PILOT REPORT: MULTIPLE SCLEROSIS AND BALANCE

Feasibility and effects of a group kickboxing program for individuals with multiple sclerosis: A pilot report

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Summary Background and purpose: Balance and mobility impairments are common in persons with multiple sclerosis (MS). The primary purpose of this pilot program was to evaluate the feasibility and the effects of group kickboxing on balance and mobility in individuals with MS. Methods: Four individuals with relapsing–remitting or secondary progressive MS participated in a group kickboxing program two times per week for 8 weeks. Outcome measures included the Berg Balance Scale (BBS), Dynamic Gait Index (DGI), Timed Up and Go (TUG), walking speed and the Activities Specific Balance Confidence Scale (ABC). Results: Following training, 3 of 4 participants had improvements in BBS performance. All participants demonstrated improvements in the DGI. Changes in the TUG, ABC, and walking speed were more variable. Conclusion: Group kickboxing appears to be a feasible exercise activity for individuals with MS and may lead to improvement in select measures of balance. Further investigation may be warranted. © 2010 Elsevier Ltd. All rights reserved.

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Background and purpose

Abnormalities in balance have long been recognized as a common impairment associated with multiple sclerosis (MS) and are often reported as an initial symptom (Grenman, 1985; Herrera, 1990; Shepard et al., 1990; Nelson et al., 1995). In a recent investigation involving 354 middle-aged and older adults with MS, 93.7% reported problems with balance and mobility and more than 50% had experienced an injurious fall (Peterson et al., 2008). Deficits in postural control and gait have been found in even minimally impaired individuals with MS (Benedetti et al., 1999; Karst et al., 2005; Martin et al., 2006). Balance problems may lead to self-imposed activity limitations which can further contribute to decreased mobility and functional independence.

Researchers have investigated a variety of methods for improving balance in individuals with MS. Specific interventions have included: computerized force plate training (Kasser et al., 1999), impairment focused activities (Smedal et al., 2006), task-based functional exercises (Lord et al., 1998), sensory (altered vision and support surface) and motor focused training (weight shifting, reaching) (Cattaneo et al., 2007b) and home exercise training (Jackson et al., 2007). Results from these studies have generally been positive, with improvements in a variety of clinical measures including the Berg Balance Scale (BBS), Timed Up and Go (TUG) and Dynamic Gait Index (DGI). While there is no universally accepted method for improving balance in persons with MS, it is important to consider that due to its chronic and progressive nature, any balance training intervention should be feasible to practice and maintain throughout the course of the disease. Therefore, it is important to develop balance activities that are cost-effective and can be carried out on a long-term basis in a community setting. One possible way to accomplish this is to utilize established community-based group exercise programs that may have the potential to improve balance.

Several researchers have investigated the effects of movement-based training programs on individuals with MS that are more commonly offered in the community setting. In a randomized controlled trial, Stephens et al. (2001) measured changes in balance and balance confidence following eight classes of Awareness Through Movement Training (ATM). ATM is a learning based approach in which participants are verbally led through movement exploration activities. The movements are usually small and slow with a strong focus on the kinesthetic experience. Following training, there were significant improvements in several measures of postural control using a force plate and increased balance confidence as measured by the Activities Specific Balance Confidence Scale (ABC). Tai Chi is another movement focused activity that has been studied for its possible effects on balance (Maciaszek and Osinski, 2010). Tai Chi is often practiced in groups with an emphasis on slow movements and transitions between various postures known as "forms". Similar to ATM, an important component of the activity is the conscious awareness of the movement being performed. In a pilot study involving 8 individuals with MS, Mills et al. (2000) evaluated the effects of Tai Chi on balance and depression. Following 2 months of individual instruction and daily home practice, there were significant improvements in single leg balance ability and in the depression—dejection component of the Profile of Mood States (POMS) scale.

Kickboxing is another movement-based activity that has become increasingly popular as a form of exercise and is often provided in a group format in fitness and recreation centers. Kickboxing typically involves the throwing of various punches, kicks and knees individually or in combination. During practice, participants often aim their punches and kicks at padded targets held by another participant or instructor. Heavy bags that hang from the ceiling are also commonly used to develop more powerful kicks and punches. While most would consider kickboxing to be a rather intense activity, it can be adapted to persons with balance impairments by performing the activities while sitting or using chairs and poles for upper extremity support when standing. Although the therapeutic value of kickboxing has never been reported in the literature, the types of movements and activities common to kickboxing have been supported in a relatively large body of balance training research in older adults. In a systematic review, Whipple (1997) described the common elements of successful balance training programs used for older adults. These essential elements, which he referred to as the five "V's", include: fast interactive movements of head and body (velocity), vertical movements of body against gravity leading to an increase in hip and thigh muscle strength (verticality), moderate to high intensity exercises that include full weight bearing (vigor), alters availability of visual information (vision), and challenges the vestibular system (vestibular). Upon initial observation kickboxing appears to incorporate all of the five "V's" in a single activity. For example, it involves the following; fast movement of the limbs and trunk while punching and kicking (velocity), punching, kicking and kneeling while in a standing position (verticality), powerful and repetitive punching and kicking (vigor), directing punches and kicks toward moving visual targets (vision), and rapid movement and rotation of head and upper body (vestibular). Further evidence also suggests that lower extremity power, which is function of muscle force production in a given amount of time, is related to postural control in individuals with MS (Chung et al., 2008). The movements associated with kickboxing often require rapid force development which theoretically may influence muscle power development.

More diverse evidence from postural control and motor learning research also suggests that intensity of training and systematic progression are important for increasing the potential benefit of balance activities and other therapeutic interventions (Shumway-Cook and Wollacott, 2007). While previous balance training interventions for persons with MS have generally demonstrated positive outcomes, it is possible that they may not have been challenging enough to achieve maximum benefit. Therefore, the purpose of this pilot case series was to evaluate the safety and feasibility of a relatively intensive 8-week group kickboxing program on four individuals with MS and to measure changes in balance and mobility.
Methods

Participant description and selection

Four individuals with MS were recruited from the community using contacts with local support groups as well as referrals from local physical therapists. Specific characteristics and demographics for each of the participants can be found in Table 1. Each participant met the following inclusion criteria: a confirmed diagnosis of relapsing–remitting or secondary progressive MS, ability to ambulate a minimum of 10 m with or without an assistive device, and a minimum score of 23 on the mini-mental status exam. 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 any anticoagulant medications or who required regularly scheduled intravenous steroid therapy were also excluded. Prior to training, each participant provided a signed medical release to exercise and therapy were also excluded. Prior to training, each participant provided a signed medical release to exercise and signed an informed consent that had been approved by the University of Dayton’s Institutional Review Board.

Kickboxing program

The kickboxing program was performed 2 times per week for 8 consecutive weeks at a local kickboxing studio. Instruction was provided by three individuals with an average of 15 years of martial arts and kickboxing experience including several state, national and international championship titles. At least one instructor and one assistant were present for each training session. However, on most occasions two instructors were present. On the initial visit, a maximum training heart rate (HR) value was determined for each participant based on the HR reserve (HRR) method also known as the Karvonen method (Karvonen et al., 1957). This value was set at 75% of HRR. During training each participant wore a strapless electrocardiograph (ECG) heart rate monitor (Sportline, Yonkers, NY, USA) so that heart rate could be checked periodically during the exercise program. Participants were also instructed in the use of the 10-point Borg category-ratio scale (CR 10) (Whaley et al., 1997) 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 as outlined by the American Heart Association and American College of Sports Medicine (Nelson et al., 2007). Blood pressure was also assessed before and after the first three exercise sessions to ensure a normal response to the exercise and then every 2–3 sessions after that. If systolic blood pressure was greater than 180 mm Hg or the diastolic is greater than 110 at anytime during the exercise program the participant would be asked to stop or not be allowed to begin the exercise session and their physician would be contacted. During training, two of the participants who required the use of an assistive device for walking, were supported with a simple harness system to prevent falls. The safety harness (FallTech, Compton, CA, USA) was attached to a ceiling truss by a rope and simple climbing “ascender” (Wild Country, Derbyshire, England, UK) which allows easy adjustment of the height and amount of support provided. The harness was only used as a spotting device and not for consistent support. A small amount of slack was maintained in the system to allow for normal freedom of movement.

At the beginning and end of each kickboxing session participants performed a 5–10 min warm-up and cool-down consisting of both seated and standing large amplitude rhythmic movement of the trunk and limbs combined with diaphragmatic breathing. During the first two weeks of the program participants focused on common punches including the jab, cross and hook (Fig. 1). The jab is performed with the lead fist, which is thrown straight ahead and the arm is fully extended. The cross punch is a typically thrown with the dominant hand and crosses over the midline of the body. A hook is performed by rotating the trunk, swinging the flexed arm in a horizontal arc into the kickboxing bag or focus mitts. 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 3–5 common kicks and kneeling movements were introduced including the front kick, side kick, and knee thrust (Fig. 1). A front kick is performed facing the bag or focus mitts for 8 consecutive weeks at a local kickboxing studio.

Table 1  Participant characteristics.

<table>
<thead>
<tr>
<th></th>
<th>Participant 1</th>
<th>Participant 2</th>
<th>Participant 3</th>
<th>Participant 4</th>
</tr>
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<tbody>
<tr>
<td>Age (yrs)</td>
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<td>54</td>
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<td>29.2</td>
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<tr>
<td>Type of MS</td>
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<td>RR</td>
<td>SP</td>
<td>RR</td>
</tr>
<tr>
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<td>1</td>
<td>6</td>
<td>6.5</td>
</tr>
<tr>
<td>Assistive device</td>
<td>None</td>
<td>None</td>
<td>FC</td>
<td>RW</td>
</tr>
<tr>
<td>% of Sessions attended</td>
<td>87.5</td>
<td>87.5</td>
<td>93.8</td>
<td>87.5</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; EDSS, expanded disability status score; RR, relapsing–remitting; SP, secondary progressive; FC, forearm crutch; RW, rollator walker.
punching progression, participants initially kicked imaginary targets then progressed to physical targets held by an instructor (kick pads) or heavy bags.

During weeks 6–8 participants practiced various punch, kick and knee combinations as well as footwork (forward, backward and side stepping movements).

During the course of training the intensity of the kicks, punches or knees were adapted to each participant’s ability level by adjusting the speed, power or amplitude of the movement through verbal cues and adjusting location of the target. Participants progressed by increasing the intensity, time and repetitions of each activity while decreasing the rest between skills. They were also progressed by increasing the complexity of the combinations of punches, kicks and knees which also increased cognitive demand. During each session participants were given as many breaks as needed to perform a total of 30–40 min of active training.

Outcome measures

All outcome measures were assessed at approximately the same time of day and in the same order one week prior to initiating training and within one week of completing the kickboxing program. Walking speed was calculated for both habitual and fast-paced walking. This was determined by measuring the time required for each participant to cover the middle 10 m of a 14-m walking course (Sullivan et al., 2007). 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 (ICC = 0.92, 95% CI = 0.86–0.95) in persons with MS (Nilsagard et al., 2007).

Balance and functional performance were assessed using the Berg Balance Scale (BBS) Timed Up & Go test (TUG) and the Dynamic Gait Index (DGI). The BBS is a task performance test consisting of 14 items of increasing difficulty which are scored using a five-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, 95% CI = 0.91–0.98) in persons with MS (Cattaneo et al., 2007a). The TUG involves recording the time required for the participant to stand from a standard arm chair 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, 95% CI = 0.83–0.95) in individuals with MS (Nilsagard et al., 2007). The DGI measures higher level mobility and dynamic balance and includes eight 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, 95% CI = 0.71–0.93) (Cattaneo et al., 2007a).

Self-perceived balance confidence was evaluated using the Activities Specific Balance Confidence Scale (ABC). This measure assesses the patient’s level of confidence while performing 16 common activities of daily living. 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, 95% CI = 0.80–0.97) (Cattaneo et al., 2007a).

Prior to the study, each participant was also given a general neurologic examination. The findings from the exam were used to determine a Kurtzke Expanded Disability Status Scale (EDSS) rating (Kurtzke, 1983). The EDSS is a standardized assessment used to quantify level of impairment and disability and provide a common framework to describe patient status. Scores can range from 0 to 10, with a higher score indicating greater disability. This scale was used only to describe our participants initial disability status and not as an outcome measure. Participant’s scores ranged from 1.0 (no disability with minimal signs of the disease) to 6.5 (constant bilateral assistance to walk about 20 m without rest).

Results

Participant compliance was high during training, ranging from 87.5 to 93.8% of total sessions attended (Table 1). All missed sessions were due to conflicts in scheduling or weather conditions. No adverse events were experienced related to blood pressure or heart rate values exceeding the predetermined cut-off points. We had one adverse event of a minor foot strain that was experienced in the weight bearing foot of one participant while kicking the heavy bag. However, the individual was able to finish the session with a decrease in exercise intensity and wearing a shoe for added support. Full activity was resumed, without pain on the subsequent training session.

Table 2 summarizes the pre- and post-test values for each of the balance and mobility outcome measures. Changes in both comfortable and fast gait speed were relatively small and variable. For the TUG, participants 1 and 2 demonstrated little change, while participants 3 and 4 each demonstrated an improvement of 24%. For the BBS, participants 2, 3 and 4 demonstrated improvements (5, 5, and 9 points respectively) while participant 1 had no improvement due to a ceiling effect, which is known weakness of the BBS in higher functioning individuals. (Salbach et al., 2005). Therefore, it is at least plausible that our subjects made meaningful changes in their BBS performance. One participant showed no improvements in the BBS performance due to a ceiling effect, which is known weakness of the BBS in higher functioning individuals. (Salbach et al., 2001) The largest (10–37.5%) and most consistent improvements were found for the DGI (Table 2). There are several reasons why this may have occurred. First, the DGI is a measure of higher level dynamic balance involving walking, pivot turning, head turning and stepping over and around objects. Many of these same skills were practiced and used during the kickboxing training which fits with principles of specificity of training. Additionally, the DGI does not have a significant ceiling effect and therefore would be more likely to demonstrate change in our higher functioning participants.

Discussion

To our knowledge, this is the first report on the possible therapeutic benefits of kickboxing in a clinical population. One of our primary objectives was to evaluate the feasibility and safety of providing a kickboxing to individuals with MS who have mild to moderate disability. Overall, we found the program to be practical and safe for our participants. During our training we maintained a 1:2 instructor to participant ratio to err on the side of safety, however we feel this ratio could be higher with careful selection of the appropriate participants and the use of proper safety equipment and exercise adaptations. During our training, the two participants with moderate disability (EDSS 6–6.5) utilized a simple safety rope and harness to prevent falls when practicing kicking and kneeing activities. The safety harness allowed them to challenge themselves maximally and lose their balance on several occasions without falling. If a harness system was not available participants could utilize chairs or poles for upper extremity support while practicing more aggressive kicking activities. However, using upper extremity support would change the task and may not allow them to challenge themselves maximally as when using a harness. Joint protection is another important safety consideration when performing the ballistic movements associated with kickboxing. Participants utilized wrist and hand wraps under their boxing gloves if needed and were given verbal and manual cues to avoid extremes of range of motion such as knee and elbow hyperextension during punching and kicking. Additionally, sessions were typically broken in to short bouts of activity (2–3 min) followed by similarly timed rest breaks to reduce chances of excessive fatigue and conduction block that can be associated with demyelinating diseases such as MS. During training we also found it necessary to use fans to keep several of the participants cool who experienced some level of heat intolerance.

Another major objective of this case series was to measure changes in balance following training. Balance performance was primarily assessed using the BBS and the DGI. Following training, three of our participants demonstrated improvements in their BBS scores (5, 5 and 9 points). Minimal detectable change (MDC) values or minimal clinically important differences (MCID) have not been established for persons with MS. However, for individuals with stroke and Parkinson’s disease the MDC values range from 3 to 6 points. (Stevenson, 2001; Lim et al., 2005). Therefore, it is at least plausible that our subjects made meaningful changes in their BBS performance. One participant showed no improvements in the BBS performance due to a ceiling effect, which is known weakness of the BBS in higher functioning individuals. (Salbach et al., 2001) The largest (10–37.5%) and most consistent improvements were found for the DGI (Table 2). There are several reasons why this may have occurred. First, the DGI is a measure of higher level dynamic balance involving walking, pivot turning, head turning and stepping over and around objects. Many of these same skills were practiced and used during the kickboxing training which fits with principles of specificity of training. Additionally, the DGI does not have a significant ceiling effect and therefore would be more likely to demonstrate change in our higher functioning participants.

Despite the overall improvements in measures of balance performance there was not a corresponding improvement in perceived balance confidence as measured by the ABC. One possible explanation for this finding is that due to the aggressive nature of the kickboxing program and testing procedures, the participants’ actual balance deficits
may have been exposed to a greater degree than they were previously aware of. This heightened awareness of deficits may have led to a decrease or lack of change in perceived balance despite the improvements in physical measures. These findings are similar to Cattaneo et al. (2007b) who also found no change in the ABC or Dizziness Handicap Inventory despite improvements in the BBS and DGI following a 3 week balance training intervention.

The TUG and walking speed were used to assess functional mobility. Following training, the two participants with minimal disability demonstrated little change in TUG performance, while the two moderately impaired participants each improved by 24%. This finding was somewhat expected considering the two higher functioning individuals were already demonstrating near normal performance for the test, leaving little room for measurable improvement. Measures of gait speed showed smaller and more variable changes for all participants. Since two of the participants were already walking at normal velocities (Bohannon, 1997), and walking speed was not specifically practiced, this outcome was also somewhat expected.

When interpreting the findings of this investigation, it is also important to be aware of several significant limitations. First, this was a small case series using highly motivated volunteers so applicability of these finding to others with MS is limited. Second, we used a single pre- and post-test design so changes in performance due to a learning effect cannot be ruled out. Additionally, testing was performed by non-blinded evaluators introducing the possibility of evaluator bias.

**Conclusion**

The primary purpose of this study was to evaluate the feasibility and effects of a group kickboxing training for persons with MS. With proper screening and precautions we found kickboxing to be safe and feasible. Following training 3 of the 4 participants had improvements in BBS performance and all participants demonstrated improvements in higher level balance as measured by the DGI. Changes in the TUG, ABC, and walking speed were more variable. From a clinical and practical perspective,
kickboxing is a novel exercise activity that may warrant further investigation.

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References


