Fall Neuro STEP-UP Journal Club:

Efficacy of Balance and Eye-Movement Exercises for PwMS (BEEMS)

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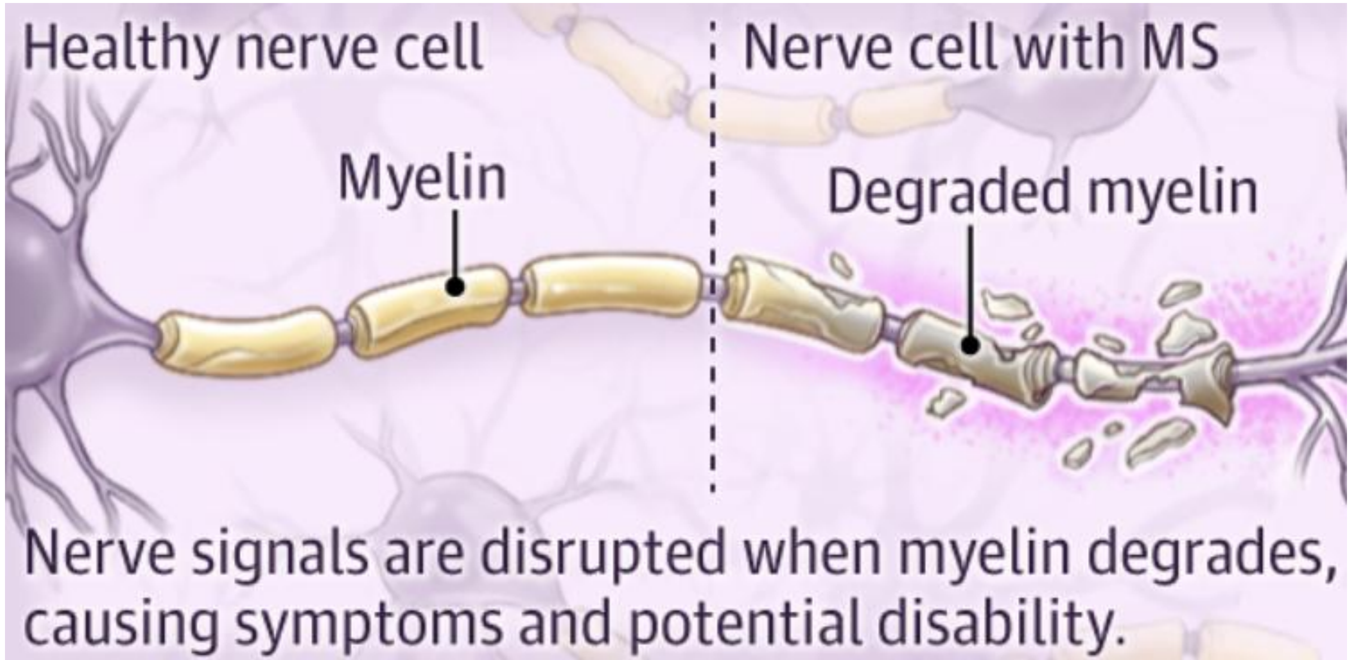
Background

What is Multiple Sclerosis (MS)?

- Chronic, inflammatory, neurodegenerative condition involving demyelination of the CNS



McDonald Criteria

- Dissemination of Space
  - Juxta/Intracortical
  - Periventricular
  - Infratentorial
  - Spinal cord

- Dissemination of Time
  - New lesion on follow-up MRI with reference to baseline scan

Four Types of MS

- Clinically Isolated Syndrome (CIS)
- Relapsing-Remitting MS (RRMS)
- Secondary Progressive MS (SPMS)
- Primary Progressive MS (PPMS)

Balance

VESTIBULAR SYSTEM

SOMATOSENSORY SYSTEM

VISUAL SYSTEM

Current Research

Effects of Different Exercise Therapies on Balance Function and Functional Walking Ability in Multiple Sclerosis Disease Patients-A Network Meta-Analysis of Randomized Controlled Trials

Zikang Hao [1], Xiaodan Zhang [1], Ping Chen [1]

Affiliations + expand

PMID: 35742424
PMCID: PMC9222772
DOI: 10.3390/ijerph19127175

- Focus on improving balance and gait with strength training and nonspecific balance activities
- Aquatic exercise, aerobic exercise, yoga, Pilates, virtual reality, whole-body vibration, and resistance training

Current Research

Saccadic eye movements are able to reduce body sway in mildly-affected people with Multiple Sclerosis

Felipe Balistieri Santinelli [1], Richard E A van Emmerik [2], Fabiana Araújo Silva [3], Luis Felipe Itikawa Imaizumi [3], Tiago Penedo [3], Ana Maria Canzonieri [4], Sérgio Tosi Rodrigues [5], Paula Favaro Polastri Zago [5], Fabio Augusto Barbieri [3]

Affiliations + expand

PMID: 30738874
DOI: 10.1016/j.msard.2019.02.005

- Healthy adults can reduce postural sway and improve balance with integration of eye movements
- Mildly-affected PwMS and non-MS controls reduced postural sway with saccadic eye movements
- Integration of dynamic visual control and postural control preserved in mildly affected PwMS

What is BEEMS?

- Program developed by University of Colorado School of Medicine
- BEEMS has three main components:
  - Standing balance on different surfaces
  - Mobility-based balance in walking with and without head movements
  - Visual stability → voluntary saccadic eye, smooth pursuit movements, and dynamic gaze fixation

Research Question?

Is BEEMS training more effective at improving balance, dizziness, and fatigue compared to a wait-listed control in persons with MS?

Methods

Methods

Inclusion Criteria:

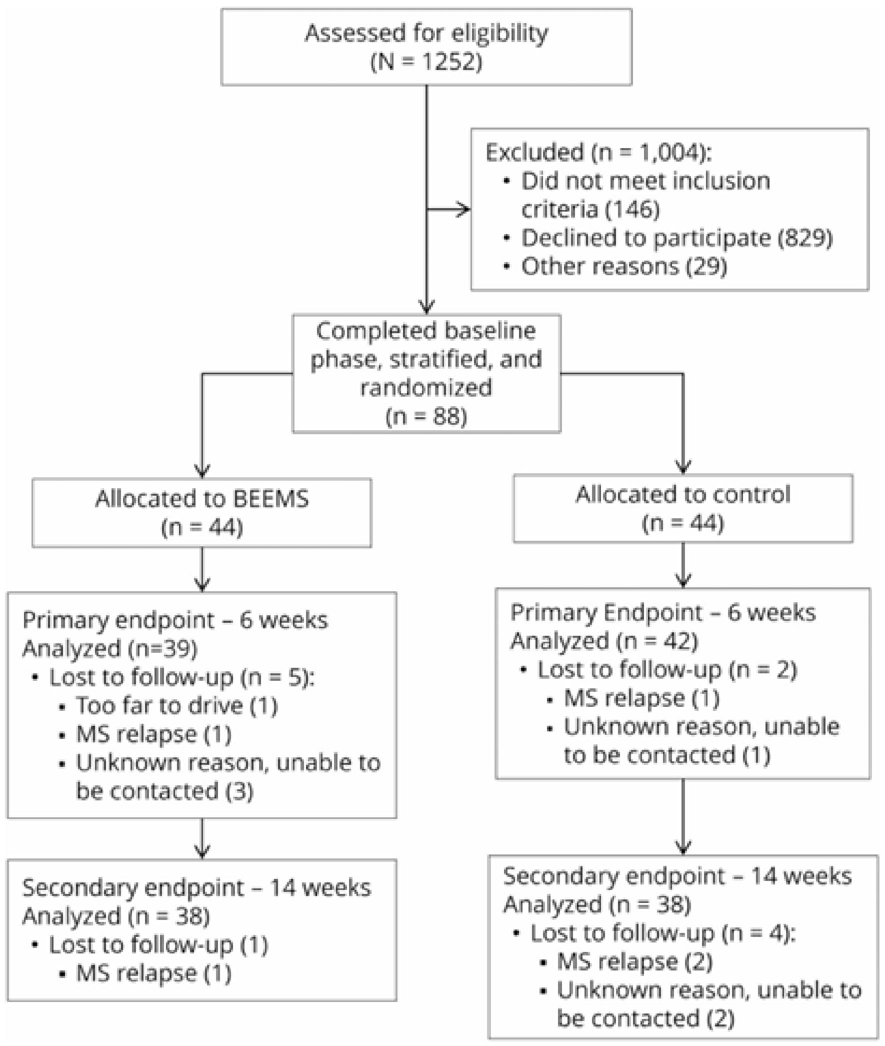
- Clinically definite MS
- Ambulation of 100m with no greater assistance than a unilateral device
- Age of 18 to 60 years
- CDP-SOT composite score ≤82/100
- MFIS total score ≥22/84

Exclusion Criteria:

- Nonambulatory
- LE orthoses
- LE spasticity > 1 on Modified Ashworth Scale
- Another neurologic disorder contributing to balance problems
- Relapse within 3 months
- Contraindication of PA

Experimental Design

- Enrolled 88 participants with MS
- 16-week examiner blinded RCT
- Participants randomized into BEEMS or control → stratified by evidence of brainstem/cerebellar lesions
- Treatment consisted of 3 phases: 2-week baseline, 6-week phase 1, 8-week phase 2
- Controls were waitlisted for intervention → offered intervention post-study



Measures

- Computerized Dynamic Posturography – SOT
- Modified Fatigue Impact Scale (MFIS)
- Clinical signs of brainstem/cerebellar involvement → dysmetria (limb or saccadic), nystagmus, diplopia during smooth pursuits)
    - Confirmed with neurologist specialized in MS for MRI scans
- Dizziness Handicap Inventory (DHI)
- Multiple Sclerosis Quality of Life Inventory
- Perceived Deficits Questionnaire (PDQ)
- Short Form-36 Health Status Questionnaire (SF-36)
- InVision SMART Balance Master → Gaze Stabilization Test (GST) and Dynamic Visual Acuity Test (DVAT)
- Timed 25-Foot Walk (T25FW)

Statistical Analysis

- SAS version 9.4 → 2-sided test of hypothesis and a significance level of 0.05
- Participant characteristics → reported as means and SDs; used t tests, $\chi 2$ tests, or Wilcoxon-rank sum tests
- Primary and secondary aims → used linear mixed-effects models for each outcome as a function of group, time, time squared, group-by-time squared interaction, and lesion involvement

Results

Table 2 Mixed-model baseline, 6-week, and 14-week estimates and difference in change outcome values for BEEMS and control groups and for BEEMS participants with and without lesion involvement

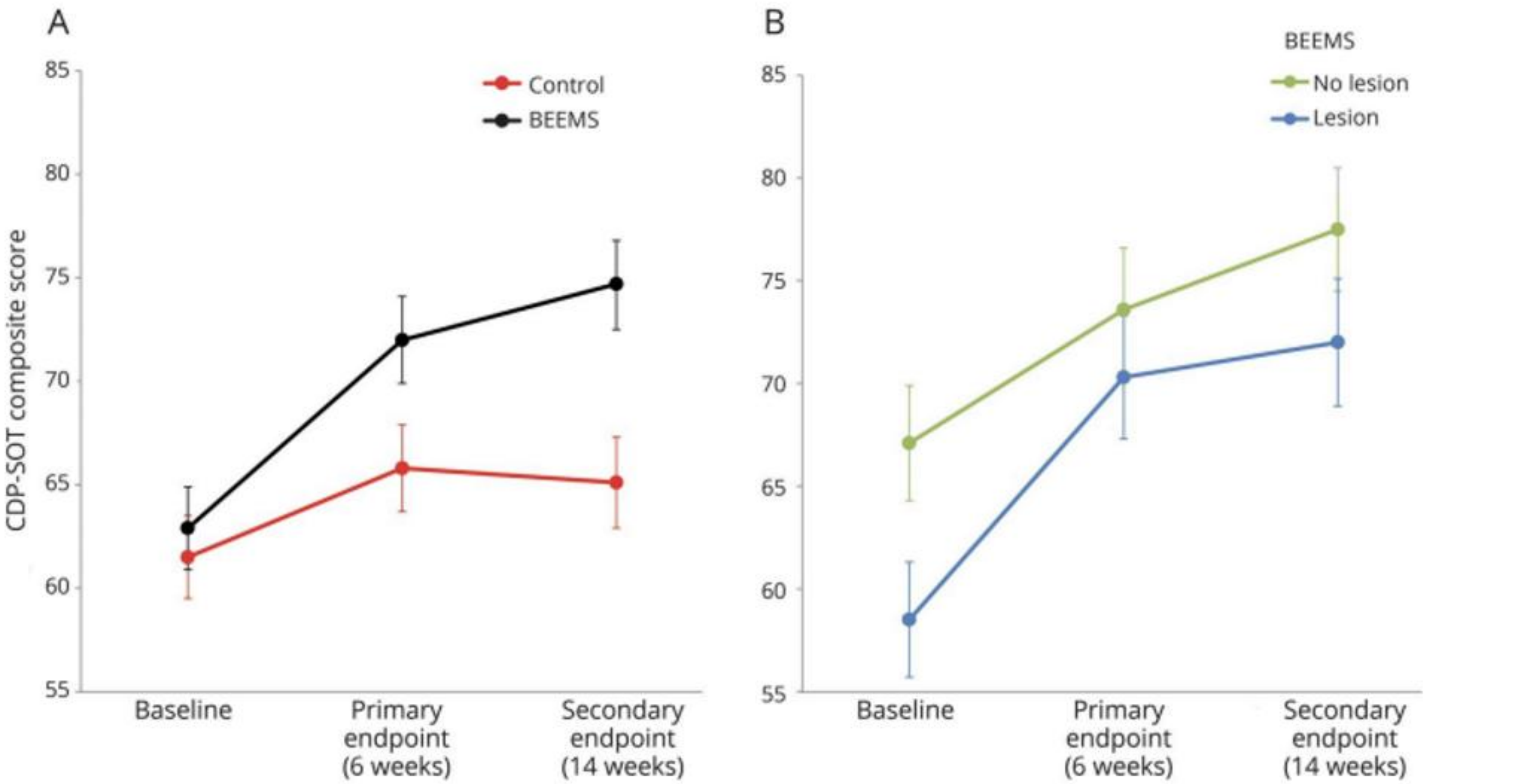
Measure	BEEMS			Control			Difference in 6-wk change (95% CI; *p* value)	Difference in 14-wk change (95% CI; *p* value)
	Baseline (n = 44)	6 wk (n = 39)	14 wk (n = 38)	Baseline (n = 44)	6 wk (n = 42)	14 wk (n = 38)		
CDP-SOT composite score	62.9 (2.0)	72.0 (2.1)	74.7 (2.1)	61.5 (2.0)	65.8 (2.1)	65.1 (2.2)	4.89 (1.39 to 8.38; *p* = 0.006)	8.32 (4.73 to 11.9; *p* < 0.0001)
CDP-SOT 1 and 2 score	173.4 (1.8)	179.0 (2.0)	179.5 (2.0)	174.0 (1.8)	171.9 (2.0)	172.5 (2.0)	7.64 (3.87 to 11.4; *p* < 0.0001)	7.54 (3.66 to 11.4; *p* = 0.0002)
CDP-SOT 3–6 score	235.7 (8.8)	276.1 (9.5)	289.0 (9.5)	229.5 (8.8)	249.7 (9.5)	245.9 (9.6)	20.3 (4.53 to 36.0; *p* = 0.01)	36.9 (20.7 to 53.1; *p* < 0.0001)
DHI total score	40.9 (3.5)	27.8 (3.8)	23.0 (3.8)	41.3 (3.3)	40.7 (3.4)	37.4 (3.4)	−13.5 (−17.7 to −7.25; *p* < 0.0001)	−13.9 (−19.3 to −8.62; *p* < 0.0001)
MFIS total score	49.9 (2.1)	35.8 (2.3)	32.5 (2.4)	48.7 (2.1)	46.0 (2.3)	43.6 (2.3)	−11.4 (−15.7 to −7.0; *p* < 0.0001)	−12.3 (−16.7 to −7.79; *p* < 0.0001)
MFIS physical score	23.9 (1.0)	17.7 (1.2)	16.0 (1.2)	23.0 (1.0)	21.8 (1.1)	20.7 (1.1)	−5.05 (−7.30 to −2.80; *p* < 0.0001)	−5.72 (−8.02 to −3.41; *p* < 0.0001)
MFIS cognitive score	21.6 (1.1)	15.4 (1.2)	14.2 (1.2)	21.4 (1.1)	20.3 (1.2)	19.3 (1.2)	−5.06 (−7.13 to −2.98; *p* < 0.0001)	−5.3 (−7.4 to −3.2; *p* < 0.0001)
MFIS psychosocial score	4.42 (0.26)	2.77 (0.31)	2.44 (0.31)	4.34 (0.26)	3.95 (0.29)	3.61 (0.30)	−1.26 (−1.90 to −0.62; *p* = 0.0001)	−1.25 (−1.91 to −0.60; *p* = 0.0002)
PDQ total score	37.8 (2.1)	29.5 (2.3)	29.0 (2.3)	37.6 (2.1)	36.8 (2.2)	35.3 (2.2)	−7.43 (−11.1 to −3.77; *p* < 0.0001)	−6.48 (−10.2 to −2.72; *p* = 0.0008)
SF-36 Physical Component score	35.8 (1.3)	39.8 (1.4)	41.0 (1.4)	35.4 (1.3)	35.8 (1.4)	37.3 (1.4)	3.47 (1.12 to 5.81; *p* = 0.004)	3.20 (0.79 to 5.62; *p* = 0.01)
SF-36 Mental Component score	42.6 (1.6)	48.0 (1.7)	48.2 (1.7)	42.9 (1.6)	42.8 (1.7)	44.6 (1.8)	5.57 (2.43 to 8.71; *p* = 0.0006)	3.93 (0.70 to 7.16; *p* = 0.02)
GST, °/s	127.0 (4.6)	142.8 (5.5)	139.4 (5.5)	125.7 (4.7)	139.7 (5.5)[a]	137.2 (5.7)	1.88 (−11.5 to 15.2; *p* = 0.78)	0.94 (−12.7 to 14.6; *p* = 0.89)
DVAT (logMAR) score	0.17 (0.02)	0.13 (0.02)	0.08 (0.03)	0.13 (0.02)	0.10 (0.02)	0.06 (0.03)	−0.01 (−0.03 to 0.01; *p* = 0.27)	−0.03 (−0.07 to 0.02; *p* = 0.27)
T25FW, s	6.19 (0.30)	5.99 (0.30)	5.71 (0.32)	5.54 (0.30)	5.448 (0.30)	5.40 (0.31)	−0.15 (−0.31 to 0.02; *p* = 0.08)	−0.34 (−0.73 to 0.04; *p* = 0.08)

Table 2 Mixed-model baseline, 6-week, and 14-week estimates and difference in change outcome values for BEEMS and control groups and for BEEMS participants with and without lesion involvement *(continued)*

Measure	Lesion			No lesion			Difference at baseline (95% CI; *p* value)	Difference in 6-wk change (95% CI; *p* value)	Difference in 14-wk change (95% CI; *p* value)
	Baseline (n = 22)	6 wk (n = 19)	14 wk (n = 18)	Baseline (n = 22)	6 wk (n = 20)	14 wk (n = 20)			
CDP-SOT composite score	58.5 (2.8)	70.3 (3.0)	72.0 (3.1)	67.1 (2.8)	73.6 (3.0)	77.5 (3.0)	−8.57 (−16.4 to −0.70; *p* = 0.03)	5.26 (0.34 to 10.2; *p* = 0.04)	3.06 (−1.92 to 8.04; *p* = 0.23)
CDP-SOT 1 and 2 score	170.3 (2.5)	176.8 (2.8)	175.4 (2.8)	176.5 (2.5)	181.1 (2.8)	183.4 (2.8)	−6.14 (−13.2 to 0.95; *p* = 0.09)	1.83 (−3.40 to 7.06; *p* = 0.49)	−1.86 (−7.16 to 3.43; *p* = 0.49)
CDP-SOT 3–6 score	216.4 (12.5)	269.4 (13.5)	277.2 (13.6)	254.4 (12.5)	282.8 (13.4)	300.7 (13.4)	−38.0 (−73.0 to 3.05; *p* = 0.03)	24.7 (2.51 to 46.8; *p* = 0.03)	14.5 (−7.90 to 37.0; *p* = 0.20)
DHI total score	44.5 (4.9)	27.1 (5.4)	25.8 (5.4)	37.3 (4.9)	28.4 (5.3)	20.4 (5.3)	7.23 (−6.63 to 21.1; *p* = 0.30)	−8.44 (−17.6 to 0.71; *p* = 0.07)	−1.79 (−11.0 to 7.48; *p* = 0.70)
MFIS total score	53.2 (3.0)	35.2 (3.3)	33.1 (3.4)	46.7 (3.0)	36.3 (3.3)	31.9 (3.3)	6.52 (−1.87 to 14.9; *p* = 0.13)	−7.64 (−14.0 to −1.33; *p* = 0.02	−5.28 (−11.7 to 1.11; *p* = 0.10)

Measure	Lesion			No lesion			Difference at baseline (95% CI; *p* value)	Difference in 6-wk change (95% CI; *p* value)	Difference in 14-wk change (95% CI; *p* value)
	Baseline (n = 22)	6 wk (n = 19)	14 wk (n = 18)	Baseline (n = 22)	6 wk (n = 20)	14 wk (n = 20)			
MFIS physical score	25.5 (1.5)	17.1 (1.7)	16.2 (1.7)	22.3 (1.5)	18.2 (1.6)	15.7 (1.6)	3.14 (−1.01 to 7.28; *p* = 0.14)	−4.24 (−7.55 to −0.94; *p* = 0.01	−2.66 (−6.01 to 0.69; *p* = 0.12)
MFIS cognitive score	22.9 (1.5)	15.4 (1.7)	14.5 (1.7)	20.3 (1.7)	15.3 (1.7)	13.7 (1.7)	2.64 (−1.70 to 6.98; *p* = 0.23)	−2.57 (−5.34 to 0.41; *p* = 0.09)	−1.83 (−4.74 to 1.08; *p* = 0.21)
MFIS psychosocial score	4.80 (0.37)	2.67 (0.43)	2.40 (0.44)	4.05 (0.37)	2.85 (0.43)	2.45 (0.43)	0.75 (−0.30 to 1.80; *p* = 0.16)	−0.93 (−1.88 to 0.01; *p* = 0.05)	−0.81 (−1.76 to 0.15; *p* = 0.10)
PDQ total score	38.3 (3.0)	29.1 (3.3)	30.3 (3.3)	37.4 (3.0)	29.9 (3.3)	27.9 (3.3)	0.82 (−7.62 to 9.26; *p* = 0.85)	−1.58 (−7.25 to 4.09; *p* = 0.58)	1.56 (−4.19 to 7.30; *p* = 0.59)
SF-36 Physical Component score	35.9 (1.8)	41.0 (2.0)	42.0 (2.0)	35.8 (1.8)	38.6 (2.0)	40.0 (2.0)	0.06 (−5.14 to 5.25; *p* = 0.98)	2.39 (−0.99 to 5.78; *p* = 0.16)	1.92 (−1.51 to 5.34; *p* = 0.27)
SF-36 Mental Component score	40.0 (2.2)	46.5 (2.4)	46.5 (2.4)	45.2 (2.2)	49.6 (2.4)	49.9 (2.4)	−5.24 (−11.4 to 0.89; *p* = 0.09)	2.11 (−2.24 to 6.46; *p* = 0.34)	1.82 (−2.58 to 6.23; *p* = 0.41)
GST, °/s	120.2 (6.6)	134.1 (7.9)	134.2 (8.0)	133.6 (6.5)	151.2 (7.7)	144.6 (7.7)	−13.4 (−31.7 to 5.04; *p* = 0.15)	−3.74 (−22.6 to 15.1; *p* = 0.70)	2.95 (−16.4 to 22.0; *p* = 0.76)
DVAT (logMAR) score	0.18 (0.03)	0.14 (0.03)	0.08 (0.04)	0.16 (0.03)	0.13 (0.03)	0.08 (0.04)	0.02 (−0.07 to 0.12; *p* = 0.61)	−0.01 (−0.04 to 0.02; *p* = 0.47)	−0.03 (−0.10 to 0.05; *p* = 0.47)
T25FW, s	6.33 (0.43)	6.11 (0.43)	5.82 (0.45)	6.07 (0.43)	5.87 (0.43)	5.61 (0.45)	0.26 (−0.96 to 1.48; *p* = 0.67)	−0.02 (−0.27 to 0.23; *p* = 0.86)	−0.05 (−0.63 to 0.53; *p* = 0.86)

Figure 2 Mixed-model estimated changes in balance based on CDP-SOT composite score



Computerized dynamic posturography-sensory organization test (CDP-SOT) composite score–adjusted estimates were based on the mixed-model estimates and standard error. (A) Balance and Eye-Stability Exercises for Persons With Multiple Sclerosis (BEEMS) participants (n = 44) and control participants (n = 44). (B) BEEMS lesion includes BEEMS participants with brainstem/cerebellar lesion involvement (n = 22); BEEMS no lesion includes BEEMS participants without brainstem/cerebellar lesion involvement strata (n = 22).

Strengths and Limitations

- Strengths
  - Research on different approach to balance impairments in PwMS
  - Longer training duration and larger sample size compared to other studies
  - No significant differences in participant characteristics
  - Randomization, blinding, and criteria appropriate
- Limitations
  - Sample size was insufficient to compare BEEMS, controls, and by lesion/no lesion
  - VOR was measured by GST and DVAT which neither directly measures VOR function
  - No follow-up to study to determine if results last
  - Difficulty replicating study → specific parameters, home-exercise program
  - Generalizability → only including mildly affected PwMS

Future Research

- Impact of BEEMS on physical activity and total energy expenditure?
- Does BEEMS improve dysmetric saccadic fixation (fatigue)?
- Use direct measures to detect gain in VOR? → determine whether compensation vs. central adaptation
- Comparison of BEEMS protocol directly to nonspecific balance training
- Longitudinal study

Clinical Application

- Improved balance and dizziness can increase daily physical activity, reduce deconditioning, and improve perceived effort and motor command efficiency
- Fatigue is exacerbated by high cognitive loads to maintain instability → improve fatigue with dual task training (processing different sensory information) during training
- Although more research needs to be done , more tools in the toolbox to treat balance and instability in individuals with MS
  - Vestibular rehabilitation and eye/head/limb coordination conditions should be included in physical therapy interventions

Questions?

References:

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