.54$ seconds, respectively, as measured after completion of the program. Stride length of the left and right legs increased from $94.80 \pm 11.57$ cm and $90.49 \pm 8.70$ cm to $110.92 \pm 0.89$ cm and $109.16 \pm 5.76$ cm, respectively, by the end of the program. The heel-to-heel base of support of the left and right legs increased from $12.96 \pm 2.12$ cm and $12.91 \pm 0.29$ cm to $17.94 \pm 1.12$ cm, and $17.50 \pm 0.85$ cm, respectively, by the end of the program.

**Discussion**

Only 2 case studies reporting rehabilitation of 3 individuals with PSP are available in the literature. Both studies used conventional exercise programs to investigate the effect of rehabilitation on strength, ambulation, coordination, and balance. Our case report is the first to report fall reduction, improved gait, and improved balance following intervention with an individual with PSP. Falls and poor balance are serious symptoms in PSP, with up to 63% of the patients with PSP reporting these 2 problems.

No literature reports exist of the use of treadmill training for patients with PD to improve balance and reduce the number of falls, and no reports exist of use of this intervention with individuals with PSP. We trained a patient with PSP on the treadmill with a partial body weight support system 3 times a week for 8 weeks. The 3-times-a-week training was similar to the
protocol used by Miyai et al.27 Their results showed improvement during a 4-week intervention and no tendency to reach a plateau. Based on the literature, body weight support treadmill training often lasted up to 12 weeks in patients with neurological disorders.56,57 Taken together, we selected 8 weeks for our training. We used the treadmill as a means to impose gait and balance training strategies, such as having the patient walking forward, backward, and sideways. As each session progressed, the patient was encouraged to walk without handrail support. Sudden balance disturbance was conducted by suddenly turning the treadmill on and off while the patient stood on the treadmill belt facing in different directions. This training strategy was intended to simulate loss of balance situations encountered in daily life, while providing a safe environment for the patient to practice protective stepping strategies in order to regain his balance.

Following the training, the patient’s balance improved, as indicated by the reduced number of falls, the timed foam standing test, and the FRT. Mobility improved as demonstrated by increased gait speed, decreased timed turns, and decreased timed 5 steps. The Get Up & Go Test includes 3 major components of mobility: sitting to standing, walking, and turning. This test did not show change, perhaps because the test may not be sensitive enough to detect changes in each of the 3 components. Another explanation could be that the training did not address the potentially important deficits in sequencing motor subtasks into a complex motor plan. Impairments in motor sequencing are common occurrences in people with lesions of basal ganglia structures. The timed tests of 2 components (walking and turning) improved, however, as indicated by increased gait speed and decreased timed turning. The instrumented walkway measured gait speed over approximately 3 m, a distance comparable to that of the Get Up & Go Test. In addition, our training did not target sit-to-stand ability. Task-specific rehabilitation for patients with PD has been recommended.58 Sit-to-stand training may be necessary to improve this function. Perhaps a lack of change in the sit-to-stand task incorporated into the Get Up & Go Test masked any change in gait speed and turning. This is supported by the improvement in the 15.2-m walk that included 2 components: walking 7.6 m and turning. That is, the 15.2-m walk was able to detect the combination of both changes; however, task-specific measures that target individual functional tasks may be more sensitive to interventions in patients with PD.40

Balance, as measured by the Berg Balance Scale, was slightly improved after the training. The scale is a measure of balance in sitting, standing, transfer, reaching, and turning. During the initial examination, the patient did quite well in performing these activities, which was indicated by the highest score for most items of the scale. Therefore, the total score did not change much after he completed the training, even though his balance did improve, as indicated by the FRT, the LOS test, and the reduction of falls. The result was also to be expected because the training was not task specific for

### Table 1.
Means and Standard Deviations of Pretraining, Midtraining, and Posttraining Assessments of Mobility and Balance

<table>
<thead>
<tr>
<th>Measure</th>
<th>Pretraining</th>
<th></th>
<th>Midtraining</th>
<th></th>
<th>Posttraining</th>
<th></th>
<th>% Change&lt;sup&gt;a&lt;/sup&gt; (Pretraining to Posttraining)</th>
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<tr>
<td>15.2-m (50-ft) walk (s)</td>
<td>17.02</td>
<td>1.45</td>
<td>14.24</td>
<td>2.50</td>
<td>12.63</td>
<td>0.64</td>
<td>25.79 †</td>
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<td>360° turn (s)</td>
<td>4.98</td>
<td>0.44</td>
<td>4.69</td>
<td>0.70</td>
<td>4.50</td>
<td>0.61</td>
<td>9.64 †</td>
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<tr>
<td>Get Up &amp; Go Test (s)</td>
<td>12.80</td>
<td>1.74</td>
<td>15.74</td>
<td>1.04</td>
<td>13.50</td>
<td>2.47</td>
<td>5.47 †</td>
</tr>
<tr>
<td>5-step test (s)</td>
<td>16.23</td>
<td>2.18</td>
<td>14.79</td>
<td>0.18</td>
<td>14.51</td>
<td>0.75</td>
<td>10.60 †</td>
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<tr>
<td>Functional Reach Test (cm)</td>
<td>23.93</td>
<td>3.35</td>
<td>24.97</td>
<td>1.93</td>
<td>27.51</td>
<td>6.53</td>
<td>14.97 †</td>
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<td>Foam standing (s)</td>
<td>9.60</td>
<td>1.45</td>
<td>16.98</td>
<td>2.49</td>
<td>17.28</td>
<td>0.38</td>
<td>80.00 †</td>
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<td>Berg Balance Scale</td>
<td>45/56</td>
<td>49/56</td>
<td>47/56</td>
<td>47/56</td>
<td>4.44</td>
<td>4.44</td>
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</tr>
</tbody>
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* † = improvement in performance, ‡ = decrease in performance.

* Figure 2.
Reaction time (in seconds) from the limits of stability (LOS) test.

Following the training, the patient’s balance improved, as indicated by the reduced number of falls, the timed foam standing test, and the FRT. Mobility improved as demonstrated by increased gait speed, decreased timed turns, and decreased timed 5 steps. The Get Up & Go Test includes 3 major components of mobility: sitting to standing, walking, and turning. This test did not show change, perhaps because the test may not be sensitive enough to detect changes in each of the 3 components. Another explanation could be that the training did not address the potentially important deficits in sequencing motor subtasks into a complex motor plan. Impairments in motor sequencing are common occurrences in people with lesions of basal ganglia structures. The timed tests of 2 components (walking and turning) improved, however, as indicated by increased gait speed and decreased timed turning. The instrumented walkway measured gait speed over approximately 3 m, a distance comparable to that of the Get Up & Go Test. In addition, our training did not target sit-to-stand ability. Task-specific rehabilitation for patients with PD has been recommended.58 Sit-to-stand training may be necessary to improve this function. Perhaps a lack of change in the sit-to-stand task incorporated into the Get Up & Go Test masked any change in gait speed and turning. This is supported by the improvement in the 15.2-m walk that included 2 components: walking 7.6 m and turning. That is, the 15.2-m walk was able to detect the combination of both changes; however, task-specific measures that target individual functional tasks may be more sensitive to interventions in patients with PD.40

Balance, as measured by the Berg Balance Scale, was slightly improved after the training. The scale is a measure of balance in sitting, standing, transfer, reaching, and turning. During the initial examination, the patient did quite well in performing these activities, which was indicated by the highest score for most items of the scale. Therefore, the total score did not change much after he completed the training, even though his balance did improve, as indicated by the FRT, the LOS test, and the reduction of falls. The result was also to be expected because the training was not task specific for
balance in each of the activities on the scale. The Berg Balance Scale also has been reported to have low sensitivity for people who fall. This scale may not have been the best instrument for detecting balance problems in this patient.

Balance also was measured by the reaction time during the LOS test from the Balance Master System. Reaction time for 7 directions improved after the treadmill training. These changes were expected because the balance perturbation training was task specific and targeted forward, backward, and sideward balance retraining.

Spatial gait characteristics, including step length, stride length, and heel-to-heel base support, improved after training. Temporal gait characteristics, including step time, gait speed, and cadence, also improved. The gait speed and cadence improvements are similar to those reported after 4 weeks of body weight support treadmill training in 10 patients with PD. These investigators reported that gait speed increased about 17% and that the number of steps increased approximately 12% after 4 weeks of the treadmill training. Our data showed that gait speed improved approximately 26%, whereas the number of steps improved 8% after the 8-week treadmill training. Even though our gait measures reflect only pretraining and posttraining changes, our mobility measures suggest that walking, turning, and stepping continued to improve with training from 4 to 8 weeks. This provides some evidence that gait improvements may not reach a plateau after only 4 weeks of training and that the optimal length of intervention may be longer than 4 weeks. In addition, the gait speed of the patient at the end of training was in the range for normal for elderly people without neuromuscular impairments. The optimal length of training for the most beneficial outcomes, however, still needs to be determined.

Many patients with PD or parkinsonian syndromes experience freezing problems. Up to 48% of individuals with IPD reported freezing at the initiation of walking, whereas 23% reported freezing during walking. Forty-five percent of patients with PSP reported freezing. Our patient did not complain of episodes of freezing; therefore, we did not measure freezing before and after intervention. We did attempt to include step initiation as part of our training protocol. The treadmill was started at a speed of 1.5 mph while the patient was facing backward on the treadmill in the harness but with zero body weight support. The patient was asked to walk a few steps backward on the treadmill, then to step off the back of the moving belt to stand on the floor. Our patient was not able to master the task of stepping off the treadmill, but simply slid off instead. We did not continue to use this in his training; however, for patients with PD who experience freezing during step initiation, this step training might be helpful.

Our patient’s outcomes suggest that the treadmill might be an appropriate apparatus to reduce falls and improve balance and mobility in patients with PSP. On the treadmill, patients are required to undergo much more intensive training than when they walk on level ground. With a body weight support system, extraneous muscular contractions are reduced. EMG and kinematic recordings demonstrated that treadmill and body weight unloading reduce gait asymmetry as well as induce the acquisition of motor patterns similar to normal gait. In addition, the repetition and consistent nature of walking on a moving treadmill might help the patient to repeatedly practice the movement under controlled conditions. By having a support system, the patient is also relieved from the fear of falling. Repeated practice may encourage more automatic responses, thus improving balance and reducing falls. Furthermore, challenging balance by practicing without holding the handrails may

<table>
<thead>
<tr>
<th>Gait Variablea</th>
<th>Pretraining</th>
<th>SD</th>
<th>Posttraining</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed (cm/s)</td>
<td>73.40</td>
<td>10.47</td>
<td>100.05</td>
<td>0.78</td>
</tr>
<tr>
<td>Cadence (steps/min)</td>
<td>93.75</td>
<td>3.04</td>
<td>109.85</td>
<td>0.50</td>
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<tr>
<td>No. of steps</td>
<td>5.50</td>
<td>2.12</td>
<td>6.00</td>
<td>1.41</td>
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<tr>
<td>Step time [s]</td>
<td>0.66</td>
<td>0.03</td>
<td>0.62</td>
<td>0.01</td>
</tr>
<tr>
<td>Step length [cm]</td>
<td>43.76</td>
<td>5.52</td>
<td>49.66</td>
<td>4.32</td>
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<tr>
<td>Stride length [cm]</td>
<td>94.80</td>
<td>11.57</td>
<td>90.49</td>
<td>8.70</td>
</tr>
<tr>
<td>Heel-to-heel base of support [cm]</td>
<td>12.96</td>
<td>2.12</td>
<td>12.91</td>
<td>0.29</td>
</tr>
</tbody>
</table>

* The patient walked at his preferred speed.

Table 2.
Means and Standard Deviations of Pretraining and Posttraining Gait Variables as Documented on the GAITRite System
enhance the patient’s balance development. The mechanisms for the improvements observed need to be explored.

This case report has many limitations. A controlled study is needed to conclude that this new training strategy is an effective method to decrease falls in patients with PSP and impaired balance. The method for decreasing falls needs to be compared with other interventions such as strength and flexibility training. A longer follow-up period of the fall incidence is needed to determine the length of carryover for the training. Other factors, such as the extent and chronicity of lesion, functional level of subjects, age, the use of harness support, varying treadmill speed, and the use of handrail support also need to be investigated.

References


