Nonpharmacological Methods for Reducing Falls Risk Among Individuals Living with Progressive Supranuclear Palsy

ABSTRACT

Progressive Supranuclear Palsy (PSP) is a fatal neurodegenerative disorder that is characterized by gaze palsy, bradykinesia, postural instability, and mild dementia. PSP is one of the most common parkinsonian disorders, second only to Parkinson's disease. Of primary concern to individuals with PSP are issues related to reduced mobility, particularly with regards to their increased frequency of falling backwards. Although medical treatment (predominantly pharmaceutical) has been found to be effective for improving some symptoms including slowness and rigidity, most of these interventions are only partially effective in maintaining and improving balance and gait. Mobility issues in PSP are, therefore, addressed primarily through fall prevention programs delivered by physical and occupational therapists. In this review article, we will provide an overview of the current literature that explores nonpharmacological methods for reducing fall risk among individuals living with PSP.

KEYWORDS: progressive supranuclear palsy, falls prevention, gait, balance, gait training, balance training, adaptive equipment

Pre-test CME Quiz

Progressive Supranuclear Palsy (PSP) is a fatal neurodegenerative disorder that is characterized by gaze palsy, bradykinesia, postural instability, and mild dementia.[1] PSP is one of the most common parkinsonian disorders, second only to Parkinson's disease (PD).[2] In addition to the aforementioned cardinal features, people living with PSP also experience frequent falls, many of

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which occur in a backwards direction.[3,4] Although some of these falls happen unexpectedly, clinical practice suggests that some occur in relation to impaired visual motor control,[5-7] or reduced ability to properly correct for changes in centre of gravity during sit-to-stand transfers and gait initiation.[8]

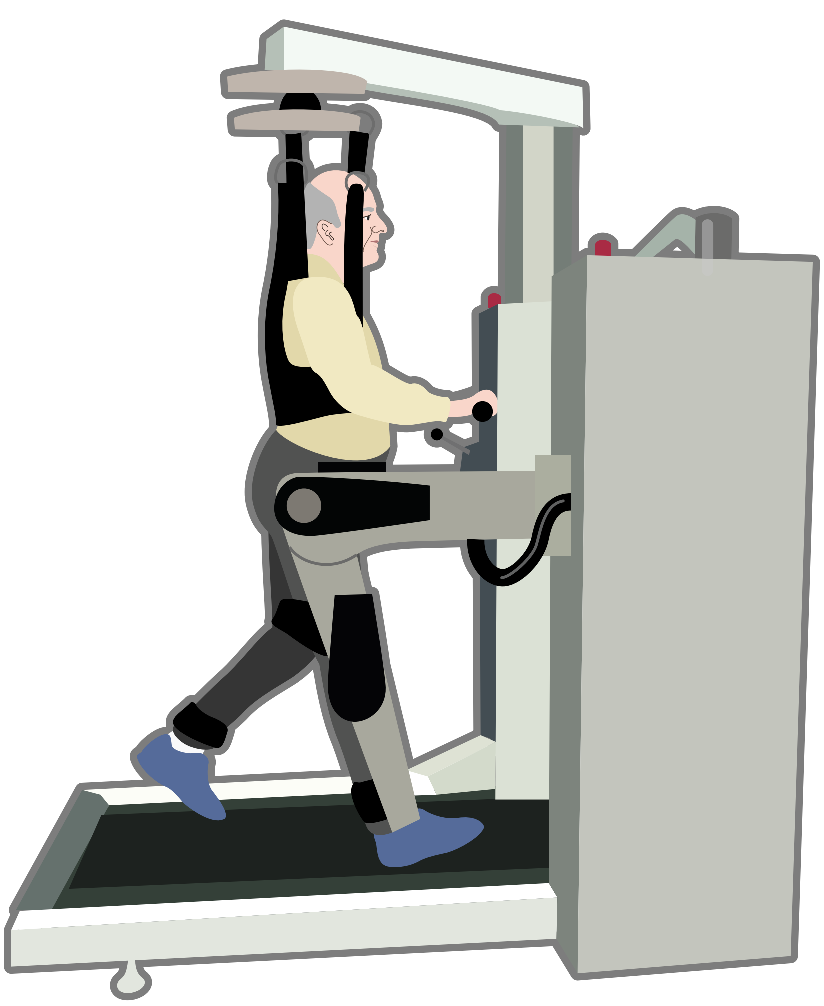
Given that the typical clinical presentation of PSP bears a great resemblance to that of PD (i.e., rigidity, bradykinesia, postural instability), PSP is difficult to differentiate from PD.[9] Despite the substantial symptom overlap between PSP and PD,[3,4,10] however, PSP progresses at a much faster rate, with falls occurring earlier in the disease course.[11] These frequent reoccurring falls are debilitating, and can have a significant impact on patient quality of life. Currently, there is no cure for PSP and, as is the case with PD, medical treatment is predominantly limited to symptom management. Although some pharmaceutical treatments have been demonstrated to be successful in the management of rigidity and bradykinesia,[12] these treatments tend to be largely ineffective in ameliorating balance and gait. As a result, individuals with PSP are often referred for team-based treatment approaches that include pharmaceutical treatment, physical rehabilitation, and education on a range of adaptive equipment and rehabilitation strategies.

The objective of this review is to consolidate the existing knowledge base concerning the effects of non-pharmacological management of falls risk for individuals living with PSP. The rehabilitation strategies reviewed in this paper are organized into the following three domains: gait interventions, cognitive interventions, and adaptive equipment and rehabilitation strategies.

Gait Interventions

Postural control involves a combination of sensory, motor, and cognitive systems. PSP impairs all three of these systems. In one of the earliest studies to evaluate gait interventions for individuals with PSP, Izzo *et al.,*[13] demonstrated the effectiveness of several novel gait exercises in improving ambulation for a single individual with PSP. These exercises, which were experimental at the time, included limb coordination activities, tilt board balancing, and trunk flexion. Although the exercise program had little effect on fine motor coordination, improvements were noted in standing balance, and ability to scan the environment. These improvements were qualitatively supported by patient-reported feelings of greater safety during ambulation, upon completion of the exercise program.

Several years later, Sosner *et al.,*[6] published a case series that focused on gait interventions for two individuals with PSP. Each patient engaged in an individualized rehabilitation program that involved strength training with progressive resistive and isokinetic exercises, coordination exercises, gait training, transfer training (consisting of repeated ambulatory motions to and from a bed and chair), and range of motion activities. In addition, one of the patients received instruction on how to reorient their head position to compensate for downward gaze impairment. During post-intervention analysis, it was observed that both patients achieved independent ambulation and experienced a decreased frequency of falls. Unfortunately, the authors did not provide a description of the frequency or duration of the individualized exercise sessions, nor did they provide information regarding the effectiveness of the rehabilitation program on improving balance, coordination, strength, or transferring abilities.


Treadmill training with body weight support

Suteerawattananon *et al.*,[14] conducted another case study in which they assessed the benefit of treadmill training with body-weight support. One individual with PSP was examined as he engaged in walking training, as well as balance and step training. The 1.5-hour interventions were conducted three times per week, over the course of eight weeks. Walking training involved having the subject practice multidirectional walking movements (i.e., forwards, backwards, and sideways) on a treadmill with the unloading harness supporting 15% of his body weight. In balance and step training, patient body weight was not supported by the harness, and patient balance was systematically perturbed throughout the intervention, with the participant given the freedom to take as many steps as were necessary to regain his balance. Suteerawattananon *et al.*,[14] found that falls decreased 65.5% over the eight-week course of intervention. Moreover, marked improvements in mobility were noted, as demonstrated by improvements in the following spatial-temporal parameters of gait: step length, stride length, heel-to-heel base of support, step time, gait speed, and cadence. Interestingly, the patient's post-intervention gait measurements were found to be comparable to the norms of age-matched men with no known neuromuscular disorders.

Most recently, Steffen *et al.,*[15] conducted a longitudinal case study of a single individual with PSP. This individual completed one hour of community-based group exercise twice a week over a two-year period. Each session consisted of trunk and lower extremity stretching, lower extremity strengthening exercises, upright balance and strengthening exercises, and treadmill walking (forwards and backwards). In addition to the group exercise sessions, the patient participated in 2 blocks of individualized physical therapy sessions, implemented to increase the intensity of the intervention. The first block entailed 14 one-hour sessions that consisted of balance training, strengthening and stretching exercises, transitional movement practice, gait training, stair training, and safety education. The second block consisted of 14 sessions that involved 40 minutes of treadmill training with a body weight support system. The patient trained by walking in each of four directions (forward, backward, left, and right) with 10% of their body weight unweighted. Although the training time for each direction varied based on tolerance, on average the patient walked forward and backward for 6 minutes in each direction at a speed of 2.3 km/h and 1.6 km/h respectively. Walking in either of the lateral directions proved more difficult, and the patient was only able to tolerate 6 minutes of walking in each direction (left/right) at 1.0 km/h. Steffen *et al.,*[15] found that over the two-year time-frame, tests of balance showed improved stability, and patient falls decreased from two falls per month to one fall per month. The longitudinal design of this study is particularly revealing despite the fact that individuals with PSP are expected to experience a progressive decline in function, the participant maintained independent mobility, and experienced fewer falls over the two-year study period. The results of this study suggest that an ongoing balance and gait training strategy may decrease fall frequency, and may potentially lead to a slower decline of gait performance. Given these findings, referral to a personal trainer or other supervising exercise professional might be worthwhile in maintaining mobility and independence.

Cognitive Interventions

Wulf *et al.,*[16] explored the correlation between attentional focus and balance (postural sway) among older adults with PD, using the rationale that postural sway is positively correlated with an increased risk of falls. The researchers examined three different attentional focus conditions: internal focus, external focus, and no specific focus (i.e., a control condition). In each condition, participants stood upright on an inflated rubber disk. Subjects within the internal focus condition were directed to stand in such a way as to reduce foot movements in their maintenance of balance. In the external focus condition, participants were instructed to focus on the edge of the rubber disk, in order to minimize body movements and promote balance. The internal focus condition did not produce a statistically significant balance improvement, but the external focus condition did produce a significantly reduced amount of postural sway. Although individuals with PSP are prone to falling in a backward direction, as opposed to those with PD who are more likely to fall forwards, Wulf *et al.'s*[16] research provides insight into the importance of encouraging individuals to focus their attention on "controlling" their environment, and accommodating these risks directly (as opposed to adopting internally directed strategies).

In a six-week trial, Nicolai *et al.,*[17] studied the effect of audio-biofeedback training on balance performance for 8 individuals with PSP, to improve posture and dynamic balance. Audio-biofeedback involves providing individuals with an auditory stimulus in response to the position of their body in space. For the purpose of this study, patients received feedback in the following two ways: i) the patient was asked to reach and maintain a predefined posture, and if the patient's body strayed from the target position, an auditory cue directed the patient to make the necessary postural corrections; ii) during a sit-to-stand transfer activity, the patient was asked to bend forward until an auditory cue sounded, indicating that the patient was in the correct position to initiate the transfer (thus directing them to stand up). Nicolai *et al.,*[17] incorporated these forms of audio-biofeedback into an intervention program that included exercises from the following 6 domains: postural control in sitting and standing positions (range of motion, endurance for maintaining predefined positions), transfers (sit-to-stand, stand-to-sit), sway (differences in base of support, weight shifting, additional upper body movements), reaching and/or stepping in one direction, and stepping in different directions with the option of additional upper body movements, walking and stopping, and turning. The training was delivered three times per week for approximately 45 minutes each session. Dynamic balance was evaluated using the Berg Balance Scale, functional mobility was assessed using the timed up-and-go test, transfer ability was assessed using a modified five-chair-rise test, and overall quality of life was measured using the Parkinson's Disease Questionnaire (PDQ-39). As the intervention progressed, mean scores of the Berg Balance Scale increased, suggesting that balance was improving, and improvements within the communication and cognitive sections of the PDQ-39 suggested that patients were also experiencing positive psychosocial effects from the intervention. Interestingly, these effects were still present four weeks after the intervention, thus suggesting that audio-biofeedback may be an effective long-term management technique. It should be noted, however, that despite these positive findings, patient scores did not improve on either the timed up-and-go, or the five-chair-rise task. One possible explanation for this discrepancy is that both of these assessments were scored based on the speed in which the activity was completed, despite the fact that the provided training did not focus on improving velocity.

Another recent development in the domain of cognitive strategies for the management of fall risk among individuals living with PSP is dual-task training. Simply put, dual-task training is intended to reduce the deleterious effects of dual-task interference, which is the degradation of performance on one or more tasks that result when the tasks are performed concurrently.[18,19] Lindemann *et al.,*[20] studied the effects of dual-task interference on fall frequency. Results suggested that individuals that were less capable of safely engaging in multiple concurrent tasks were at an increased risk for falls. Specifically, individuals with PSP that demonstrated more falls were likely to increase their speed when engaged in a secondary task. This agrees with other authors that have suggested that the application of a "posture-first strategy" (i.e., concentrating on walking, in preference to concentrating on the secondary task that is being performed concurrently) may be associated with a reduced risk of falling.[21] Although at the time of this writing there have been no published studies that have investigated the effectiveness of dual-task training among individuals with PSP, this intervention has been successfully applied in similar populations, such as individuals with Parkinson's disease.[22]

Yogev-Seligmann *et al.,*[22] implemented a training program designed to improve dual task performance while walking among 7 individuals with PD. Individuals completed 12 training sessions lasting twenty five minutes each, over a 4 week period (3 sessions per week). In each session, participants practiced walking while completing the following three cognitive tasks: i) verbal fluency task (i.e., participants were asked to recall as many words as possible that start with a particular letter, in a one minute timeframe), ii) serial subtraction (participants were asked to subtract by 3's or 7's starting from a 3 digit number), and iii) information processing (participants were presented with an arithmetic problem and asked to respond as quickly as possible). Results suggested that the training program produced significant improvements in gait speed and gait variability, and that these improvements were still present one month after the last training session.

Despite the fact that training on individual components within the dual-task paradigm has produced significant performance improvements, there is increasing evidence to suggest that there may be value in practicing the task-switching portion of dual-tasking. In other words, training individuals to multi-task in a general way may have an impact on specific aspects of performance when completing two concurrent tasks.[23,24] In addition, it is important to consider principles of motor learning when developing a dual-task training program. Specifically, Yogev-Seligmann *et al.*,[22] integrated the following five principles into the construction of their program:

i) Task Specific Training.

This principle holds that there is a domain specificity to practice – in other words, one needs to practice gait, in order to demonstrate gait improvement. Not only does this reinforce context-specific components to the gait task, but it increases the face validity of the training activity, and may increase adherence among individuals within the training group.

ii) Feedback.

If we hold to the concept that the improvements that occur secondary to dual-task training are accompanied by positive changes in cognitive strategies, explicit performance feedback should improve future performance. Not only does performance feedback provide behavioural reinforcement for an individual's actions, thereby allowing an individual to consciously direct his or her own cognitive strategies, but it may also allow an individual to consciously suppress inappropriate motoric actions.

iii) Intensity.

This principle remains somewhat equivocal, as the ideal level of practice intensity (or frequency) has yet to be identified. Research suggests, however, that a reasonable practice frequency may be a thrice weekly training program, 4 weeks in duration.[25]

iv) Variability of practice.

Variability of task type is important for two important reasons: it maintains patient interest in the intervention (thereby improving adherence), and it encourages transfer to a variety of domains (owing to the aforementioned domain specificity of dual-task training).[26]

v) Increasing the level of difficulty.

As individuals become more accomplished at the training task, it is important that the intervention be scalable (or gradeable) in terms of difficulty. This allows individuals to progress through the training program with a task that remains challenging for the duration of the training period.

Adaptive Equipment and Rehabilitation Strategies

Limitations in the ability of individuals with PSP to shift their gaze may prevent them from properly fixating on planned footfall locations during stepping tasks, thus placing them at an increased risk for a fall. Interventions that allow individuals to adopt a better gaze strategy (that involves increased attention to the locations of their footfalls) are therefore likely to improve gait and minimize fall risk.

Di Fabio *et al.,*[27] focused specifically on gaze-shift strategies used by individuals with PSP when vertical gaze palsy impairs the eye-movement component of gaze control. In this study, participants were asked to engage in two different tasks: a gaze stabilization task and a platform stepping task. In the gaze stabilization task, subjects were instructed to keep their gaze fixated on objects on the floor during a passive head pitch at a specified angle. In the platform stepping task, the researchers measured the accuracy in footfall location compared to gaze by subtracting the gaze-to-footfall position from the gaze angle. Results demonstrated a statistically significant association between the vertical gaze fixation score, and the stability of vertical gaze angle, within both the gaze stabilization task, and the platform stepping task, thus suggesting that individuals with PSP rely on head pitch to enhance gaze angle during ambulation. These findings support the early research conducted by Izzo *et al.,*[13] and Sosner *et al.,*[6] wherein patients were taught to compensate for downward gaze impairments by scanning their environment and using head movements respectively.

In a related study, Zampieri and Di Fabio[5] compared two multifocal rehabilitation techniques: one that addressed balance, eye movement, and visual awareness training, and another that consisted solely of balance training among individuals with PSP. Participants were randomly assigned to either the treatment or the control group. Balance exercises practiced within both groups included tandem stance with eyes open and then closed, completing 360° turns while walking on the spot, shifting from sitting to standing (and from standing to sitting), and rectifying postural sway. The group that received eye movement and visual awareness training participated in additional experimental conditions in which they were asked to perform computer-assisted saccadic exercises, auditory feedback saccadic techniques, and foot-eye coordination exercises. Although both treatment protocols demonstrated statistically significant improvements (thereby suggesting that balance training is at least partially effective in ameliorating the balance impairments demonstrated by individuals with PSP), individuals that completed eye movement

IF A PATIENT IS UNSTEADY ON HIS OR HER FEET, A CLINICIAN SHOULD CONSIDER RECOMMENDING A CANE OR A WALKER.

and visual awareness training, in addition to balance training, demonstrated a significant increase in gait velocity. Furthermore, the treatment effects were greater for the treatment protocol that included both balance and visual awareness training strategies.

Although it is easy to attribute a fall to the natural progression of the disease, there are several strategies that can be implemented to help prevent falls from occurring. For example, if a patient is unsteady on his or her feet, a clinician should consider recommending a cane or a walker. Regardless of the device that is selected, one needs to ensure that it is set to the correct height (the handgrip should be level with the crease of the patient's wrist when he or she stands with shoulders relaxed and arms hanging at the side). If a cane is selected, a rubber cap must be affixed to the bottom to increase friction and prevent slipping. In the winter months, patients should consider attaching an ice-cap (or cleat) for added outdoor traction.

Example of a walker with weighted basket and cane with rubber tip

The foregoing are excellent recommendations for any patient that is experiencing gait abnormalities or unsteadiness, but it may also be advisable to modify some recommendations so that they are specifically pertinent to the fall risks experienced by individuals with PSP. For example, if recommending a walker, a model with a low basket can be weighted to provide counterbalance. Given the tendency for individuals with PSP to fall backwards, the added weight in front may serve to provide additional stability for the individual by preventing the walker from tipping backwards. Regardless of the intervention chosen, patient education is of paramount importance. Patients must be reminded to lock their brakes before sitting down or standing up, and must be told that they should not pull on the walker when rising to a standing position, as this may cause it to tip

Table 1: A Summary of Fall Prevention Strategies Used in Mitigating Risk Among Individuals with PSP

- Wear footwear that have a non-slip sole, and that fit properly
  - avoid slippers that are backless as they can easily fall off and cause a trip
  - consider being fit for a custom foot orthosis that raises up the back heel such that the centre of gravity shifts forward, as this may help to minimize the risk of falling backwards
- When doing a task, or going to an appointment, plan ahead and leave lots of time
  - avoid rushing to answer the telephone, use a cordless phone and keep it near at all times
- Talking can be distracting and may place you at risk for a fall
  - avoid or keep conversations to a minimum while engaged in activities that require the maintenance of balance
  - make a conscious effort to pay attention to balance and walking, especially when going down stairs
- Arrange household furniture to allow unobstructed passage between rooms
  - ensure furniture placement allows walker to be kept in front at all times
  - keep floors clear by minimizing clutter, and gathering up loose articles
  - store pet-related items such as food, water, and toys off to the side
  - use a long handled duster and dustpan, and use a reacher to assist in picking up objects off of the floor or retrieving objects from high places
  - remove scatter mats throughout the house or at minimum make sure they are non-slip and the edges are fastened down with double-sided tape
- When transferring take your time, changing positions too quickly could make you become dizzy and cause you to lose your balance
  - install a superpole or m-rail in the bedroom to assist with bed mobility and transfers
  - install a raised toilet seat or fasten grab bars beside the toilet to provide additional leverage to assist with transfers
  - use a tub transfer bench when entering and exiting a bathtub
  - install grab bars beside and inside the bathtub/shower
  - place a non-slip mat or slip resistant strips within the bathtub/shower
- Ensure solid handrails are installed securely on both sides of stairs both inside and outside of the home
  - keep stairs, landings and walkways free of debris and clutter
  - ensure that stairways are well lit
  - consult an optometrist about prism glasses to correct for gaze impairment
  - install non-slip stair treads/strips, or coat stairs with slip resistant treatment or if carpeted, ensure carpeting is securely fastened
  - always keep one hand free to hold onto a handrail

SUMMARY OF KEY POINTS

Although PSP and PD share many symptoms, PSP is distinguished by a faster rate of progression and falls occurring in the backward direction.

Of primary concern to individuals with PSP are issues related to reduced mobility, particularly with regards to their increased frequency of falling backwards.

Mobility issues in PSP are addressed primarily through physical rehabilitation programs and prescription of adaptive equipment.

Cognitive interventions focusing on attentional focus and control, audio-biofeedback techniques, and dual-task training may also be considered in the management of fall risk.

(they should be taught to push up from the surface on which they are seated, and then grab hold of the handle grips of the walker).

Although gait aids, as discussed above, are commonly recommended as a means of reducing the risk of falls among individuals with balance impairment, several additional strategies, many of which are implemented by occupational and physical therapists, also serve this purpose. A summary of the most prominent strategies are presented in Table 1. This table is formatted for distribution to patients.

Conclusions

Despite the fact that there remains no cure for PSP, there are a number of nonpharmacological strategies that may be employed by an individual, to mitigate the risk of falling. Although there is some evidence to suggest that physical rehabilitation strategies (including targeted exercise programs and physical therapy interventions) are effective in reducing falls risk within this population, there are a number of cognitive and sensory rehabilitation strategies that may be employed (most notably dual-task training). Furthermore, attention to some of the specific symptoms of PSP (e.g., the tendency of individuals to fall backwards, rather than forwards) may suggest particular physical modifications to mobility devices such as walkers are warranted. Finally, patient education is critical, to ensure that individuals are making appropriate and safe use of the interventions described herein.

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CLINICAL PEARLS

Although pharmaceutical treatments have been demonstrated to be successful in the management of rigidity and bradykinesia, these treatments tend to be largely ineffective in ameliorating balance and gait.

Mobility issues in PSP are most effectively managed non-pharmacologically through fall prevention programs delivered by physical and occupational therapists.

Interventions that direct attention to the postural task are likely to improve gait and minimize fall risk..

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Post-test CME Quiz

Members of the College of Family Physicians of Canada may claim MAINPRO-M2 Credits for this unaccredited educational program.

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