Standing Data Disproves Biomechanical Mechanism for Balance-Based Torso-Weighting

Ajay Crittendon[1], Danielle O'Neill[1], Gail L. Widener[2], Diane D. Allen[1]

[1]*Graduate Program in Physical Therapy UCSF/SFSU*, [2]*Physical Therapy Department Samuel Merritt University*

Introduction

- Walking impairments can cause frequent falls and limitations in activities and participation in daily life for people with multiple sclerosis (PwMS).[1]
- Balance-Based Torso-Weighting® (BBTW), a non-pharmaceutical intervention in which patients wear strategically placed light weights on the trunk, has resulted in immediate functional improvements in PwMS, including increased gait speed.[2-4]
- Proposed mechanisms for the effect of BBTW include joint compression, a biomechanical shift reflecting weight placement, increased afferent input about body segments, and improved conscious awareness.
- The purpose of this study was to examine the potential biomechanical mechanism by comparing average weight location after BBTW with the center of pressure changes during quiet standing with and without weights.

Methods

- Inclusion: diagnosis of MS, physician approval; or, age, height, and weight-matched healthy control
- 38 female volunteers gave informed consent

	People with MS (n=20)	Healthy controls (n=18)
Mean age in years (SD), range	49.4 (13.4), 25-68	47.3 (11.2), 29-69
Mean years with diagnosis (SD)	12.8 (8.2)	
EDSS score equivalent	4.1 (1.6), 2-6	
Number (%) claiming falls in the past 6 months	11 (55%)	2 (11%)

MS = multiple sclerosis, SD = standard deviation, EDSS = Expanded Disability Status Scale

- Completed medical questionnaire listing MS-related symptoms and recent fall history
- BBTW protocol[2-4] assessed balance response to perturbations in standing to determine placement of light weights (0.36% to 1.6% body weight) on a snug garment

Figure 1. BBTW™ Garment and Weights

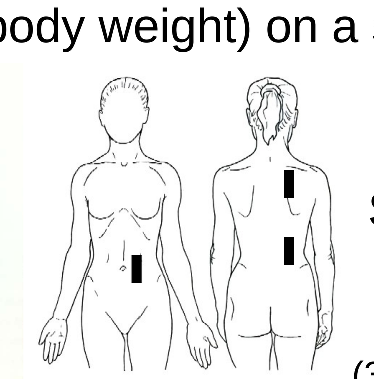


Figure 2. Sample Weight Placement on Garment (3 half-pound weights)

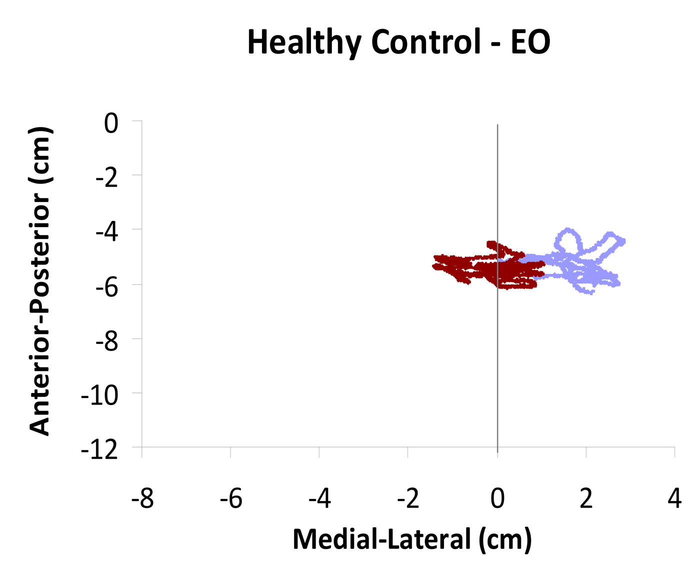
- Quiet standing trials on Kistler forceplate
  - With torso garment but no weights, participants stood on a forceplate as still as possible for 10 seconds with eyes open, then 10 seconds with eyes closed
  - With weights on, (0.75-2.75 pounds) participants repeated the two standing trials

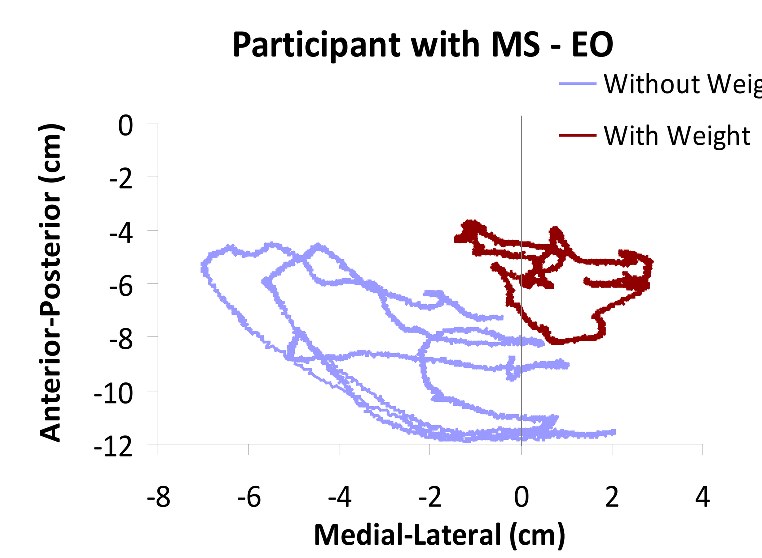
Data collection and analysis

- Weight placement designation: posterior/ anterior/ equal, right/ left/ central, upper/ lower
- Center of pressure (COP):
  - Designated medial-lateral (x) and anterior-posterior (y) using BioWare software
  - Average COP examined in each direction (x, y)
- Weight placement and COP compared in two groups (MS and HS) and four conditions: eyes open (EO) and closed (EC), non-weighted (NW) and weighted (W)
- Statistical Analyses (alpha set at .05)
  - Chi-square tests compared COP changes with weight placement

Results

- Some participants showed changes in COP with weighting. Graphs show examples of COP traces. In the x direction, 0 = midline. In the y direction, people faced towards 0, heels at -8.





- Percent agreement between the direction of COP displacement and placement of most weight ranged from 15% to 44.4%
- PwMS had lower percentages of agreement than healthy controls but difference was not statistically significant (Chi-square p=0.0512)

Percent Agreement between Direction of COP Displacement and Weight Placement

	Eyes Open (x and y directions)	Eyes Closed (x and y directions)	Y Direction (EO and EC)	X Direction (EO and EC)	Total
MS	30%	15%	20%	25%	22.5%
HS	33.3%	41.7%	30.6%	44.4%	37.5%
Combined	31.6%	27.6%	25%	34.2%	29.6%

MS: Participants with MS; HS: Healthy controls; EO: Eyes open; EC: Eyes closed

- Direction of change in average COP displacement from non-weighted to weighted conditions significantly differed from direction of placement of weights.
- Many COP displacement changes with weighting were very small. A minimal detectable change (MDC) was calculated using the formula MDC = SD * sqrt (1- correlation r). The chi-square analysis was repeated using a value for direction of change only when change was greater than MDC in each direction. Again, direction of change in average COP displacement significantly differed from direction of placement of weights.

Chi-square COP-MDC Agreement with Weight Placement

	Chi-square value	P-Value
Combined (MS & HS)	25.289	0.0001
MS	24.2	0.0001
HS	4.5	0.0339

- COP: center of pressure; MDC: minimal detectable change; MS: participants with multiple sclerosis; HS: healthy controls
- All data based on whether COP changes were significantly greater than the minimal detectable change (MDC)

- BBTW increased gait velocity in PwMS (t-test, p=0.002) compared to gait without weight.

Discussion

- If the mechanism behind BBTW was strictly a biomechanical shift, changes in COP would reflect the changes in center of mass in the direction of the greatest weight placements. Therefore, the data would show a high percent of matches between weight placement and the direction of COP changes.
- However, these data indicate that COP changes match the direction of weight placement only about 30% of the time. Statistically, we reject the null hypothesis of no difference from random agreement (matching 50% of the time) and we reject the unidirectional alternative hypothesis of high agreement.
- A mechanism other than a biomechanical shift appears to have been in effect.
- Further research is needed to test alternative mechanisms underlying gains in gait velocity and balance with BBTW.
- Despite the weighting average of only 0.9% of body weight (1.38lbs), participants weighted with BBTW had immediate improvement in gait speed.

Conclusion

While BBTW has been shown to increase gait speed in PwMS, the mechanism for change is unknown. These data disprove the hypothesis of a strictly biomechanical mechanism underlying its effectiveness. Further study is needed to investigate other possible mechanisms for this promising intervention.

Acknowledgement: This study was supported by Award Number R15HD066397 from the Eunice Kennedy Shriver National Institute of Child Health and Human Development. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Eunice Kennedy Shriver National Institutes of Child Health and Human Development or the National Institutes of Health.

References

1.Nilsagard Y, Lundholm C, Denison E, Gunnarsson LG. Predicting accidental falls in people with multiple sclerosis--a longitudinal study. *Clin Rehabil.* 2009;23:259-269.

2.Gibson-Horn C. Balance-based torso-weighting in a person with ataxia and multiple sclerosis: A case report. *J Neurol Phys Ther.* 2008;32:139-146.

3.Widener GL, Allen DD, Gibson-Horn C. Balance-based torso-weighting may enhance balance in persons with multiple sclerosis: Preliminary evidence. *Arch Phys Med Rehabil.* 2009;90:602-609.

4.Widener GL, Allen DD, Gibson-Horn C. Randomized clinical trial of balance-based torso-weighting for improving upright mobility in people with multiple sclerosis. *Neurorehabil Neural Repair.* 2009;23:784-791.