Balance-Based Torso-Weighting in a Patient with Ataxia and Multiple Sclerosis: A Case Report

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Objective: The use of external body weights, although controversial, is occasionally employed to improve balance or mobility in patients with ataxia or tremor. This case report describes the effect of torso-weighting to counteract directional balance loss in a woman with relapsing/remitting multiple sclerosis.

Case Description: Clinical examination of a 40-year-old woman after multiple sclerosis exacerbation revealed loss of balance in the posterior direction during quiet standing as well as loss of dynamic balance in the posterior and lateral directions. The patient's standing posture was with her trunk posterior to her pelvis. She exhibited decreased strength in both extremities and trunk, diminished sensation in the right lower extremity and palms, and an unstable ataxic gait. Difficulty with walking and severe fatigue and dizziness were also reported. Standing balance and alignment were examined during (1) quiet standing with eyes open and eyes closed, (2) transitional movements, and (3) multidirectional trunk perturbations. The patient demonstrated a loss of balance and alignment in the posterior direction in all tests.

Intervention: Based on balance examination results, the patient was fitted with a 0.5-lb vest containing 1.5-lb of additional weight placed anteriorly on the torso at the level of the umbilicus. Progressive balance, gait, and functional activities were repeated both with and without weighting the torso over six weeks.

Outcome: Immediately on weighting, the patient demonstrated less sway in quiet standing, increased stability when perturbed, improved body alignment, and less ataxia during gait. The patient was able to accomplish more challenging activities with better balance while weighted. Functional improvement in walking and improved control during balance activities were demonstrated in later treatment sessions without weighting.

Conclusion: Placing small amounts of weight asymmetrically on the torso, based on directional loss of balance and alignment, seemed to assist this patient in maintaining balance during static and dynamic activities. Additional research may help determine whether this intervention is applicable to others with directional losses of balance, ataxia, or multiple sclerosis to improve balance control.

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INTRODUCTION

Multiple sclerosis (MS) is an unpredictable, disabling disease that causes demyelination of the central nervous system resulting in progressive neurologic dysfunction.[1] Although the clinical course of the disease varies dramatically, primary impairments can include ataxia, postural instability, balance deficits, sensory loss, weakness, incoordination, abnormal tone, fatigue, pain, and visual and cognitive dysfunction.[1–4] Many of these impairments affect gait and present challenges for clinicians to successfully address. Sixty-five percent of individuals with MS remain ambulatory for 20 years after diagnosis.[4] Therefore, interventions that effectively improve balance stability and mobility are important.

The use of external body weights, although controversial, is occasionally employed to improve balance or mobility in patients with ataxia or tremor.[1,5–13] It has been reported that weighting the limbs or axial skeleton controlled extraneous movement in some subjects, whereas in others, weighting seems to have been detrimental.[1,5–13] The following studies specifically report axial weighting to address ataxia. Morgan[9] found improvement in gait in 11 of 14 patients with ataxia (Friedreich's ataxia, MS, cerebellar degeneration, cerebrovascular accident, and trauma) when they were weighted at the waist and the lower extremities. One severely disabled subject was able to walk while weighted, but could not walk without the use of the weights. Morgan hypothesized there was an optimum amount (1–2 kg) and position (on the trunk and/or extremities) for the weight. He noted that too much weight resulted in increased subject unsteadiness. Lucy and Hayes[12] and Clopton et al[13] used standardized weight placement to determine the effects of weighting. Lucy and Hayes[12] investigated whether placing 1.36 kg of weight on each shoulder of subjects with cerebellar ataxia would affect stance stability. Ataxia was reported for subjects in this study as resulting from a variety causes: MS, cerebellar infarct, brainstem stroke, Freidreich's ataxia, pontocerebellar degeneration, cerebellar degeneration, cerebellar atrophy due to alcoholism, and cerebellar dysfunction due to dilantin toxicity. Weighting decreased lateral sway when subjects were tested in the eyes open (EO) condition, suggesting improved lateral stability. Anteroposterior (AP) sway was not affected when considering the whole group. One of the subjects with MS had a reduction in both AP and lateral sway with his EO while weighted. However, the same subject became more unstable in both directions with eyes closed while weighted. Lucy and Hayes concluded that more research was indicated because the effects of weighting were inconsistent. Clopton et al[13] reported that three of five subjects with cerebellar ataxia due to cerebral palsy, cerebrovascular accident, encephalopathy, asphyxia, and traumatic brain injury exhibited improvement in some gait parameters when 10% of a subject's body weight was placed on the subject's shoulders and then on his or her waist. More specifically, two subjects showed improvement when weights were placed on their shoulders; one in step length and the other in gait velocity. Two subjects demonstrated improvement when the weights were placed at the waist; one subject improved in gait velocity and had carryover in performance, and the other improved in cadence. One subject improved with either type of weighting. Clopton et al concluded that axial weighting was not supported by their data due to inconsistent effects of weighting found in the subjects and that deterioration was more prevalent than improvement. However, when one reviews the overall positive results reported in the three studies cited above, a hypothesis that axial weighting could improve some aspects of balance and mobility shows some merit.

The rationale for the use of weighting has been justified using different theoretical bases. Lucy and Hayes[12] and Clopton et al[13] used weighting for joint compression. These studies suggest that increasing sensory input via the application of additional weight may increase afferent input from deep pressure receptors, thus facilitating cocontraction of the muscles and increasing stability.[14,15] Morgan[9] considered a biomechanical theory of weight application, as he reported that placing weights in certain areas on the body may change the subject's ability. Changing the center of mass (COM) by placing additional mass at appropriate locations alters the moment of inertia, affecting movement.[16] Patients with ataxia often have difficulty controlling their body movements. Weighting may provide increased afferent input regarding a change in the biomechanical relationship, thus resulting in increased body control. Others[5] view weighting as a means to improve awareness of the part of the body that is weighted and therefore increase concentration or awareness.

This case report describes the use of information gained from the examination of an individual with MS with balance difficulty (direction of loss of balance) to guide asymmetric placement of a small amount of weight on the torso. This balance-based torso-weighting (BBTW) method combines assessment and intervention in a five-step process: (1) assessment of balance and alignment in standing, transitional movements, and in response to multidirectional trunk perturbations; (2) identification of the direction of sway or balance loss; (3) placement of small amounts of weight on the torso to counter the loss of balance control; (4) reassessment of abnormalities in balance and alignment found in during initial assessment; and (5) adjustment in the amount or placement of the weight (repeat steps 1–4 until improvement is attained in standing balance or reactive response to perturbation). Once improvement is obtained, the individual wears the weight while other aspects of physical therapy intervention are performed.

CASE DESCRIPTION

History

A 40-year-old woman was hospitalized for an acute episode of severe dizziness, right-sided numbness, and inability to maintain a sitting or standing position. Magnetic resonance imaging showed areas of increased T2 signal in the right frontal, occipital, and left parietal lobes of the brain and in the lateral cervical spinal cord at the level of C2. MC had a diagnosis of C2 transverse myelitis consistent with relapsing/remitting MS (RRMS). MC recalled two previous episodes of vertigo, each of which resolved after approximately one week. One month before hospitalization, MC noted numbness and tingling in her face, arm, and leg (one the left side more than the right). She also reported increased fatigue and inability to walk quickly. During hospitalization, MC received intravenous Solu-Medrol and physical therapy to address problems with bed mobility, transfers, balance, and gait. She was subsequently discharged with a front-wheeled walker and referred for home-based physical therapy.

MC was seen by a neurologist before referral for home-based physical therapy. At this visit, MC exhibited normal vital signs (blood pressure, 114/76 mm Hg; pulse rate, 60 beats per minute; and respiration, 16 breaths per minute). Cranial nerve examination was positive for bilateral optic nerve pallor without afferent papillary defect. Extraocular movements were full and conjugate with normal pursuit and saccades without nystagmus. There was no visual neglect. Facial strength was normal. MC reported decreased sensation on the right side of her face. MC had intact cranial nerves (VIII–XII). The motor examination was normal, and tone was normal. Rapid alternating movements were within normal limits, with a slight decrease in left vs right speed of movement. MC's gait was slow and demonstrated ataxia. Her tendon reflexes were 2+/4 and symmetrical without clonus. Bilateral flexor response to plantar stimulation was present. Vibration sense was normal at distal interphalangeal joints of both fingers and great toes. The patient reported a mild reduction of sensation in her hands and feet. Her family history was significant for late-stage spinal muscular atrophy when her mother was in her 70s.

Examination

The patient and her newlywed husband lived in a single-story condominium with a one-step entrance. During the initial visit one week after discharge from the hospital, MC complained of difficulty with walking, fatigue, and dizziness. Using a numerical analog scale[17] (1–10 where 10 equals maximum), to assess dizziness and fatigue, MC reported 6/10 dizziness in sitting, 9/10 with ambulation, and 10/10 with 360° turns. She rated her fatigue 9/10. MC reported spending 18 hours per day in bed, and her maximum tolerance for upright (sitting and standing combined) was 30 minutes. She reported that if she wanted to get to another area of the home when there was nobody around, she would creep on all fours with her head lowered to decrease the dizziness. Prior to this episode and diagnosis of MS, the patient was independent in all aspects of daily living. MC's profession involved the development of training modules and teaching of educational programs. Her job required 10-hour days and frequent travel. She was unsure whether she wanted to return work, as she felt she may not be up to the demands of the job. Previously, she reported exercising regularly and enjoyed taking long walks at the beach. MC stated she understood the diagnosis of MS and the possible effects of the disease. Her goals were to be able to function as normally as possible in her home and to ambulate in the community.

MC was aware of, and responsive to, her surroundings, as well as oriented to person, place, time, and date. She followed all commands during the examination and communicated using fluent speech. MC reported that she weighed 115 pounds and was five feet two inches tall.

Her cardiopulmonary system was normal; her resting heart rate was 65 beats per minute, her respiration rate was 15 breaths per minute, and her blood pressure was 122/80 mm Hg. She had no open wounds or scars and had good skin color.

MC had full pain-free range of motion in the cervical and spinal lumbar regions and extremities. Muscle strength[18] in her upper extremities was 4/5, abdominals 3−/5, and trunk extensors 3/5. Bilateral lower extremity strength at the hip was 3− to 3/5. Knees and ankle strength rated 4+/5. Decreased sensation to light touch was noted on the right lower extremity, bilateral soles of both feet, and palms of both hands. No other sensory tests were conducted. MC had normal muscle tone[19] when tested in **the** supine position at the ankle (anterior tibialis, gastrocnemius, and soleus) and knee (quadriceps and hamstrings) muscles. Nonequilibrium coordination testing performed while sitting revealed no upper extremity ataxia in finger-to-nose testing with her EO. Dysdiadochokinesis was noted in the left upper extremity with rapid alternating supination and pronation. Bilateral heel-to-shin tests showed jerkiness and inability to move her heel in a straight line up and down the shin.

Static sitting balance and postural alignment were good. Dynamic sitting balance tests revealed ability to reach in several directions without loss of balance; however, her movements were guarded, stiff, and slower than normal. She used both arms to accomplish the supine to sit and sit to stand tasks. The initial transition to stand was jerky with increased sway in the AP direction. The bed-to-chair transfer was slow and required contact guard and verbal cues from the therapist to control posterior imbalance.

MC demonstrated poor standing and postural alignment as evidenced by increased posterior sway and inability to stand independently without a wide base of support (feet approximately 12–14 inches apart). She stood with a posterior lean (approximately 10 degrees) with her head and trunk aligned posterior to her feet from the lateral view. Her hips were adducted and internally rotated. A bilateral loss of arch in her midfoot was noted. Both the removal of visual cues and posterior perturbations with EO resulted in immediate loss of balance in the posterior direction without protective strategies. She also demonstrated slow reactions to anterior and lateral directional perturbation testing.

MC was able to ambulate 60 feet with contact guard to minimal assist without a device. Her gait[20] was slow and guarded with her trunk positioned posterior to her hips. When she placed her weight on either of her lower extremities, her trunk leaned to the opposite side and the weight-bearing knee hyperextended from initial contact through mid- and terminal stance. Lower extremity adduction past midline occurred every three to four steps (left crossed in front of right). While turning, MC's trunk swayed posteriorly, and she appeared to wait for her trunk to come around and forward before continuing to turn. In addition, MC appeared visually dependent when walking in that she stared at a reference point on the wall and walked toward it. When asked to ambulate without staring at the wall and without the walker she became unsteady, blinking her eyes trying to focus and required increased assistance. She stated she needed to stare at the wall to control her balance and dizziness. MC reported feeling a sense of disequilibrium and thought she might fall without an assistive device. She was unable to use the front-wheeled walker that she was discharged from the hospital with because the wheels of the walker got stuck in the shag carpet in her home.

Evaluation and Diagnosis

MC demonstrated impairments in balance during quiet standing and dynamic movement, body alignment, muscle strength, coordination, endurance, fatigue and dizziness as well as visual dependence as a result of an exacerbation of RRMS. These impairments affected her ability to function independently in her home and perform leisure activities.

Her primary problems were a combination of posterior loss of balance, poor alignment, and lack of vertical awareness. I hypothesized that if I weighted her torso anteriorly, it would decrease the postural instability and improve her alignment.

Prognosis

According to Shapiro,[4] individuals with RRMS tend to have partial or full recovery from exacerbations. Therefore, MC had good potential to achieve her goals.

Plan of Care

Physical therapy was provided in the home for weekly one-hour sessions for six weeks.

The short-term two-week goals were as follows:

- Improve balance, alignment, and vertical awareness.
- Decrease assistance in transfers and ambulation from contact guard/minimal assist to supervision throughout the home on various types of flooring including tile, shag carpeting, and hardwood, with or without the assistance of a cane for 100 feet with decreased visual dependence.
- Demonstrate independence with home exercise program (HEP) in two visits, focusing on strength and habituation of dizziness.

- Increase combined upright tolerance of sitting and standing from 30 minutes to 2 hours at a time per day.

The long-term 6-week goals were as follows:

- Independent home and community ambulation with or without a cane.
- Improve gait speed with less ataxia.
- Improve standing and dynamic balance as noted by the ability to maintain Romberg EO and eyes closed (EC)[21] for 30 seconds nonweighted and stand in the heel-toe position for 10 seconds with EO.
- Improve sitting-to-standing transitions from supervision to independent without posterior imbalance.
- Improve lower extremity and trunk strength from 3− to 3/5 to 3 to 3+/5.
- Reduce fatigue as noted by the ability to be upright for four to five hours per day (combination of sitting and standing activities).
- Demonstrate independence in performance of the HEP.
- Decrease self-reported dizziness from 6/10 in sitting to 2/10, from 9/10 to 5/10 during walking forward, and from 10/10 to 6/10 during 360-degree turns.
- Return to her previous participation in activities such as walking on the beach or on a treadmill at the gym.

Intervention

The physical therapy intervention and HEP designed for this patient from the second through sixth visits combined the use of torso-weighting while performing functional tasks and then the same activities not weighted. As MC improve, progressively more difficult balance, gait, and strengthening tasks associated with activities of daily living were added. The treatment description and rationale are described in Table 1. MC wore the weighted vest for a half hour twice daily during the final three weeks of the treatment period. This plan of care was developed based on the findings during the second visit.

During the second visit, MC stood independently in the EO Romberg position with a large amount of AP sway and loss of vertical alignment posterior. She was unable to stand in eyes closed Romberg or resist posterior perturbation. Two 0.5-lb weights were placed in the anterior portion of a vest at the level of the umbilicus. This placement was chosen because of the proximity to the trunk's center of gravity[20] Reassessment revealed a reduction in AP sway, the ability to stand independently in EC Romberg for three seconds and increased resistance to posterior perturbations. An additional 0.5 lb of weight was added above the umbilicus. With the additional 0.5 lb (a total 1.5 lb), her head and trunk became aligned over her feet, and she maintained the EC Romberg position independently for 10 seconds (Table 1). Responses to perturbation were faster and more forceful. MC stated that "The vest centers me. It gives me a point where I'm not going to fall off. This is how I'm supposed to feel." Improved control in gait was noted: lateral trunk lean decreased and knee hyperextension was less bilaterally. After wearing the weighted vest for 15 minutes, the vest was removed and MC immediately reverted to the gait pattern exhibited before weighting. Because of the positive changes seen with the weighted vest and concerns about fatigue, no additional weights were added to the vest. The total amount of weight (including the weight of the vest) was two pounds, just over 1.5% of MC's body weight.

Outcomes

The outcomes of nonweighted and torso-weighted activities during each visit are described in Table 2. Videos that illustrate the changes observed when the patient donned the BBTW are listed in Table 2 and can be found at jnptextra.org. By the sixth visit, all goals had been met. Gait at self-selected speeds without the torso weight was nearly normal without gait deviations. However, increased gait speed resulted in ataxia. MC reported she had good and bad days. On bad days, she continued to wear the weighted vest for longer periods because the torso-weighting helped to stabilize her during functional activities. She agreed to continue using the weighted vest for two 30-minute sessions daily during her HEP and while performing functional activities.

MC returned three months later and agreed to be examined using the following standardized tests: Timed Up and Go,[22] Romberg,[21] Sharpened Romberg[23] (SR) EO, EC, and single-leg stance. All tests were video recorded with the patient's consent. Three conditions were chosen to determine the continued effects of BBTW: baseline (BL), nonweighted vest (NW), and her weighted vest (BBTW). All three conditions were not examined in all tests to minimize fatigue. The Timed Up and Go was evaluated in all three conditions (***see Video 5-TUG***). The results of TUG can be seen in Table 3. The Romberg test was timed in both NW and BBTW conditions. SR EO and SR EC were conducted for a maximum of 30 seconds in the BL and the BBTW conditions with the patient alternating each lower extremity in the posterior position. Single-leg stance was evaluated for 60 seconds in the BL and BBTW conditions. Table 4 contains the Romberg, sharpened Romberg and single leg stance results.

DISCUSSION

This case report describes the response of a woman with MS and ataxia to the application of weights asymmetrically on her trunk, based on the BBTW method in combination with strength, balance, and gait training. We applied BBTW after the examination, which indicated that weight should be placed anteriorly because this patient had a posterior loss of balance. The amount of weight was determined by observed changes in the patient's balance and alignment in standing, transitional movements, and multidirectional perturbations. Morgan[9] mentioned that there seemed to be an optimal placement and amount of weight where balance stability was most improved. Once weighted forward, with 1.5 lb (plus a 0.5-lb vest), MC performed better in all aspects of balance including decreased sway in standing, enhanced ability to react to balance challenges, improved verticality, and gait. Because she demonstrated very positive changes immediately on donning the weighted vest, no alternative placements were tried.

The weight used in this case report was smaller than the amount reported in virtually all previous studies (<1 kg) at the low end in the Morgan study,[9] one third the amount reported by Lucy and Hayes,[12] and one fifth that of Clopton et al.[13] No studies to date suggest the placement of weight based on the direction of balance instability or describe a system of assessment, weighting, and reassessment to tailor to an individual's specific needs—the approach used with the patient described in this case report. The Morgan study[9] seemed to be the only study that took the individual patient and amount of weight into account. However, Morgan did not provide a basis for the weights used on each subject.

The theory behind weighting is not clear; however, the clues provided by this case may help direct further research. If the reason for improved performance is that weighting helps compress the joints and therefore adds sensory stimuli for cocontraction,[14,15] then adding a weighted vest should be beneficial for postural stability. However, more weight can also be fatiguing, a primary consideration for MC. In this case, a very low amount of weight was used compared with other studies, and good results were obtained. Future studies may need to vary the amount of weight applied to any individual to determine whether the compressive force is the critical feature for this intervention. If improved performance results from the change in the COM, one would expect that

TABLE 1. Patient Treatment and Rationale

	Treatment	Rationale
Visit 2		
BBTW	Weight the patient with 1.5-lb weight placed anterior in a vest	Counter posterior balance loss by applying a 1.5-lb weight to improve balance, alignment, and verticality
Balance control	Static standing EO and EC in the Romberg position	Challenge standing balance with narrow base support and elimination of vision
	Transitional movement from sitting to standing and standing to sitting	Practice control COG control in a functional task
Gait training	Ambulate with BBTW vest	Practice ambulation with improved balance and upright posture
Vestibular	Repeated rolling, supine to sitting, and head turns	Habituation exercises to decrease dizziness
HEP	Lower extremity strengthening exercises	Increase strength of lower extremities
Visit 3		
Balance control	Static standing EO and EC Romberg	Practice standing with small base of support and elimination of vision
	Semitandem and tandem stance	Challenges standing balance, lateral control
	Lunge forward/sideways trying to bring feet back into the Romberg position	Practice transitional movements out of the BOS and return to small BOS
Gait training	Forward and backward walking, turning 360 degrees	Challenge anticipatory control and the vestibular system and practice functional activities
HEP added	Practice walking, lunging, and performing balance exercises with the BBTW vest and without the vest next to the kitchen counter for safety twice daily to tolerance	Repeated practice of specific tasks with BBTW vest to retrain balance control and alignment. After practice with the correct balance and alignment, the same activities are practiced without the weight to optimize carryover
	Supine pelvic tilt stabilization exercises	Increase abdominal and trunk strength and control
Visit 4		
Gait training	Environmental gait training on various surfaces: concrete, grass, and steps	Challenge dynamic gait by altering the task with various environments and surfaces
HEP added	Standing hip exercises at counter: hip flexion, extension, abduction to tolerance	Increase lower extremity control and strength
Visit 5		
Balance control	Tandem stance	Challenges standing balance, lateral control
	0.5 lb added to the to the back of the vest	Provide a posterior pull toward initial impairment of posterior balance loss. Addition of weight increases strength program
Gait	Ambulate while reading a magazine with 12-point font	Multitask: challenge gait by holding magazine, gaze stabilization to look at magazine to read, walking, and balance
HEP added	Sitting to standing until fatigued with BBTW vest	Increase LE strength and control of COG with additional weight in the vest
Visit 6		
Re-examination	Reassess status	Assess final outcomes
HEP added	Lunge in all directions of the clock	Directional challenges to promote stepping strategies

All exercises were performed with BBTW first and then repeated in the nonweighted state.

Abbreviations: BBTW, balance-based torso-weighting; EO, eyes open; EC, eyes closed; COG, center of gravity; HEP, home exercise program; BOS, base of support; LE, lower extremity.

TABLE 2. Outcomes: Comparison of Nonweighted and Balance-Based Torso-Weighting (BBTW) Conditions

	Nonweighted	Balance-based torso-weighting: 1.5 lb
Visit 2		
Balance	EO Romberg large AP sway primarily posterior	EO Romberg: 30-sec small sway
	EC Romberg: immediate posterior loss of balance without protective strategies	EC Romberg: 10 sec small sway posterior
	COG transition required both hands to push up from sit to stand	COG transition required one hand for sit to stand
	Initial stance control unsteady posterior sway	Initial stance steady no posterior sway
Posture and alignment	Patient's trunk and head lean posterior to feet, hips internally rotated and adducted, pronated flat feet without arch in the midfoot	Patient stands with head and trunk positioned over the BOS and with less internal rotation of hips, develops a slight arch bilaterally in her midfoot. Patient states "This is how I am supposed to feel, the vest centers me. I don't feel like I am going to fall off"
Gait	Ambulates with a cane with supervision or without a cane with contact guard to min assist. Slow ambulation, wide-based gait, lateral trunk instability, bilateral knee hyperextension during initial through terminal stance	Ambulates without cane with close supervision occasional contact guard. Ambulates with a smaller base of support, faster speed, improved trunk stability without lateral lean and less hyperextension at the knees
Dizziness*	Walking: 9/10	Walking: 6/10
Visit 3		
Balance	Romberg EO = 30 sec, EC = 15 sec	Romberg EO, EC: = 30 sec
	Tandem stance/heel-toe: large amplitude trunk and arm movements for balance control.	Tandem stance/heel-toe: demonstrates improved trunk control with less arm movement (***see Video 1-TandemStance***)
	Dynamic lunges forward and sideways: posterior loss of balance unable to return to Romberg position (12 in. apart)	Lunges forward and sideways: improved balance control during lunge and returns to Romberg position without loss of balance
	Patient states " I am hanging on with my toes"	Patient states "I don't have to think about my balance. I can concentrate on the exercise"
	Needs to sit to put on weighted vest	
Gait	Ambulation without an assistive device demonstrates improved trunk control from prior visits, no lower extremity scissoring, bilateral knee hyperextension present	Ambulates without an assistive device faster with improved motor control (***Video 2-WalkingDemo and Video 3-PatientReport***)
	Backward ambulation without an assistive device is slow, uses arms out to the side and vision	Backward ambulation without a device is faster without arms for balance control
	Slow turns	Improved turning ability while weighted
Visit 4		
Gait	Ambulation without an assistive device demonstrates improved motor control over visit 3 as demonstrated by decreased knee hyperextension than previous visit	Ambulation without an assistive device and without any gait deviations
	Ambulates slowly in new environment outside	Ambulates 13 sec faster when weighted than without the weight in same 200-ft walk outside
	Requires close supervision on steps and grass	Requires distant supervision on step and grass
Posture and alignment	Stands taller with decreased posterior lean than previous week	Normal posture and alignment when wearing the weight
Visit 5		
Balance and gait	Able to stand to put on and take off weighted vest	
	Tandem stance: 18 sec	Tandem stance: 30 sec
	Walking and reading: slow ambulation, unsteady, staggers, blinks eyes trying to focus	Patient ambulates faster with improved motor control while weighted, able to turn while looking at paper without losing balance
	Patient states "I have to watch where I am going" (***Video 4-WalkRead***)	Patient states "I can do this and I am not as dizzy"
Dizziness*	Walking: 4/10	Walk: 1/10
	Walk and read: 9/10	Walk and read: 4/10
	Turns: 5/10	Turns: 2/10
Visit 6		
Gait	Ambulation close to normal at self-selected gait speeds without an assistive device. At fast speeds, ataxia returns	Ambulates at fast speeds without ataxia when weighted

* Numerical analog scale 0–10 (10 = worst possible dizziness).
Abbreviations: EO, eyes open; EC, eyes closed; COG, center of gravity; BOS, base of support.

TABLE 3. Three-Month Follow-up TUG Scores in Seconds

	BL	NW	BBTW
TUG	9.1	9.0	6.9

Abbreviations: BL, baseline; NW, nonweight; BBTW, balance-based torso-weighting; TUG, Time Up and Go.

adding a greater proportion of the subject's mass (more weight) would make a larger difference (up to a point). If the improved performance is because of a change in awareness that improves concentration on the task, then weighting while the individual walks and reads, as MC did, might result in deterioration of balance and gait. MC did not demonstrate this response.

Future studies may need to determine whether the placement of weight is a critical factor. Quiet standing is inherently unstable resulting in small amounts of postural sway due to the interplay of destabilizing forces acting on the body and the actions of the postural control system to maintain upright stance.[25,26] Given the fact that two thirds of body weight is contained in the head, arms, and torso, timely corrective torques must be generated to counter the destabilizing forces.[26] If the individual is unable to counteract the destabilizing forces, identification of the direction of loss may assist determining the location to weight the body. Once MC was weighted anteriorly, she could react to posterior destabilizing forces.

Other clues to the reason why weighting seems effective may come from MC's comments when weighted. After torso-weighting, MC's posture changed to a more upright position and she stated that "This is how I'm supposed to feel." Improvement in alignment may have allowed recognition of a previous internal representation of her body's position in space. Jenka[20] proposes that the sense of touch can facilitate increased body orientation. He describes the use of light touch contact of a fingertip to provide sensory information as a balance aid to decrease body sway. Weighting could have a similar effect on body orientation. When the weight was removed, MC said that "It is like I have sunk down again." This suggests that postural tone may have changed. One would think that the weight might pull her down, but it actually seemed to increase her upright ability. Schenkman and Butler[27] postulate that postural tone is a key element for normal postural stability in the erect position. MC's statement "I don't have to think to move" suggests that BBTW may have helped the patient access previously learned or automatic movement strategies, which then allowed less reliance on cognitive or voluntary control.

TABLE 4. Three-Month Follow-up Romberg, Sharpened Romberg, and Single-Leg Stance Scores (in Seconds)

	Baseline		BBTW	
	EO	EC	EO	EC
Romberg test	30.0	30.0	30.0	30.0
SR				
L leg back	30.0	21.0	30.0	30.0
R leg back	27.2	9.4	30.0	28.4
SLS				
R	5.0	NT	49.0	NT
L	19.0	NT	22.9	NT

Abbreviations: BBTW, balance-based torso-weighting; EC, eyes closed; EO, eyes open; SR, sharpened Romberg; L, left; R, right; SLS, single-leg stance; NT, not tested.

MC reported less dizziness and turned more easily when she was weighted. Although the vestibular system was not assessed directly, quiet standing, tandem stance, and deviation from vertical are often examined in individuals with vestibular disorders.[28] MC demonstrated both increased sway, deviation from vertical, and posterior falls when she closed her eyes. If these results were because of somatosensory problems instead of vestibular dysfunction, the mechanism for improvement with weighting could well be related to increased sensory input. Alternatively, the patient's diagnosis of MS and impaired perception of vertical and loss of antigravity tone could be related to a central vestibular disorder that could result in disequilibrium, imbalance, and ataxia.[28] However, it is difficult to determine how the weighting might have affected a primary vestibular dysfunction.

Some of MC's improvements were probably due to spontaneous recovery and increased ability gained from her overall rehabilitation and the HEP. However, MC functioned at a higher level immediately after donning the torso weight. I believe that torso-weighting gave her a sense of her capability and future potential.

Limitations

Thorough sensory testing of the vestibular and somatosensory systems might offer a better understanding of how weighting may have helped this patient. This report is based on a single patient and cannot be generalized to the greater population of those with MS or ataxia. No definitive conclusions can be made about whether BBTW contributed to this patient's recovery.

CONCLUSION

The use of a systematic assessment, treatment, and reassessment approach to examine and treat postural alignment and static and dynamic postural control appeared beneficial for this patient with MS. Further study is warranted to determine the effectiveness of the broader application of BBTW in patients with MS and in other neurologic diagnoses where balance is impaired.

REFERENCES

1. O'Sullivan SB. Multiple sclerosis. In: O'Sullivan SB, Schmidt TJ, eds. *Physical Rehabilitation: Assessment and Treatment.* 4th ed. Philadelphia, PA: FA Davis; 2004.
2. Kidd D, Barkhof F, McConnell R, et al. Cortical lesions in multiple sclerosis. *Brain.* 1999;122:17–26.
3. Poser S, Wikstrom J, Bouer HJ. Clinical data and the identification of special forms of multiple sclerosis in 1271 cases studied with standardized documentation system. *J Neurol Sci.* 1979;40:159–168.
4. Shapiro RT. *Symptom Management in Multiple Sclerosis.* 3rd ed. New York, NY: Demos Medical Publishing; 1998.
5. Holmes G. The cerebellum of man. *Brain.* 1939;62:1–30.
6. Chase RA, Cullen JK, Sullivan SA. Modification of intention tremor in man. *Nature.* 1965;485–487.
7. Hewer RL, Cooper R, Morgan MH. An investigation into the value of

treating intention tremor by weighting the affected limb. *Brain.* 1972; 95:570–590.
8. Morgan MH, Hewer RL, Cooper R. Application of an objective method of assessing intention tremor-a further study on the use of weights to reduce intention tremor. *J Neurol Neurosurg Psychiatry*. 1975;38:259–264.
9. Morgan MH. Ataxia and weights. *Physiotherapy.* 1975;61:332–334.
10. Gillen G. Improving activities of daily living performance in an adult with ataxia. *Am J Occup Ther.* 2000;54:89–96.
11. Manto M, Goudaux E, Jacquy J. Cerebellar hypermetria is larger when the inertial load is artificially increased. *Ann Neurol.* 1994;35:54–52.
12. Lucy SD, Hayes KC. Postural sway profiles: normal subjects and subjects with cerebellar ataxia. *Physiother Canada.* 1985;37:140–148.
13. Clopton N, Schultz D, Boren C, et al. Effects of axial loading on gait for subjects with cerebellar ataxia: preliminary findings. *Neurol Rep.* 2003; 27:15–21.
14. Stockmyer S. An interpretation of the approach of Rood to the treatment of neuromuscular dysfunction. *Am J Phys Med.* 1967;46:950–955.
15. Goff B. The application of recent advances in neurophysiology to Miss Rood's concept of neuromuscular facilitation. *Physiotherapy.* 1972;58: 409–415.
16. Bernstein N. *The Coordination and Regulation of Movement.* London: Pergamon Press; 1967.
17. Ponce de Leon S, Lara-Munoz C, Feinstein AR, et al. A comparison of three rating scales for measuring subjective phenomena in clinical research. II. Use of experimentally controlled visual stimuli. *Arch Med Res.* 2004;35:157–162.
18. Kendall FP, McCreary EK, Provance PG. *Muscles: Testing and Function.* 4th ed. Baltimore, MD: Williams & Wilkins; 1993.
19. Bohannon RW, Smith MB. Interrater reliability of a modified Ashworth scale of muscle spasticity. *Phys Ther.* 1987;67:207–214.
20. Perry J. *Gait Analysis Normal and Pathological Function.* Thorofare, NJ: SLACK; 1992.
21. Lanska DJ, Goetz CG. Romberg's sign development, adoption, and adaptation in the 19th century. *Neurology.* 2000;55:1201–1206.
22. Podsaidlo D, Richardson S. The timed "up and go": a test of basic functional ability for frail elderly persons. *J Am Geriatr Soc.* 1991;39: 142–148.
23. Bohannon R, Larkin P, Cook A, et al. Decrease in timed balance test scores with aging. *Phys Ther.* 1984;64:1067–1070.
24. Perterka RJ, Loughlin PJ. Dynamic regulation of sensorimotor integration in human postural control. *J Neurophysiol.* 2004;91:410–423.
25. Wollacott MH, Tang PF. Balance control during walking in the older adult: research and its implications. *Phys Ther*. 1997;77:646–660.
26. Jenka J. Light touch contact as a balance aid. *Phys Ther.* 1997;77:476–487.
27. Schenkman M, Butler RB. A model for multisystem evaluation, interpretation and treatment for individuals with neurologic dysfunction. *Phys Ther.* 1989;69:538–547.
28. Keshner E. Postural abnormalities in vestibular disorders. In: Herdman SJ, ed. *Vestibular Rehabilitation.* 2nd ed. Philadelphia, PA: FA Davis; 2000:47–67.

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