Use of Awareness Through Movement Improves Balance and Balance Confidence in People with Multiple Sclerosis: A Randomized Controlled Study

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ABSTRACT

This study examined the effectiveness of a structured, group motor learning process, Awareness Through Movement (ATM), on balance, balance confidence, and self-efficacy. Twelve people with multiple sclerosis were randomly assigned to either ATM or control groups. The ATM group participated in 8 classes, 2 to 4 hours each while the control group participated in educational sessions, over 10 weeks. Six outcome measures were used: the Basic Balance Master modified Clinical Test of Sensory Interaction in Balance (mCTSIB) and Limits of Stability tests; the Activities-specific Balance Confidence Scale; a number of prospective falls; Equiscale; and the Multiple Sclerosis Self-Efficacy Scale. The ATM group exhibited significantly improved mCTSIB scores indicating an average center of pressure position closer to theoretical center, had significantly fewer abnormal mCTSIB tests, and demonstrated improved balance confidence compared to controls. There was a trend toward improvement in all other measures in the ATM group compared to controls. These results suggest that this type of motor learning intervention can be effective in improving a variety of physical and psychological parameters related to balance and postural control.

INTRODUCTION

Balance and postural control problems have been reported to be common among people with multiple sclerosis (MS). In 1949, Muller[1] reported that 78% of his patients with MS experienced balance abnormalities. More recently, others have reported that between 40% and 50% of ambulatory patients experience balance dysfunction as a symptom of their MS.[2-4] The high frequency and early appearance of postural control symptoms has led Tesio et al,[5] to conclude that balance disturbances are among the most disabling symptoms for people with MS who are able to walk.

Research on balance and falling has primarily been carried out with elderly people with the purpose of identifying risk factors and designing interventions that might prevent falling and improve quality of life. That work has established that fear of falling is a factor that limits the activity of elderly people. While people with MS are usually considerably younger in age, they may be affected by similar psychological factors related to falling.[6] It has been documented that people with MS have much reduced activity levels[7] and that this reduction in activity is highly correlated with perceived health status.[8] Thus, fear of falling and low balance confidence may be important factors for the health and well being of people with MS.

The control of posture and balance involves the integration of many systems: vestibular, visual, and somatosensory.[9] Balance disturbances in people with MS may result from dysfunction of any one or a combination of the above mentioned systems.[3] In addition, functional balance disturbances may result from the loss of neuromuscular control including the strength or coordination required to perform movements and control postural.[10] The high frequency and complexity of balance and postural control problems has caused people to consider addressing balance as an important component of rehabilitation programs for people with MS.

Therapeutic interventions for the improvement of balance and postural control have been approached with varying degrees of success from a number of theoretical directions. Sullivan[11] has presented a model of intervention development for a woman with MS using the theoretical orientation of Proprioceptive Neuromuscular Facilitation. The treatment plan Sullivan developed progressed the patient through the stages of mobility, stability, and controlled mobility to skill using a variety of positions and activities. No outcomes were described for this patient. Lord[12] has shown significant improvements in balance in a group of 30 people with MS, as measured by the Berg Balance Scale. The study compared a neurodevelopmental based facilitation approach and a task oriented approach in which interventions lasted a minimum of 15 treatments over a period of 5 to 7 weeks. Tesio et al[13] suggested a multifaceted approach to rehabilitate balance in patients with MS. Kasser et al [6] developed a balance intervention for a group of 4 people with MS using Balance Master technology in its therapeutic feedback mode. Their intervention was based on the ecological theory of perception that suggests that the interaction of the individual, the environment, and the task forms the basis for postural control and that constraints may arise from any one of these areas. In Kasser's study, all 4 subjects improved in the Limits of Stability test and 2 of the 4 improved on the Sensory Organization Test of the Balance Master. The common theme among all these approaches is the recognition of the need to learn and develop active control of the body's center of mass in a variety of tasks of increasing complexity and difficulty with varying emphasis on environmental factors.

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Awareness Through Movement (ATM) (see Appendix #1), which was developed by Moshe Feldenkrais, is a learning based approach in which participants are led by verbal suggestion through an exploratory movement process. In ATM, participants begin by doing a movement that they are able to do and slowly expand their control repertoire by exploring the kinesthetic dimensions of that movement as it is expanded into a larger functional activity. This can be done through a hierarchy of tasks and across a variety of human and object environments. The challenge for the clinician is to create a learning environment in which the individual capacity for learning, the challenge of the task, and the constraints of the environment are matched for a positive learning outcome.[14] This approach embodies the goals and processes needed to improve balance and postural control.[15,16]

A number of researchers have looked at the effects of ATM in people with MS and/or people with balance problems. In one study of 50 people with MS randomly assigned to ATM and control groups, it was found that the ATM group showed an improved sense of well being and improvements in a qualitative assessment of movement skill.[17] In a randomized crossover design involving 20 people with MS, Johnson et al[18] assessed the effects of 8 weeks of ATM on depression, anxiety, hand function, self efficacy, functional performance, and perceived stress. Significant reductions in perceived stress and anxiety were reported. Hall et al[19] studied the effects of 16 weeks of ATM and T'ai Chi compared to a no intervention control group in 60 randomly assigned elderly women. The ATM group showed significant improvements on the Timed Up and Go (TUG) and Berg Balance measures.

In a pilot study of the effects of ATM on 4 women with MS, we found that 3 of the 4 women reported large improvements on the Index of Well Being and had motion analysis measures in a supine to stand task which suggested improved balance.[20] One of those participants, who had reported multiple weekly falls before the intervention, reported no falls for 8 months following the intervention and terminated the use of Baclofen to control her spasticity. All 4 women reported subjective improvements in balance and postural control.

The purpose of this study was to test the subjective reports of improved balance in the previous study. We hypothesized that 10 weeks of learning using ATM would produce improvements in balance performance, balance confidence, and self-efficacy compared to a control group which was involved in social/educational classes only.

METHODS

Subjects/Design

Twelve subjects were recruited from local MS support groups, physician practices, and the Delaware Valley Chapter of the National MS Society. Criteria for inclusion in the study were: (1) diagnosis of definitive or probable MS and (2) ability to stand independently without an assistive device and to ambulate at least 100 feet with or without an assistive device. Additionally, subjects had to be medically stable and at least 18 years old. Applicants were excluded from the study if they (1) had had an exacerbation within a month of the beginning of the study, (2) had had surgery within 3 months of beginning of the study, or (3) were involved in another study. Prior to the intervention, demographic information was collected and baseline measures were taken on all dependent variables except falling (Table 1). Kurtzke Expanded Disability Status Scale (EDSS) scores ranged from 3.5 (fully ambulatory without assistive device) to 6.0 (intermittent of unilateral use of an assistive device to walk 100 meters with or without rest).[21] We chose to work exclusively with people at an ambulatory level so that all people in the study would be able to participate in the ATM lessons at a similar level. Participants were diagnosed with either the relapsing-remitting, progressive, or secondary progressive form of MS. The disease process was stable for all participants at the time of the study. After the beginning of the study all subjects kept a log of changes in medication, functional status, and falls. The Widener University Committee for the Protection of Human Subjects approved the study. All participants signed an informed consent prior to entering the study.

Table 1. Subject Demographic Information

	ATM	EDU
Age	56.2 ± 9.9	51.8 ± 10.2
Gender (M/F)	1/5	3/3
Educational Level	3.0±0.71	3.5±0.55
Months from Diagnosis	97.0 ± 59.1	85.8 ± 63.4
Employment Status	4.20±2.95	4.83±2.32
Kurtzke EDSS	4.6 ± 1.1	4.9 ± 1.2
Assistive Device	0.60±0.55	0.67±0.52
Sensory loss (rank)	6.0	7.0

Subjects were randomly assigned to either the Awareness Through Movement (ATM) group (n=6) or the control (EDU) group (n=6) in a pretest - post-test control group design study. The EDU group participated in 4, 90-minute educational classes presented by experts in the field. Topics included the use of acupuncture treatment for people with MS, new medications available for treatment of MS, benefits of exercise for people with MS, and social support issues encountered in the process of dealing with MS. People in the ATM group participated in 8 ATM classes (2 or 4 hours in length for a total of 20 hours). The ATM classes covered a variety of topics related to balance and mobility in lying down, sitting, and standing activities. The study was conducted during a 10-week period from July through September 1999. All classes were conducted in air-conditioned classrooms at Widener University. While some participants knew each other prior to the study, an attempt was made to prevent communication between groups by scheduling classes at different times.

The Awareness Through Movement Intervention

Two-hour classes were held in the morning. Four-hour classes spanned late morning and early afternoon with a 1-hour break for lunch. The movements in which participants engage during the ATM lessons are usually small and slow in nature with a strong focus on the kinesthetic experience. However, depending on the neuromusculoskeletal status of the participant, the lessons could be very difficult, so guidance was given to rest when needed. Ample opportunity to rest was given during each class. The ATM lessons were presented by the principal investigator, JS—a Guild Certified Feldenkrais practitioner, who was assisted during each class by 1 or 2 other Guild Certified Feldenkrais practitioners (see Appendix 1 for a description of the Feldenkrais training process). The role of the assistants was to work individually with participants to clarify, when needed, the verbal descriptions of movement problems and to help the participants develop and act on images of possible body organization and movement strategy as other participants proceeded with their exploration process. Assistants also presented alternative movement problems for the group during each class. All 6 participants were presented with the same verbal instructions and guidance at the same time.

Eight ATM classes were held over a period of 10 weeks (see Appendix 2 for more details of the specific lessons). The lessons presented were created uniquely for this group in order to address particular individual's needs. Prerecorded lessons were not used. All classes were audiotaped in full to preserve a record of the lessons presented. The first ATM class presented some basic principles related to sensing the base of support and awareness of effort, momentum and organization of body segments as they affect balance. These principles were presented for sidelying and sitting positions. Another focus of the first session was the maintenance of normal, easy breathing during movement. Subsequent classes worked with developing awareness through the movements of rolling supine to sidelying, rolling from supine to sitting, and moving from sitting to quadruped. Several classes involved movements of weight shifting, pelvic tilting, and turning the trunk while sitting in a chair and standing from sitting in the chair. Turning, weight shifting, and weight bearing in standing were also explored as was walking forward and backward and the movement of transfer from the floor to standing and back. A variety of transitional forms of each of these movements was explored. Feedback was given as summary, bandwidth, attentional, and transitional relating to knowledge of performance. Manual guidance was given when necessary to help participants find a more comfortable method of organizing their movements. The use of manual guidance was minimal. A primary goal of the process was to develop the skill of all participants in using intrinsic feedback. Participants were encouraged to explore options for movement which were unfamiliar to them and sometimes difficult for them and in the end to select a form of movement which was most comfortable and effective. In this way, an understanding was developed that many options were possible. At the beginning of each class, participants talked about how they had applied the idea of new ways of organizing their movement to the tasks of the previous week. People were encouraged to experiment with the material of the class on their own at home.

INSTRUMENTATION

Demographic and disease status information was collected before the intervention began. The Kurtzke EDDS[21] level was determined by self-report in an interview with participants. This has been demonstrated to be a reliable method of determining neurological status, especially within the range of involvement of the subjects in this study.[22,23] The self report method was used rather than a full Kurtzke assessment to minimize the impact of fatigue on subsequent measures which were taken in the pretest data collection. The full data collection procedure took approximately 2.5 hours which included adequate rest time. Subjects were scheduled for different assessments at approximately the same time of day at each data collection session. All data collection sessions were held in the morning to avoid the afternoon fatigue which many people with MS experience.

Six measures of balance performance, balance confidence, and self-efficacy were used to collect data pre- and postintervention.

BALANCE PERFORMANCE:

1. Prospective Falls Record. Starting at the beginning of the study all subjects were asked to keep a weekly record of falls. This record was turned in at each class. A fall was defined as any loss of balance that resulted in unintended contact with a supporting surface.
2. EQUISCALE. This assessment of functional balance performance was developed for ambulatory people with MS.[5] It is an 8-item performance based test containing items taken from the Berg or Tinnetti tests. Fewer items were selected to reduce the time and effort required to perform the test. This was done in an attempt to eliminate fatigue as a factor influencing the test result. The maximum score is 16. EQUISCALE has been shown to have concurrent validity with the Berg and Tinnetti scales for people with MS. We assessed our test-retest reliability with this instrument by doing a second trial 1 hour after the first at both pre- and

postintervention data collection. Reliability was (ICC(2,2) = 0.97). The same individual collected all trial data.

3. Computerized Balance Assessment. The Basic Balance Master System from Neurocom International, Inc.[24] was used to assess Limits of Stability (LOS) and sensory organization in the modified Clinical Test of Sensory Interaction in Balance (mCTSIB) protocol. The mCTSIB measures Center of Pressure (COP) Sway Velocity for 4 progressively more difficult sensory conditions (see Appendix 3 for definitions). Each measure is the average of 3 trials. The composite score was an average of all trials. Scores were reported as a performance, average velocity of sway over the 10-second trial, or as a normal or abnormal test compared to an age matched normal data set. An abnormal test was considered one where scores were more than 2 standard deviations from the mean.[25] In the LOS measures, 8 target boxes are equally spaced around the 100% LOS line. On a cue to go, subjects moved their COP away from the resting center so that the COP cursor moved into the target box as quickly as possible. The movement was recorded and the cursor returned to the center position. Starting with the box at 12 o'clock, the task progressed clockwise until the movements to all 8 targets were recorded. Measures of limits of stability assessed how quickly and directly participants were able to move their COP from the start position to a target. Five component variables were assessed: reaction time (RT), movement velocity (MV), end point excursion (EPE), maximum excursion (MXE), and directional control (DCL). The scores from all 8 targets were compiled into composite scores. Composite score data were used to represent overall performance for each component variable (Figure 1).

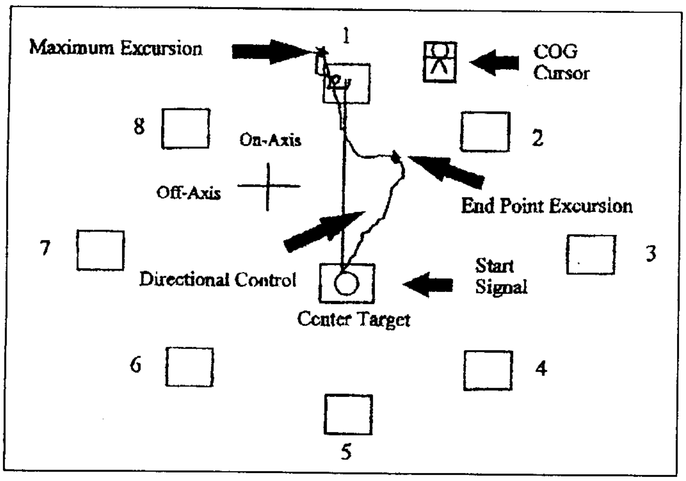

Figure 1. Shows a representation of a Limits of Stability trial on the Balance Master. Subject moves the cursor from the center to the active target on a "go" Signal. Reprinted with permission from *Neurology Report.*[6] Copyright 1999, Neurology Section, APTA.

During the testing subjects wore a gait belt and were guarded from behind by a member of the research team. The pressure platform was set up inside parallel bars that allowed subjects plenty of room to move but also allowed them to grab the parallel bars if they lost their balance. If subjects grabbed the parallel bars, the trial was terminated and repeated. At each data collection session, subjects were assessed for LOS variables 3 times. They were given an initial practice session, a test session, and a third session 1 hour later to assess test-retest reliability. The Balance Master system has been used extensively to assess balance in people with CVAs with high test-retest reliability on measures of mCTSIB (ICC .84-.88).[26] The reliability with MS has not been reported. We calculated test-retest reliability from the LOS data collected and found a range of ICC(2,3) from 0.32 and 0.74 for reaction time to 0.95 and 0.97 for maximum excursion. Seven of 10 values were above 0.80.

BALANCE CONFIDENCE:

4. Activities-Specific Balance Confidence Scale (ABC). The ABC is a 16-item, visual analog scale developed for assessing balance confidence in an elderly population.[27] Score was reported as a percent of 100. The ABC has been shown to have high test-retest reliability (r = 0.92). It also has demonstrated high discriminative ability in separating people in categories of high mobility and low mobility although not specifically fallers from nonfallers in an elderly population. It has high concurrent validity with other measures of balance performance such as the Timed-Up and Go and the Falls Efficacy Scale.[28] The authors selected this as an appropriate measure for people with MS because it is based on situation specific questions about daily activities of varying degrees of difficulty and is highly correlated with functional performance.

SELF-EFFICACY:

6. Multiple Sclerosis Self-Efficacy Scale (MSSE). This is an 18-item numerical analog assessment divided into subscales of function and control. The function subscale assesses how certain people are that they can complete a variety of activities. The control subscale asks people how much control they feel they have over certain aspects of the disease. The 2 subscale scores can be added together to give an overall score for MS self-efficacy. Scores on each subscale were reported as a raw percent score on a scale of 100. The combined subscales highest possible score was 200. The MSSE has been validated with the MS population. It has high convergent and divergent validity and has been found to have high test-retest reliability (Function r = 0.81, Control r = 0.62, Overall r = 0.75).[29]

Data Analysis

The design was a pretest, post-test control group design with independent groups. A 2-factor ANOVA with one repeated measure over time was used with parametric data produced by Balance Master measures to analyze pre- to postintervention changes. The t-test was used to analyze prospective falls data. All Balance Master and falls data met the assumptions required for parametric testing. The Mann-Whitney U or Wilcoxon Signed Rank tests were used with pre- to postchange scores with nonparametric data the ABC, EQUISCALE, and MSSE. To assess the internal consistency of our results, we tested bivariate correlations between performance, confidence, and self-efficacy variables using Pearson's r for parametric data and Spearman's rho for data including at least one nonparametric variable. Descriptive statistics were calculated for all data. An alpha level of 0.05 was used for significance. SPSS version 8.0 software was used for all data analysis.

For test-retest reliability for Balance Master LOS data and EQUISCALE, we used the 2 way mixed effect model (Method 2) for Interclass Correlation Coefficient analysis. Because of the small sample size, there was a high likelihood of making a Type II error. To assess the possible impact of Type II error, we calculated the Effect Size Index. For the T-test, this Index was derived from the difference between group means divided by its common standard deviation. A similar measure was derived for the ANOVA. Conventional values were used to interpret the Effect Index scores: 0.2 = small, 0.5 = moderate, 0.8 = large for the T-test.[30] As an estimate, because of lack of methods to calculate Effect Index for nonparametric data, the T-test method was used for our nonparametric data as well. The theoretical (n) for a power level of 0.80 was calculated for all nonsignificant means comparisons. This produced a theoretical sample size that would have to be tested to observe a significant result based on the Effect size calculated.[30]

RESULTS

A comparison of preintervention measures demonstrated pretest equivalence between the ATM and EDU group on all demographic measures and all pretest variables (Table 1). Between group preintervention equivalence was found for all of the outcome measures as well as Likert Scale assessments of educational level, employment status, use of assistive device, sensory function, and self assessed balance problems.

BALANCE PERFORMANCE

Prospective Falls

Participants in the ATM group had an average of 3.17 ± 4.49 falls during the course of the study. This represents a 34% decrease from baseline. The EDU group had an average of 4.83 ± 4.54 falls per person during the course of the study. There was no group difference postintervention.

EQUISCALE

The ATM group improved performance by 1.2% while the EDU group declined in performance by 5.0%. There was no group difference postintervention.

Computerized Balance Assessment

Results are reported for the modified Clinical Test of Sensory Interaction in Balance (mCTSIB) and the Limits of Stability.

The modified Clinical Test of Sensory Interaction in Balance (mCTSIB): Analysis of normative data shows a significant decline in the frequency of abnormal tests for the ATM group, considering all tests. For the ATM group, 19 of 30 total tests were abnormal on the pretest while only 7 of 30 were abnormal on the post-test. This change was significant (p = 0.046) using the Wilcoxon Signed Ranks Test. The EDU group had 18 of 30 tests abnormal at both pretest and post-test. There was no difference between groups at pretest and no change from pre to post-test for the EDU group (Figure 2).

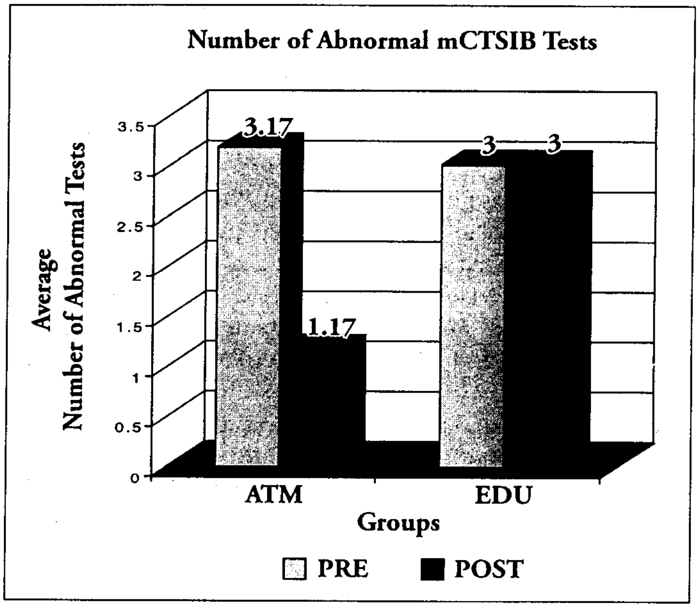

Figure 2.

The raw data were analyzed for sway velocity and for average COP position in each sensory condition. Two measures describe the Average COP position: (1) degrees (positive x-axis = zero, positive y-axis = 90) and (2) % Limit of Stability (LOS). Degrees is a measure of the angle of the COP moving counterclockwise from the positive X-axis. The X-axis is the dividing line between anterior and posterior. The Y-axis is the dividing line between left and right (eg, 150° is anterior to the L; 80° is anterior to the right). Figure 3 illustrates this concept and represents the pretest to post test change for the EDU group. The Average COP position of the EDU group during the pretest was anterior close to the midline on the right (84°) and moved far to the left (153°) in the post-test. At preintervention, the ATM group was anterior far to the left (142°) and moved toward the midline (118°) after the intervention. This change represents a significant difference, p = 0.024. Average position, % LOS, represents the percent of distance of the COP from the center equal to 0 toward the outer limit equal to 100%. The ATM

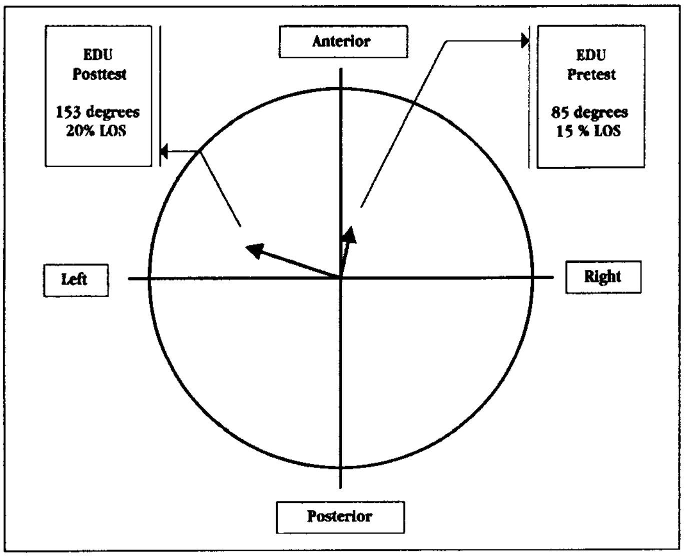

Figure 3. A representation of the average COP position in degrees and % LOS for the EDU group both pre and post intervention on the mCTSIB protocol. The outer circle indicates the 100% limit of stability. Average COP is at the tip of the arrow. The EDU group has shifted from a more centered to a less centered position.

group moved closer to the center by 8.7% and reduced its standard deviation by more than 60% while the EDU group moved away from the center by 35% and its standard deviation remained the same (see Table 2). While the % LOS change is not significant, there is a clear trend for the ATM group to more consistently reproduce a COP position closer to the virtual center.

Analysis of the sway velocity data showed that in each sensory condition, the sway velocity performance of the ATM group improved (decreased sway = increased stability; range from 4% to 24%). In each condition, the sway velocity performance of the EDU group declined (increased sway = decreased stability range from 6% to 49%). With all conditions added together to form the composite sway velocity, scores reflect the same directions of change: ATM improved 14%, EDU declined 15% for a 29% relative change. None of these changes was significant (see Table 2).

Limits of Stability Assessment (LOS): For 3 of the 5 components (RT, MXE, and DCL) ATM and EDU groups both made small changes, less than 5.1%, in the direction of improvement: Reaction time decreased, MXE increased, and DCL improved. None of these changes was statistically significant. For the other 2 components, the ATM group showed large although nonsignificant improvements in performance (MV, + 18.1%; EPE, + 8.8%) while the EDU group showed small declines in performance (MV, - 2.4%; EPE -1%).

BALANCE CONFIDENCE

Activities-Specific Balance Confidence (ABC)

The ATM group improved by 11.8% while the EDU group had a small decrease of 0.2%. This difference was significant (p=0.044) (Table 3).

SELF-EFFICACY

Multiple Sclerosis Self-Efficacy

This assessment looked at 3 dimensions of self-efficacy: control, function, and the overall combined score (total MSSE). The function score for the ATM group declined 1.2% while the EDU group declined 5.3% over the course of the study. On the control subscale, the ATM group improved by 10.5% while the EDU group declined 0.8%. On the total MSSE, the ATM group improved 4.2% while the EDU group declined 3.2%. None of these changes were significant but there was a clear trend to improvement in the ATM compared to the EDU group, especially on the control subscale (Table 4).

DISCUSSION

In the present study we have investigated the effects of 8 sessions of ATM on balance performance, balance confidence and self-efficacy. The significant decrease in abnormal performance on the mCTSIB and the associated significant change in COP average position as well as the significant improvement in the Activities Balance Confidence scores of the ATM group, confirmed our initial hypothesis that training with ATM would improve balance and balance confidence.

Table 2. Basic Balance Master: Modified Clinical Test of Sensory Interaction in Balance (mCTSIB) Scores

	Groups	Pre	Post	% Change
COP Sway Velocity Composite	ATM	1.067±.22	.917±.07	↓14%
	EDU	1.117±.29	1.283±.69	↑15%
COP Sway FI-EO	ATM	.483±.09	.40±.11	↓17%
	EDU	.467±.12	.70±.59	↑49%
COP Sway FI-EC	ATM	.967±.33	.733±.23	↓24% **
	EDU	.833±.24	1.10±.66	↑32%
COP Sway FO-EO	ATM	.917±.32	.717±.13	↓22% **
	EDU	1.15±.79	1.127±.99	↑6%
COP Sway FO-EC	ATM	1.90±.49	1.817±.33	↓4.3%
	EDU	1.983±.35	2.10±.72	↑5.9%
COP Average Position, % LOS	ATM	17.17±8.5	15.67±3.2	↓8.7%
	EDU	14.8±10.4	20.0±10.5	↑35%
COP Average Position, Degrees	ATM	142.0±66	118.4±65	↓16.5% *
	EDU	84.8±96.0	153±73	↑81%

COP Sway Velocity Composite is a composite of all four sensory conditions under which COP Sway Velocity is measured. Differences between and within groups were tested using a 2 way ANOVA with 1 repeated measure. See Appendix and Methods for definitions. * = $p < 0.05$ ** = $p < 0.01$.

Table 3. Change in Activities Balance Confidence Scores

	ATM	EDU
Pre	67.67±13.32	81.6±13 35
Post	75.67±18.38	81.4±16.26
% Change	↑ 11.8 %	↓ 0.2 %
significance level	p = 0.044	

See Discussion for a description of norms related to high and low mobility groups.

Balance Performance

Significant improvement in the ATM group relative to the EDU group was seen in the mCTSIB as a decreased number of abnormal tests overall in the ATM group and as a more centered average COP position. There was a 34% decrease in reported falls in the ATM group and a 6% increase in EQUISCALE performance relative to the EDU group. Although the last 2 measures were not significant, they are consistent with the mCTSIB finding.

To check the validity of our measures, we looked at bivariate correlations among all our outcome variables (Table 5). Strong correlations between variables would support the validity of our conclusion of improved performance. Assessing correlations is also a way of looking at individual performance in a small group. If one individual is very different in performance on a variable, the r-value will be reduced. All the variables used for correlations were pre- to post-test change scores except the Kurtzke, falls, assistive device data, and some pretest data not shown in Table 5. As a check on the validity of this use of correlation, we looked at the bivariate correlations between Kurtzke score, assistive device use, and several pretest measures of balance, balance confidence, and self-efficacy. Significant correlations with Kurtzke scores suggest that subjects with higher Kurtzke scores (more neurologically involved) were more likely to use an assistive device (r = 0.79); more likely to score low on the pretest Equiscale (r = 0.79); have a higher number of abnormal mCTSIB tests in the pretest (r = 0.72); and low MSSE function score pretest (r = - 0.59). Assistive device use is also significantly negatively correlated with pretest scores in balance performance (Equiscale: r = -0.68) and MSSE function (r = - 0.77) (some data not shown, Table 5). These strong correlations support the association of greater neurological involvement, poorer balance performance, and lower self-efficacy among all subjects at the time of the pretest. This lends validity to the use and interpretation of the correlations among pretest/post-test change data discussed below.

Among the balance performance measures, the strongest correlation was found between COP sway velocity and EQUISCALE (r = -0.85. This suggested that reduction or improved control of sway velocity was related to improved performance on the EQUISCALE tests. Decrease in sway was related to more central position. A significant correlation was also found between COP position and falls (r = 0.51). A more centralized COP position was related to a smaller number of falls. Moderate significant correlations were found between COP sway and each of the following measures: EPE (r = -0.61), MXE (r = 0.70), and COP position (r = 0.52).

Part of our reason for adopting the EQUISCALE balance test was the suggestion by Tesio[13] that it had fewer items and was less fatiguing than the Berg Balance scale. While the EQUISCALE test - retest reliability was very high, there was a ceiling effect with higher level performers. Seven of our 12 participants scored 15 or above on the 16 point scale thus limiting the responsiveness to change of this instrument for this part of sample. Had there not been a ceiling effect, this measure might have reflected more improvement related to ATM and even higher correlations with other balance performance variables. Furthermore because we used the EQUISCALE assessment we were not able to compare our balance scores with those reported by Lord[12] who used the Berg scale to assess balance changes in people with MS.

We may have observed learning effects in our Balance Master assessment of LOS. Using the Balance Master as a feedback training tool, Kasser[6] found large improvements in Limits of Stability variables indicating increased

Table 4. Change in Multiple Sclerosis Self-Efficacy Score

	ATM	EDU	ATM	EDU	ATM	EDU
	Control Subscale		Function Subscale		Total MSSE Combined Control and Function	
Pre	71.33±19.29	70.67±14.75	83.5±8.43	82.67±7.89	154.8±25.2	153.3±22.1
Post	78.83±15.0	70.00±24.26	82.5±7.5	78.5±16.31	161.3±21.0	148.5±40.5
% Change	↑ 10.5 %	↓ 0.8%	↓ 1.2 %	↓ 5.3 %	↑ 4.2 %	↓ 3.2 %

Table 5. Correlations of Change Scores and Other Variables

	Kurtz	AD	Falls	Equiscale	Abnormal	Sway	Position	EPE	MXE	DCL	ABC	MSSE f	MSSE c	MSSE
Kurtzke	1.0													
Asst Dev	**.79****	1.0												
Falls	.08	-.03	1.0											
Equiscale	-.47	-.41	-.18	1.0										
Abnormal	-.16	-.15	.30	-.18	1.0									
Sway	**.58***	.48	.20	**-.85****	.44	1.0								
Position	.08	.02	**.51***	-.34	.38	**.52***	1.0							
EPE	.02	.00	-.23	-.44	-.44	**-.62***	-.18	1.0						
MXE	.30	.37	.40	-.44	.19	**.70***	.09	-.46	1.0					
DCL	**.75****	.37	.13	-.40	.16	.38	.14	.19	.46	1.0				
ABC	**-.57***	-.41	-.25	**.74****	-.49	**-.75****	-.40	.31	-.14	-.50	1.0			
MSSE f	-.34	-.07	**-.53***	.21	-.06	-.24	**-.54***	.07	**-.63***	**-.54***	.06	1.0		
MSSE c	-.16	-.07	**-.58***	.49	**-.60***	**-.63***	-.43	**.57***	-.40	-.28	.43	.38	1.0	
MSSE t	-.14	-.05	**-.7****	.49	**-.60***	**-.58***	**-.50***	**.53***	**-.53***	-.30	.41	.43	**.63***	1.0

Table values represent Pearson's (r) correlation coefficient if both variables are scale or a Spearman's (rho) correlation coefficient if at least one variable is ordinal. All variables represent change in outcome from pretest to post test except Kurtzke, Assisitve Device and Falls. Sway = COP Sway Velocity; Position = COP Average Position in degrees; Abnormal = # of abnormal mCTSIB tests. The scale for the change variables, in most cases includes both positive and negative values. Bolded correlations are significant. * $p < 0.05$, ** $p < 0.01$.

movement velocity (11%), end point excursion (32%), and directional control (33%). We found smaller increases in movement velocity (20%) and end point excursion (10%) but also observed that, for the variables of MXE, RT, and DC, scores changed a small amount in the same direction for both ATM and EDU groups. This suggests a learning effect with the test procedure on the Balance Master. We observed no indication of a learning effect with the mCTSIB measures for which the test protocol gives no feedback.

Overall, except for some parts of the LOS assessment, all changes in balance performance measures were in the direction of improvement in the ATM group and decline in the EDU group.

Balance Confidence

There is no instrument specifically developed to assess balance confidence in people with MS. We chose to use the ABC Scale, developed for older persons with moderate to high level function because of is sensitivity to change and its ability to discriminate high from low mobility groups. The ABC also is highly correlated with performance measures,[31] and can predict high mobility as compared to low mobility in older persons (mean scores: high 80.9 vs. low 38.3; $p < 0.001$). Also in their work on the ABC, Powell et al found a level of prediction for falling which almost reached significance, ($p < 0.058$).[31]

We found a significant improvement in ABC scores for the ATM group. We also found a high correlation between the ABC and 2 balance performance measures (Table 5). An increase in the ABC was negatively correlated with sway velocity in the ATM group, and positively correlated with the EQUISCALE score. In our study, people in the EDU group had a mean pretest ABC score of 81(indicating high mobility) that did not change during the study. People in the ATM group entered the study with a mean score of 67 and increased this to 75. The ATM group as a whole would be considered to have lower mobility initially, improving almost to the level of high mobility. For people with MS, for whom falling does not have the same consequence as for older people, the measure of the influence of confidence on mobility is more important because of its relationship to health status.[8] These findings suggest that the ABC may be a useful clinical screening tool to identify people with MS for whom decreased mobility could be a health risk factor.

Self Efficacy

Based on the results of our previous work,[20] we hypothesized that the increased sense of well being that subjects reported might be based on improvements in control of their movement which also was reported. It seemed possible therefore that this might translate to the domain of self-efficacy. We used the MSSE because it has been validated with the MS population and because it assesses the domains of function and control. We found no significant change in the domain of function but did see a large nonsignificant positive change in the control domain in the ATM group. This suggested that while participants did not feel any more certain that they could complete a task, they felt more control over aspects of the disease that interfered with performing the task. We also found significant moderate correlations between changes in the MSSE control variable and changes in balance performance measures. Increases in MSSE-control scores were associated with fewer falls ($r = -0.58$), with decreases in number of abnormal mCTSIB tests ($r = -0.60$), with decreases in COP sway velocity ($r = -0.63$), and with increases in EPE ($r = 0.58$). Increases in MSSE-function scores were associated with fewer falls ($r = -0.53$); with movement of the COP position toward center ($r = -0.54$); and with decreases in MXE ($r = -0.63$), and with DCL ($r = -0.54$) (Table 5). Also the combined total MSSE change was significantly correlated with changes in COP sway velocity ($r = -0.58$), COP average position in degrees ($r = -0.50$), number of falls ($r = -0.69$), EPE ($r = 0.53$), MXE ($r = -0.53$), and change in the number of abnormal mCTSIB tests ($r = -0.60$). All these correlations support the conclusion that improvements in MSSE were related to improvements in balance and postural control resulting from the ATM intervention.

Because we were concerned about the higher likelihood of Type II error related to small sample size, we performed a power analysis (Table 6). While most variables did not show statistically significant changes, many had moderate to large Effect Index sizes and most of those changed in the direction suggesting improvement of balance resulting from participation in ATM sessions. For example, for the Balance Master COP sway velocity measures across sensory conditions we found effect sizes ranging from 0.41 to 1.27 (moderate to large) and calculated theoretical sample sizes needed to find significant changes at the $a_1 = 0.05$ level with a power of 0.80 ranging from 12 to 74, given the same effect sizes. This notion was confirmed by our finding of a significant change when using the normative data from the Balance Master to analyze COG Sway. The normative data may have greater validity for this analysis because it is corrected for age while the raw velocity scores are not. When this type of power analysis was applied to other outcome variables, we found moderate effect sizes and theoretical sample sizes of 69 to 123 for the MSSE scores, 88 for the prospective falls data and 78 to 133 for several measures of the Balance Master Limits of Stability testing. This analysis has led us to think that given the observed effect sizes, it is not unreasonable to believe that differences resulting from the intervention could reach significance for other measures in a sample of 100 subjects. Clearly more work needs to be done to establish this.

In addition to the problem of small sample size, there were several other elements of the design that should be addressed. We do not think that any of these had a serious impact on the outcome of the study. (1) There was a quantitative time difference in length of participation of groups in the study. The EDU subjects spent a total of 6 hours and the ATM subjects a total of 20 hours. The literature suggests that the most powerful element underlying empowerment is the element of social interaction.[32] Our intention for the EDU group was to provide an opportunity for people to get together socially and at the same time learn something of possible use and interest about coping with MS. The EDU group became a cohesive social group through this time as evidenced by some members of the group continuing social contact subsequently. We do not think the time factor made a significant difference in our observed out-

Table 6. Power Analysis

Variable	Effect Size	Actual p value	Theoretical (n)
ABC Scale	0.52	0.044*	**
Prospective Falls	0.38	0.537	88
Total MSSE	0.41	0.261*	71
MSSE Control	0.45	0.200*	69
MSSE Function	0.33	0.871*	123
EQUISCALE	0.26	0.276*	224
COG Sway FIEO	1.14	0.176	13
COG Sway FIEC	1.27	0.061	12
COG Sway FOEO	0.41	0.078	74
COG Sway FOEC	0.42	0.582	71
COG Sway Composite	0.83	0.175	19
COG Average Position, % LOS	0.79	0.195	21
COG Average Position, degrees	1.21	0.024	**
Reaction Time (Composite)	0.01	0.995	>1200
Movement Velocity (Comp)	0.40	0.228	78
End Point Excursion (Comp)	0.32	0.347	133
Maximum Excursion (Comp)	0.06	0.844	>1200
Directional Control (Comp)	0.34	0.562	118

There were no significant main effects in any of the means tests. * = Mann Whitney U test. All other tests were either T tests or 2 way ANOVA with 1 Repeated Measure. ** indicates test was significant for interaction of Group x Time.

comes. (2) The classes for the ATM group were 2 or 4 hours long. There was concern that such long classes might cause too much fatigue and interfere with participation in the class activities. We were very cognizant of the possibility of fatigue during the classes and provided plenty of opportunity for people to rest. There were no complaints of excessive fatigue, or a level of fatigue that elicits symptoms such as blurred vision or numbness that often happens in high level exercise testing or performance. (3) Classes were scheduled during the hot months of July, August, and September during which people with MS are more likely to experience exacerbation of symptoms related to heat. Our classes were conducted indoors in air conditioning. We observed no symptoms related to heat during the course of the study. (4) The principal investigator (JS) was involved in both presentation of the ATM intervention and assisted with Balance Master data collection.

The ATM process is designed to be one of discovery for the participant and not a process of instruction. Participants are lead to experience their bodies through multiple sensory modalities in a variety of challenges to balance, movement, or simply comfort. One of the participants became aware that she always stood with her weight on her strong leg. This did not occur to her as she tested on the Balance Master during the pretest. However during the post-test she recognized it quickly and was able to distribute her weight bearing more evenly on both feet. Another participant discovered a weight shifting strategy that reduced the pain of a burning sensation on her feet. This allowed her to stand longer, walk more easily, and have less difficulty with balance. Another participant discovered a new way to swing her leg so that it was easier to advance and made walking easier. Others found that becoming aware of and using pelvic tilting movements made transfers from sitting to standing and subsequent movement after standing easier because of improved control of the center of mass and generally decreased stiffness in the middle of the body. The most exciting part of this process was that many of these discoveries were made outside of the ATM class itself by the participants attending to their own movement strategies and exploring their own movements on their own time and within the context of their normal daily activities. This suggests that they were able to learn the process and apply it themselves in a new environment.

Possible explanations for the outcome of the ATM intervention can be drawn from the ecological theory of motor learning as discussed by Kasser and Newell.[33] The ATM intervention met all the balance training conditions suggested by the ecological theory of motor learning as presented by Kasser.[6] ATM lessons were focused on the development of kinesthetic awareness, an understanding of the movement strategies that participants spontaneously used and an exploration of strategies that might be used. The intervention was structured to progress from positions and movements which were less challenging to balance, supine and sidelying on the floor, to more challenging positions and movements in quadruped, sitting and standing. Task difficulty was progressively increased from simple movements of the extremities in sidelying to rolling to sit to supine to stand and walking with pivot turns. The environmental conditions presented mostly a firm base of support although parts of some lessons were done on foam mats. All participants attended classes together and were in a room with instructors, students, assistants, chairs, and mats that had to be negotiated so there was variability in the environment. Sensory conditions of the lessons were varied. Participants were encouraged to close their eyes during certain portions of the lessons during which they were safe to do so.

The ecological theory as presented by Newell[33] describes the concept of a perceptual-motor workspace in which a learner searches for new solutions to motor problems. The focus on body awareness in ATM presents a strong argument that ATM is a process providing guidance in the search through the perceptual-motor workspace. Through this search process there is a continuing differentiation of the properties of the perceptual-motor workspace by the learner. This differentiation provides the basis for developing and recognizing new solutions to movement problems. The process of direction of attention from habitually performed coordinative patterns to different, nonhabitual and sometimes novel coordinative patterns meets the criteria for transition information described by Newell and is evidence of a global search strategy in action. ATM seems to be an effective learning process for people who have chronic disabilities and have become limited in their repertoire of movement strategies over a course of time.

In summary, we have found significant improvements in balance and balance confidence as a result of a series of Awareness Through Movement lessons. These lessons incorporate the range of basic principles suggested for balance training into a kinesthetically based exploratory movement learning program. We have shown that a group motor learning process can be structured to produce positive changes across members of the group. This is an important finding in a time when individual reimbursement is more difficult to obtain. The changes we have observed suggest that further study of the contribution that this type of intervention could make to the rehabilitation of people with MS and other disabling diseases is warranted.

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APPENDICES

The appendices are located on the *Neuology Report* web site located at neuropt.org.

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