A Group Kickboxing Program for Balance, Mobility, and Quality of Life in Individuals With Multiple Sclerosis: A Pilot Study

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Background and Purpose: Balance and mobility impairments are common in individuals with multiple sclerosis (MS). The primary purpose of this pilot study was to evaluate the feasibility of a 5-week group kickboxing program and to measure changes in balance, mobility, and quality of life in individuals with MS associated with this training.

Methods: This single-group repeated-measures study involved a convenience sample of 15 individuals with MS who had minimal to moderate levels of disability and were recruited from the community. Eleven participants completed all phases of testing and training. The intervention was a 5-week group kickboxing program performed 3 times per week. Outcome measures were assessed 5 weeks prior to the intervention, 1 week prior to the intervention, and within 1 week of completing the intervention. Outcome measures include gait speed, Timed Up & Go test, Berg Balance Scale, Dynamic Gait Index, Mini-BESTest, Activities Specific Balance Confidence scale, and the Multiple Sclerosis Quality of Life Survey.

Results: There were significant improvements in gait speed, some clinical measures of balance, and balance confidence following the intervention but no changes were observed in health-related quality of life. There were no unanticipated adverse events and compliance was high.

Conclusion: Group kickboxing appears to be a feasible exercise activity for individuals with MS that may lead to improvement in select measures of balance and mobility. However, the clinical relevance of these findings is yet to be determined. Further investigation of this novel intervention may be warranted.

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INTRODUCTION

Abnormalities in balance are common in individuals with multiple sclerosis (MS) and are often reported as an early symptom.[1-4] In a recent investigation involving 354 adults with MS, 93.7% reported problems with balance and mobility and more than 50% had experienced an injurious fall.[5] Deficits in postural control and gait have been found in even minimally impaired individuals with MS and may lead to self-imposed activity limitations, which can further contribute to decreases in mobility and functional independence.[6-8]

Various methods have been investigated for improving balance in individuals with MS with generally positive outcomes.[9-13] However, given the chronic and progressive nature of MS, one important aspect to consider for any balance training intervention is that it should be safe and feasible to carry out on a long-term basis in a community setting. Several small studies have investigated the effects of exercise programs that are more commonly offered in group and community settings including tai chi[14] and Feldenkrais Awareness Through Movement training.[15] Both of these programs focus on the conscious awareness of movement during slow, guided activity. Following training, there were improvements in measures of postural sway, single-leg stance ability, balance confidence, and mood state. However, neither of these activities requires fast or reactive types of postural control that may be important during unexpected perturbations or losses of balance.

Fitness kickboxing is a nontraditional form of exercise that has recently gained popularity and is often provided in a community-based group format. In a recent case series involving 4 participants with MS, we observed improvements in several clinical measures of balance following an 8-week group kickboxing program.[16] Despite limited evidence specific to kickboxing, the types of movements and activities common to kickboxing have been supported in a relatively large body of balance training research. These include fast, interactive movements of the body and limbs, high-intensity exercises that incorporate full weight bearing, and activities that challenge the visual and vestibular systems.[17] Other potential benefits of kickboxing include improving aerobic and

anaerobic energy systems and addressing deficits in muscle power.[18,19]

Therefore, on the basis of the possible benefits of kickboxing and the lack of prior literature regarding its use in persons with MS, we conducted a pilot study to evaluate the feasibility of a group kickboxing program as well as changes in balance, mobility, and quality of life in individuals with MS that were associated with this program.

METHODS

Study Design

This was a single-group, repeated-measures pilot study that involved 3 outcome measure testing sessions and 2 phases (Figure 1). Initially, participants performed a baseline test (Base) followed by a 5-week "control" phase during which they resumed normal activity but received no intervention. Following the control phase, a preintervention test (Pre) was conducted, followed by a 5-week "intervention" phase of group kickboxing. A final postintervention test (Post) was administered within 1 week of completing the kickboxing program.

Participants

A convenience sample of 15 individuals with MS was recruited from the community by using contacts with support groups and clinicians. Specific characteristics and demographics for the 11 participants who completed the study are given in Table 1. Each participant met the following inclusion criteria: a confirmed diagnosis of relapsing-remitting or secondary progressive MS, ability to walk a minimum of 10 m with or without an assistive device, and a minimum score of 24 on the Mini-Mental State Examination. Exclusion criteria included the presence of any condition that would make participation in a moderate-intensity exercise program unsafe, including, but not limited to, acute thrombosis, recent myocardial infarction or significant heart disease, acute inflammation, recent surgery, acute painful orthopedic conditions, and the presence of any other neurological conditions. Subjects who were currently taking anticoagulant medications or who required regularly scheduled intravenous steroid therapy were also excluded.

Table 1. Participant Characteristics

Participants	Age, y	Sex (M/F)	MS Type	MS Onset (y)	EDSS Score	Walking Aid
P1	54	F	RR	18	1.5	None
P2	28	F	RR	5	2.0	None
P3	53	F	SP	7	3.0	None
P4	53	F	SP	7	6.5	RW
P5	54	F	RR	15	3.5	None
P6	62	F	SP	14	6.0	SPC
P7	56	F	RR	20	3.5	None
P8	59	F	SP	17	6.0	SPC
P9	48	M	SP	5	6.5	TP
P10	52	F	RR	15	1.0	None
P11	56	M	SP	10	6.0	SPC

Abbreviations: EDSS, Expanded Disability Status Scale; MS, multiple sclerosis; RR, relapsing-remitting; RW, rolling walker; SP, secondary-progressive; SPC, single-point cane; TP, trekking poles.

On the first day of testing, each participant was given a general neurological examination. The findings from the examination were used to determine an Expanded Disability Status Scale (EDSS) rating.[20] Participants' scores ranged from 1.0 to 6.5 (mean = 4.1 ± 2.1), indicating minimal to moderate levels of disability. Before training, each participant provided a medical release and signed an informed consent that had been approved by the University of Dayton's institutional review board.

Intervention

The kickboxing program was performed 3 times weekly for 5 weeks at a community-based outpatient rehabilitation center with each class lasting 1 hour. The 15 participants were divided into 3 separate groups of 5 for training. Instruction was provided by 3 individuals with an average of 15 years of martial arts and Muay Thai kickboxing experience. Two instructors were present at each training session.

On the initial visit, a maximum training heart rate (HR) value was determined for each participant on the basis of the HR reserve method (also known as the Karvonen method).[21] This value was set at 75% of HR reserve method. During training, HR was monitored periodically with a strapless watch-style electrocardiograph HR monitor (Sportline, Yonkers, New York). Participants were also oriented to the 10-point Borg category-ratio scale (CR 10)[22] and instructed not to exceed an exertion level of 5. These exercise intensity cutoff values were used so that participants would not exceed a "moderate to strong" level of exercise intensity.[23] Blood pressure was also assessed before, during, and after exercise. If systolic blood

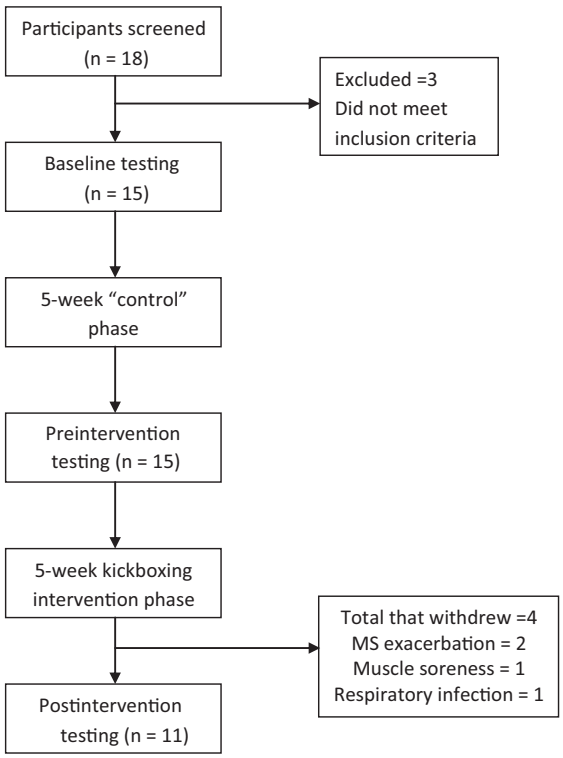

Figure 1. Flow diagram of the study. MS, multiple sclerosis.

pressure was greater than 180 mm Hg or diastolic blood pressure was greater than 110 mm Hg before or during the exercise program, the participants would not be allowed to exercise and their physician would be contacted before the next visit. During training, all subjects wore a safety harness (Miller Fall Protection, Franklin, Pennsylvania) that was suspended from an overhead rail (Figure 2). The harness was used only as a safety device in case of loss of balance and was not used to provide body-weight support.

At the beginning and end of each session, participants performed 5 to 10 minutes of warm-up and cool-down activities consisting of both seated and standing large amplitude rhythmic movement of the trunk and limbs, diaphragmatic breathing, and stretching. During the first 2 weeks of the program, participants focused on common punches, including the jab, cross, and hook (Figure 2). Initially, participants did not wear boxing gloves and threw punches at imaginary targets. As they progressed, gloves were added, and focus mitts and heavy bags were used as physical targets. During weeks 3 to 5, common kicks and kneeing movements were introduced, including the front kick, side kick, and knee thrust (Figure 2). Similar to the punching progression, participants initially kicked imaginary targets and then progressed to physical targets. Participants also held focus mitts and kick pads for each other to facilitate practice of reactive postural responses. During the course of training, the intensity of the kicks, punches, or knees was adapted to each participant's ability level by adjusting the speed, power, or amplitude of movement through verbal cues and adjusting location of the targets (see Videos, Supplemental Digital Content 1, http://links.lww.com/JNPT/A26 and Supplemental Digital Content 2, http://links.lww.com/JNPT/A27, which demonstrate common examples of the kickboxing activities). Participants progressed by increasing the intensity, time, and repetitions of each activity, while decreasing the rest between skills. They were also challenged by increasing the complexity of the combinations of punches, kicks, and knees. Typically, participants spent 2 to 3 minutes on each activity followed by similar amounts of rest.

Outcome Measures

Outcome measures were selected to represent different aspects of balance and mobility and multiple domains of the International Classification of Functioning, Disability and Health,[24] which included gait speed, Timed Up & Go (TUG), Berg Balance Scale (BBS), Dynamic Gait Index (DGI), Mini-BESTest, Activities Specific Balance Confidence (ABC) scale, and the Multiple Sclerosis Quality of Life–54 (MSQOL-54). All testing took place at approximately the same time of day and in the same order for each participant. To minimize redundancy and fatigue during testing, the clinical balance tests were administered so that any item that was duplicated between tests was performed only once and then scored using the appropriate criteria for each test.

Our primary outcome of interest was the Mini-BESTest. This test was chosen because it is only clinical balance scale that assesses reactive postural control and rapid stepping responses, which were important elements of the kickboxing program. However, because of the exploratory nature of this study and because the use of the Mini-BESTest had not been previously reported in individuals with MS, we also chose to administer a battery of more commonly used performance tests described later. The Mini-BESTest consists of 14 tasks that are designed to assess 4 subsystems of dynamic balance including anticipatory control, reactive control, sensory orientation, and

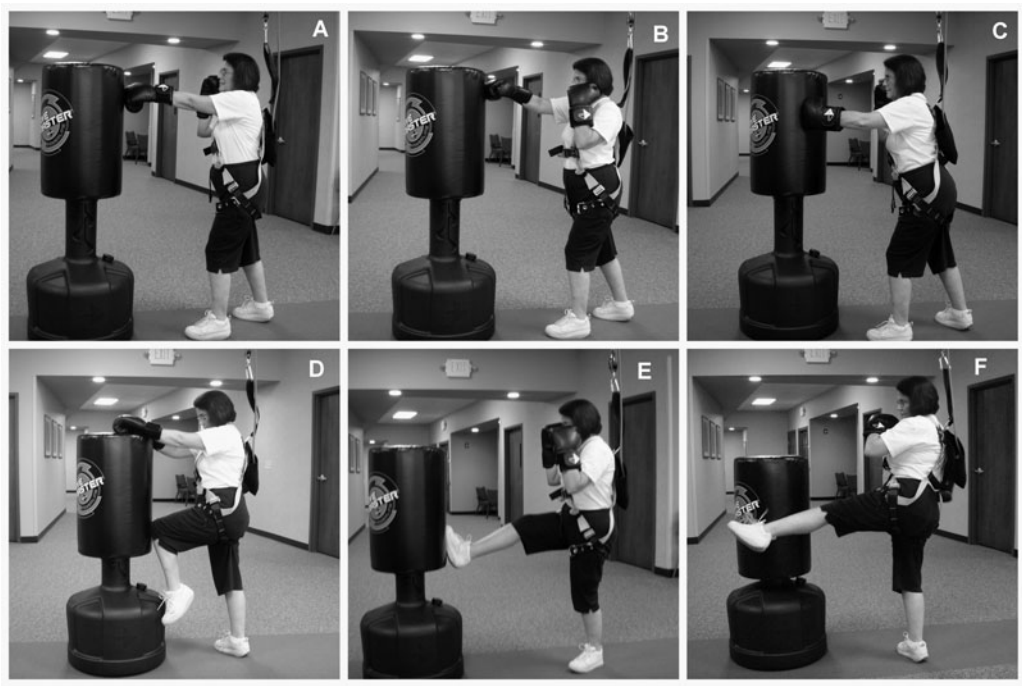

Figure 2. (A) Jab, (B) cross, (C) hook, (D) knee thrust, (E) front kick, and (F) side kick.

dynamic gait.[25] Each task is rated on a 3-point scale ranging from 0 to 2 with a perfect score of 32. The Mini-BESTest shares a number of activities with the BBS and DGI but includes several distinctive tasks such as compensatory stepping and dual tasking during gait that may be important elements of balance not addressed by the other scales. While the Mini-BESTest has not been previously used in individuals with MS, it has demonstrated high interrater and test-retest reliability as well as accuracy in identifying those who had a fall with Parkinson's disease.[26]

Walking speed was calculated for both habitual and fast-paced walking. This was determined by using a stop watch to measure the time required for each participant to cover the middle 10 m of a 14-m walking course.[27] Two trials at each pace were recorded and averaged. During the fast-paced walking, participants were given the instruction to "walk as fast as you possibly can while remaining safe." Walking speed has been shown to have good test-retest reliability (intraclass correlation coefficient [ICC] = 0.92) in persons with MS.[28] If needed, participants were allowed to use their usual assistive device and orthosis.

The TUG involves recording the time required for participants to stand from a standard armchair, walk 3 m around a cone, and sit back down in the chair using their preferred assistive device. This test has excellent reliability (ICC = 0.91) in individuals with MS.[28] The DGI measures higher-level mobility and balance during gait and includes 8 tasks: walking, walking with head turns, pivoting, walking over objects, walking around objects, and going up stairs. Performance for each task is rated on a 4-point ordinal scale (0-3). It has a maximum score of 24, with a lower score indicating worsening balance and mobility. The DGI's test-retest reliability has been evaluated in persons with MS and found to be good (ICC = 0.85).[29]

The BBS is a task performance test consisting of 14 items of increasing difficulty, which are scored using a 5-point ordinal scale (0-4). The maximum possible score is 56, with lower scores indicating more impaired balance. The BBS has demonstrated excellent test-retest reliability (ICC = 0.96) in persons with MS.[29] Perceived balance confidence was evaluated using the ABC scale. This measure assesses the patient's level of confidence, while performing 16 common tasks. The level of confidence for performing each task is assigned a percentage between 0% (no confidence) and 100% (complete confidence). The test has good test-retest reliability for individuals with MS (ICC = 0.92).[29]

Quality of life was assessed using the MSQOL-54. This instrument is a disease-specific tool adapted from the generic 36-Item Short Form Health Survey. It consists of 54 questions in several categories, including cognitive functioning, energy, social functioning, and overall quality of life. Answers to these questions are then used to calculate separate Physical and Mental Health composite scores. This test has established reliability and validity.[30]

DATA ANALYSIS

Data analyses were performed using SPSS version 18.0 (SPSS Inc, Chicago, Illinois). Because of the small sample size and the predominant use of ordinal scale measures, non-parametric statistics were used to evaluate differences between the Base, Pre, and Post test values for each outcome measure. A Friedman's analysis of variance (ANOVA)-by-Ranks Test was used with a Wilcoxon signed rank test (2-tailed) as the post hoc comparison. The a priori significance level for all statistical tests was set at $P \leq 0.05$. Because of the exploratory nature of this study, we did not correct for multiple comparisons. To determine the relative magnitude of change, we also calculated effect sizes (r) for the post hoc Wilcoxon signed rank tests, using the z-sore (Z) divided by the square root of the total number of observations (N) or $r = Z/\sqrt{N}$.

RESULTS

Of the 15 participants who began the study, 11 completed the kickboxing program and all phases of testing. One participant dropped out because of muscle soreness during training, 2 participants dropped out because of an exacerbation of MS symptoms unrelated to study participation, and one participant did not complete training because of an upper respiratory tract infection (Figure 1). Compliance for the participants who completed training ranged from 73% to 100% (mean = 90%) of total sessions attended. No unanticipated adverse events were experienced during training.

The mean Base, Pre, and Post test values for each of the outcome measures are summarized in Table 2. Based on Freidman's ANOVA, there was a statistically significant effect for testing session (Base, Pre, and Post), for habitual gait speed ($P = 0.001$), fast gait speed ($P = 0.015$), TUG ($P = 0.003$), DGI ($P = 0.03$), Mini-BESTest ($P = 0.013$), and ABC scale ($P = 0.042$). There was no overall significant effect for the BBS ($P = 0.164$).

Post hoc analysis showed no significant differences between any of the Base and Pre test values but did show significant differences between most of the Pre and Post as well as Base and Post test values with small to medium effect sizes (r). Between Pre and Post test values, there were significant improvements in habitual gait speed (10%, $P = 0.004$, $r = 0.61$), fast gait speed (9%, $P = 0.045$, $r = 0.43$), TUG (11%, $P = 0.037$, $r = 0.45$), DGI (13%, $P = 0.007$, $r = 0.57$), Mini-BESTest (21%, $P = 0.021$, $r = 0.50$), and the ABC scale (19%, $P = 0.015$, $r = 0.77$). Between the Base and Post test values, there were improvements in habitual gait speed (15%, $P = 0.003$, $r = 0.63$), fast gait speed (11%, $P = 0.014$, $r = 0.52$), TUG (20%, $P = 0.003$, $r = 0.63$), and Mini-BESTest (35%, $P = 0.006$, $r = 0.60$).

During post hoc data analysis, it became apparent that disability level might have influenced responses to the intervention for some of the outcome measures. Our participants demonstrated a wide range of disability levels as indicated by EDSS scores ranging from 1.0 to 6.5. Based on the individual scores of our participants, we divided them into 2 separate disability level groups, EDSS score ≤ 3.5 (n = 6) and EDSS score ≥ 6.0 (n = 5). While our small sample prevented us from doing detailed analysis, we did calculate mean change scores for each group for the Mini-BESTest and ABC scale because these measures demonstrated the most consistent improvements and represented both physical and self-perceived aspects of balance. For the Mini-BESTest, participants with an

Table 2. Outcome Measure Values for Baseline, Preintervention, and Postintervention[a]

Outcome Measure	Baseline	Preintervention	Postintervention	P[b]
Comfortable Gait Speed, m/s	1.00 (0.41)	1.04 (0.39)	1.15 (0.42)[c,d]	0.001
Fast Gait Speed, m/s	1.21 (0.47)	1.23 (0.43)	1.34 (0.47)[c,d]	0.015
Timed Up & Go, s	12.18 (6.99)	10.95 (5.99)	9.77 (5.04)[c,d]	0.003
Berg Balance Scale (max = 56)	48.6 (6.7)	49.1 (7.2)	50.6 (6.1)	0.164
Dynamic Gait Index (max = 24)	17.2 (4.5)	16.5 (4.9)	18.5 (4.7)[c]	0.035
Mini-BESTest (max = 32)	17.4 (6.4)	18.7 (7.5)	22.8 (4.9)[c,d]	0.013
ABC scale (max = 100%)	65.3 (29.9)	60.9 (31.1)	72.5 (25.4)[c]	0.042
MSQOL-54 (max = 100%)				
Physical Health Composite	...	54.2 (18.8)	61.3 (18.6)	...
Mental Health Composite	...	71.0 (21.7)	74.9 (21.4)	...

Abbreviations: ABC, Activities Specific Balance Confidence; MSQOL, Multiple Sclerosis Quality of Life.
[a]All values are expressed as mean (±standard deviation).
[b]*P* value for Friedman's ANOVA.
[c]Significant difference between Preintervention and Postintervention ($P \leq 0.05$) for post hoc Wilcoxon.
[d]Significant difference between Baseline and Postintervention ($P \leq 0.05$) for post hoc Wilcoxon.

EDSS score $\leq$ 3.5 demonstrated a mean Pre to Post test improvement of 2 points (range = −1 to 10) while participants with an EDSS score $\geq$ 6.0 demonstrated a mean improvement of 6 points (range = −1 to 10) For the ABC scale, participants with an EDSS score $\leq$ 3.5 demonstrated a mean Pre to Post test improvement of 8 percentage points (range = 0-11) while participants with an EDSS score $\geq$ 6.0 demonstrated a mean improvement of 17 percentage points (range = −3 to 42).

Because of an error in administering the MSQOL-54 during the baseline testing, only Pre and Post data were available for analysis (Wilcoxon). There were no significant differences between the Pre and Post values for either the Physical Health Composite ($P = 0.110$) or Mental Health Composite ($P = 0.213$) scores.

DISCUSSION

Gait and Balance Outcomes

The largest and most consistent improvements were seen for our primary outcome measure, the Mini-BESTest. The Mini-BESTest is a measure of dynamic balance and includes some of the same tasks as the DGI. However, the Mini-BESTest is the only measure that includes tests of reactive postural control. This is assessed by having participants lean outside of their base of support into the tester's hands and then releasing the participants unexpectedly so that they must take a quick step to prevent a fall. This test is repeated in 4 directions (forward, backward, left, and right). When we evaluated the individual scores of our participants, changes in the reactive stepping tasks accounted for a majority of the improvements in the Mini-BESTest. A major component of kickboxing involves repeated fast stepping and kicking, as well as responding to the punches and kicks delivered by a sparring partner. These types of activities involving fast and reactive types of postural control may have been critical elements of the kickboxing program. Since the Mini-BESTest is a relatively new balance measure, minimal detectable change (MDC) or minimal clinically important difference (MCID) values have not been established nor has its predictive validity for fall risk. Although this makes it difficult to interpret the significance of our findings, we do feel that the Mini-BESTest may be an important tool for future studies. To guide future research, we also used the data from the Mini-BESTest to derive a sample size estimate for a randomized controlled trial. Using the mean changes and variability estimates from our pilot study, the computed effect size was 0.68 with a power of 0.8, which resulted in a sample size estimate of 19 per group.

Following the training, there were increases in habitual and fast gait speed ranging from 9% to 15%. However, these improvements did not exceed the MDC values of 17% to 29% previously reported for individuals with MS.[28,31] In retrospect, we had not anticipated substantial changes in gait speed since our training program did not include speed-focused gait activities.

There were also consistent improvements in the TUG. While TUG performance is highly dependent on gait speed, it showed relatively greater improvements (11%-20%) than gait speed alone. Based on principles of specificity of training, this may have been due to the fact that the TUG also involves transitional movements and quick turning, which were important elements of the kickboxing program. The MDC for the TUG has not been reported for individuals with MS but ranges from 13% to 23% for individuals with a stroke who have mild to moderate hemiparesis.[32]

A significant improvement was seen in the DGI from Pre to Post, with a mean change of 2 points or a 12% improvement. The DGI measures dynamic balance during gait and includes activities such as walking with head turns, negotiating obstacles, changes in gait speed, and quick turns. These types of activities may have been more likely to be influenced by the activities performed during kickboxing than the BBS. While MDC or MCID values have not been established for the DGI for individuals with MS, the MDC% change for persons with stroke and Parkinson disease is 13.3% and 16.6%, respectively.[33,34]

There was no significant improvement in BBS scores following training. Two important factors likely led to this result. First, the BBS has a known ceiling effect in higher functioning individuals,[35] which was evident by the fact that 3 of our participants achieved the maximum score of 56 points at sometime during the testing with 6 scoring 50 points or higher during baseline testing. Second, the BBS does not include tests

involving gait or reactive postural control and therefore may be less likely to show improvements in the more dynamic types of balance activities associated with kickboxing training.

Balance Confidence and Quality of Life

Following training, there was a significant improvement in the ABC scale with a mean improvement of 19% (Pre to Post). The MDC or MCID for the ABC scale has not been determined for persons with MS; however, our participants' improvement does exceed the MDC of a 13% change established for individuals with Parkinson disease.[36] Anecdotally, several participants also commented that they were able to perform activities in the kickboxing program that they "never thought possible."

Health-related quality of life was measured by the MSQOL-54. While both the Physical and Mental Health Composite scores showed improvement from Pre to Post, our study was likely underpowered to show statistical significance of the relatively modest changes (Table 2). The fact that the program was only 5 weeks in length may be another reason for the limited change in MSQOL scores. Participants may not have had sufficient time to realize quality-of-life–related benefits. Despite these nonsignificant findings, several individuals described their participation in the program as "life changing" and "empowering" and nearly all wanted to continue the program after it was finished. One individual stated that "it just felt good to hit something and take out my frustrations about MS" and several others echoed this sentiment.

Influence of Disability Level on Outcomes

As mentioned in the "Results" section, we did a preliminary analysis of the change in Mini-BESTest and ABC scale scores on the basis of our participants' EDSS level. Our results indicated that participants with an EDSS score of 6.0 to 6.5 had a larger average improvement in both the Mini-BESTest and ABC scale following the intervention than those with EDSS scores of 1.0 to 3.5. An EDSS score of 6.0 to 6.5 includes people whose impairment limits function to the extent that the use of an assistive device is required for ambulation but who still use walking as their primary means of mobility. It is logical, therefore, that these individuals may have the most to gain from the intervention while also minimizing the risk of a ceiling effect for the outcome measure. On the basis of this preliminary information, it appears that disability level may be an important factor to consider for future trials.

Safety and Feasibility

Another primary objective of this study was to evaluate the safety and feasibility of providing group kickboxing program to individuals with MS in a community setting. Overall, we found the program to be practical and safe for our participants. There were no unanticipated adverse events. Several participants complained of moderate levels of muscle soreness following the first several sessions of the program and one participant dropped out of the study because of ongoing soreness. There were no reports of pseudoexacerbations such as blurred vision or transient motor or sensory disturbances.

During the program, we maintained an instructor-to-participant ratio of 2:5, but we feel that this ratio could be higher with careful selection of the appropriate participants and the use of proper safety equipment and exercise adaptations. During training, our participants used an overhead harness to prevent falls. While the safety harness allowed them to challenge themselves maximally without fear of falling, we did not feel that it was essential to safely perform the program. If a harness system was not available, participants could utilize chairs or poles for support if needed.

Joint protection is another important safety consideration when performing the ballistic movements associated with kickboxing. One participant utilized a wrist brace, and another a hinged knee brace as precautionary protective measures. Participants were also given verbal and manual cues to avoid extremes of range of motion such as knee and elbow hyperextension during punching and kicking. In addition, sessions were partitioned into short bouts of activity (2-3 minutes) followed by similarly timed rest breaks, to reduce chances of excessive fatigue and conduction block associated with MS. We also found it necessary to use large oscillating fans to reduce heat intolerance.

Limitations

When interpreting the findings of this investigation, it is important to be aware of its limitations. This was a small nonrandomized pilot investigation using highly motivated volunteers, so applicability of these finding to others with MS is not known. Testing was performed by nonblinded evaluators introducing the possibility of evaluator bias. In addition, the timeframe for the study was relatively brief and there was no long-term follow-up testing. The lack of established MCID values for our outcome measures also makes it difficult to interpret the clinical relevance of our findings.

CONCLUSION

The primary purpose of this study was to evaluate the feasibility of a 5-week group kickboxing program and any associated changes in balance, mobility, and quality of life in persons with MS. With proper screening and precautions, we found kickboxing to be safe and feasible in a community setting. Following training, participants demonstrated improvements in a variety of measures of balance and mobility but no improvements in quality of life. While the clinical significance of our findings still needs to be determined, group kickboxing appears to be a novel activity that may influence multiple domains of balance and mobility and may warrant further investigation.

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