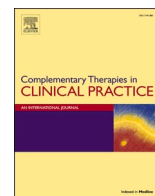


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# Complementary Therapies in Clinical Practice

journal homepage: [www.elsevier.com/locate/ctcp](http://www.elsevier.com/locate/ctcp)

## A crossover pilot trial of the feasibility, acceptability, and effectiveness of LoveYourBrain Yoga for community-dwelling adults with multiple sclerosis

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### ARTICLE INFO

#### Keywords:

Yoga  
Meditation  
Multiple sclerosis  
Fatigue  
Community-based rehabilitation  
Crossover trial

### ABSTRACT

**Background and purpose:** Among people with multiple sclerosis (MS), yoga has potential to improve fatigue and other symptoms that undermine quality of life. The aim of this study was to assess the feasibility, acceptability, and effectiveness of LoveYourBrain Yoga, a six-week yoga with psychoeducation program, on fatigue and other health-related outcomes among people with MS in a rural, community-based setting in the United States.

**Methods:** This non-randomized 2x2 crossover pilot trial compared LoveYourBrain Yoga to a control among 15 people with MS. People were eligible if they were adults with MS (EDSS score  $\leq 6$ ), English-speaking, and ambulatory. Paired t-tests and Wilcoxon signed rank sum analyses assessed mean differences in PROMIS-Fatigue<sub>MS</sub>, Multiple Sclerosis Impact Scale, Symbol Digit Modalities Test, NIH Neuro-QoL measures, and Liverpool Self-Efficacy scale. We assessed feasibility using recruitment and retention rates, mean attendance, fidelity, and acceptability using satisfaction measures.

**Results:** Significant improvements in fatigue (MD -4.34, SD 5.26,  $p = 0.012$ ), positive affect and wellbeing (MD 2.76, SD 3.99,  $p = 0.028$ ), and anxiety (MD -4.42, SD 5.36,  $p = 0.012$ ) were found after LoveYourBrain Yoga compared to the control. Participants reported high satisfaction (M 9.5, SD 1.4) and a majority (92.3%) reported 'Definitely, yes' to recommending it to a friend or family.

**Conclusion:** LoveYourBrain Yoga is feasible and acceptable when implemented in a rural, community-based setting for people with MS. It may improve a range of MS symptoms and offer a means for acquiring new skills for stress reduction, anxiety management, and overall wellbeing.

### 1. Introduction

Multiple sclerosis (MS) is a common progressive neurologic disease affecting nearly 1 million people in the United States [1]. People with MS experience diverse physical, emotional, cognitive, and psychological symptoms [2]. One of the most common and disabling symptoms is fatigue, defined as a lack of physical and mental energy [3]. In studies, 75%–87% of patients with MS complained of fatigue, and a majority indicated fatigue as one of the top three most problematic symptoms they experienced [4–6]. MS-related fatigue is associated with depression [6], poor work-place productivity [7], and can undermine community integration [8], one of the ultimate objectives of rehabilitation and

predictors of quality of life [9].

Yoga is an integrative health therapy involving physical movement, breathing exercises, meditation practices, and moral principles that is increasingly being offered to people with neurological conditions (e.g., MS, traumatic brain injury (TBI), stroke) for rehabilitation [10–12]. In people with MS, yoga was among the six most popular forms of complementary and alternative medicine used for symptom management [13]. A meta-analysis of ten randomized controlled trials comparing yoga to usual care found significant improvement in fatigue (SMD = -0.872 95% CI -1.467 to -0.277;  $p = 0.004$ ) among 693 people with MS [14]. However, the studies were found to have high or uncertain risk of bias and only one study was among a North American

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<https://doi.org/10.1016/j.ctcp.2022.101607>

Received 23 March 2022; Received in revised form 21 May 2022; Accepted 22 May 2022

Available online 30 June 2022

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sample, so further research is necessary to ascertain the potential of offering yoga for addressing fatigue and other health-related outcomes among people with MS in the United States.

LoveYourBrain Yoga is a free, six-week yoga with psychoeducation program delivered through community-based yoga studios for groups of people with TBI in the United States and Canada [12,15,16]. A retrospective study of 705 people with TBI in 38 states in the United States and 5 Canadian provinces reported significant improvement in quality of life, resilience, cognition, and positive affect from participating in the LoveYourBrain Yoga program [12]. Given the similarities in symptoms (e.g., fatigue, cognitive impairments, imbalance, weakness, anxiety, and mood disorders) between people with TBI and MS, there is potential to apply LoveYourBrain Yoga to the MS population. This program may also offer unique advantages, such as the inclusion of psychoeducation, which involves the provision of information and activities to enable patients to better understand and cope with their injury [17]. Psychoeducation has not yet been combined with yoga for the MS population, despite evidence that it can improve self-efficacy, depression, anxiety, stress, and pain among people with MS [18]. Notably, a higher sense of self-efficacy has been found to predict lower fatigue severity [19].

The primary aim of this study was to conduct a pilot study evaluating the feasibility and acceptability of applying the LoveYourBrain Yoga program to people with MS. The secondary aim was to evaluate its effectiveness in improving fatigue and other health-related outcomes for this population.

## 2. Materials and methods

The study received approval from the Dartmouth College Committee for the Protection of Human Subjects. We adhered to the CONSORT reporting guidelines for pilot and feasibility studies [20].

### 2.1. Design

This non-randomized, 2x2 crossover pilot trial compared the LoveYourBrain Yoga program to a control condition with a three week washout period among individuals with MS. Participants were evenly assigned based on scheduling availability to Group 1, which received the LoveYourBrain Yoga program in Period 1 and the control in the Period 2, or to Group 2, which received the control in Period 1 and the LoveYourBrain Yoga program in Period 2.

### 2.2. Sample size

A decrease in the mean PROMIS Fatigue<sub>MS</sub> scores of approximately 10 points from 61.9 to 51.3 represents a clinically significant shift in fatigue from severe to moderate [21]. To achieve 80% power, we needed at least 14 people (7 people per group) to detect a minimum difference in the mean fatigue score of 10, assuming a within patient standard deviation of 5.5 [21].

### 2.3. Participants

People were eligible if they had a MS diagnosis with an Expanded Disability Status Score (EDSS) score equal to or less than 6 within the last six months, were 18 years of age or older, comfortable reading, writing, and speaking English, ambulatory, willing to refrain from participating in yoga and meditation for the duration of the study, medically stable for 8 weeks prior to baseline visit, and provided informed consent.

### 2.4. Recruitment

Recruitment was conducted from April to August 2019. The study coordinator pre-screened a list of 216 patients with MS generated by the Dartmouth Hitchcock Medical Center (DHMC) Analytics Institute for those patients who met basic eligibility criteria (e.g., EDSS score on the

medical record), lived within an hour and a half driving distance from DHMC, and had been seen as a patient in the past five years. As a result, 50 patients were identified as potentially eligible for the study and received information about the study either from a letter sent on behalf of the study co-PI (AS), a Neurologist at DHMC, during medical appointments with the study co-PI (AS), or by being contacted by the study coordinator. Of this group, 16 said they were not interested (e.g., not available, travel distance, no childcare), 13 did not respond, and 6 said they were interested but did not schedule a screening visit (e.g., due to pregnancy complications, significant previous yoga experience).

### 2.5. Experimental conditions

LoveYourBrain Yoga is a free, six-week, manualized, group-based yoga with psychoeducation program that includes 10 min of a breathing exercise, 45 min of gentle yoga, 15 min of meditation, and 20 min of group discussion with psychoeducation [15]. Specifically, participants are taught three breathing exercises (i.e., ujjayi breath, three-part breath (dirga pranayama), and equal belly breathing (sama vritti)) and six meditations (i.e., body scan, progressive muscle relaxation, finding love within visualization, mountain meditation, guided color visualization, and loving-kindness (metta) over the course of the program. The gentle yoga encompasses supine, all fours, and standing poses that are repeated within and between classes to support learning and memory. See Supplementary File A for the first class outline, which includes a majority of the gentle yoga poses included in the six-week curriculum. The psychoeducation includes didactic material, question prompts, and exercises based on weekly themes that have been empirically shown to promote resilience: role model identification, mental flexibility, realistic optimism, facing fear, social support, meaning and purpose [22]. In this study, participants were also sent an email including a summary of the class theme, the quote used to portray the class theme, and an online link to the specific meditation practice. The full curriculum is available upon request. Yoga classes were held at a community-based yoga studio and wellness center in a rural area of Vermont (i.e., population <2500) [23]. The studio had yoga mats, blankets, and blocks available to participants and was kept at a comfortable temperature using fans and air conditioning to avoid exacerbating symptoms from heat. Yoga classes were led by one certified yoga instructor and an assistant who was available to provide additional support (e.g., setting up props, welcoming late-comers). One pair of lead and assistant instructors taught the program in Period 1 and a different pair of lead and assistant instructors taught the program in Period 2. Lead instructors had been trained by LoveYourBrain to offer adaptive yoga for individuals with neurological conditions and had previously taught the LoveYourBrain Yoga program for people with TBI. Yoga instructors were provided with a checklist to document completion of and/or any deviations from the protocol in each class.

The control condition asked participants to refrain from participating in yoga and meditation for the duration of the study period.

### 2.6. Study procedures

The study coordinator conducted the baseline visit at DHMC, which included obtaining written informed consent, confirming eligibility, and collecting demographic information, MS history, and outcome measures. The study Neurologist completed an EDSS assessment at the baseline visit if the EDSS score had not been performed in the past year. Participants completed study questionnaires and assessments at baseline (up to eight weeks before the start of Period 1), within two weeks after Period 1, and within two weeks after Period 2. Between Period 1 and 2, there was a three week washout period where participants were instructed to refrain from any yoga or meditation practice. Adverse events were monitored and documented by the yoga instructors during each class and by the study coordinator during each follow-up visit.

## 2.7. Measures and data collection

Data collection was conducted from July 2019 to December 2019.

## 2.8. Feasibility

To assess feasibility, we described the total number of people who were recruited to participate, mean attendance, retention rates, and fidelity of implementation using self-reported checklists of yoga teacher adherence to core curriculum components [24]. Based on the sample size calculation of 14 participants to be able to detect a clinically significant shift in fatigue, we considered the intervention to be feasible if recruitment efforts successfully met this threshold.

## 2.9. Acceptability

To assess acceptability, participants were asked to rate satisfaction by responding to the questions, "Overall, how satisfied are you with your experience in the LoveYourBrain Yoga program?" (0 'extremely dissatisfied' to '10 extremely satisfied') and "Would you recommend the LoveYourBrain Yoga program to family or a friend?" ('Definitely yes', 'Probably yes', 'Probably no', and 'Definitely no'). Based on previous research on the acceptability of LoveYourBrain Yoga [16], we considered the intervention to be acceptable if the mean satisfaction rating was >9.0. Participants also were asked to respond to the question, "Overall, how satisfied are you with the following components of the LoveYourBrain Yoga program?" by rating their level of satisfaction (1 'extremely satisfied' to 5 'not at all satisfied') with different components of the program (e.g., location, timing, duration, structure, etc.). Finally, participants responded to open text questions about their perceptions of the benefits of participating and areas for improvement.

## 2.10. Sociodemographic characteristics and MS history

We collected information from participants' medical charts on demographic characteristics (i.e., age, gender, race, ethnicity) and MS history, including disease course (i.e., relapsing/remitting, secondary progressive, primary progressive, and progressive relapsing), EDSS score, and concomitant medications.

## 2.11. Effectiveness

The primary outcome was self-reported fatigue, defined as 'an overwhelming, debilitating, and sustained sense of exhaustion that decreases one's ability to carry out daily activities', measured by the PROMIS-Fatigue<sub>MS</sub> short form [21]. This measure is validated in the MS population and has shown content validity and discriminative validity [21].

Secondary outcomes were assessed using nine measures. The Multiple Sclerosis Impact Scale (MSIS-29), a valid and reliable 29 item questionnaire, was used to measure the impact of MS on people's lives [25]. The neuropsychological test, Symbol Digit Modalities Test (SDMT), which has been validated in people with MS, was used to assess information processing speed [26]. NIH Neuro-QoL short-form measures, including Anxiety v1.0, Depression v1.0, Sleep Disturbance v1.0, Cognitive Function v2.0, Positive Affect and Wellbeing v1.0, were used to assess these domains of quality of life [27]. Pain interference was assessed using the NIH PROMIS short-form measure, Pain Interference v1.0 6b, which has shown sensitivity to change in studies of interventions expected to impact pain [28]. Finally, self-efficacy was assessed using the 11-item measure Liverpool Self-Efficacy scale, which has been validated in patients with MS and has high test-retest reliability (ICC = 0.79) [29].

## 2.12. Data analysis

Measures of feasibility and acceptability were analyzed using descriptive statistics. We also used directed content analysis to analyze qualitative data from open text responses to questions about participants' perceptions of the benefits and areas for improvement [30]. To assess effectiveness, we analyzed mean differences in outcomes after participating in the LoveYourBrain Yoga program compared to the control by conducting paired t-tests for normally distributed outcomes and Wilcoxon signed rank sum analyses for outcomes that were skewed. Significance was assessed at a level of 0.05 and a power of 0.80. We assessed carryover effects using two sample t-tests or Wilcoxon rank sum analyses.

## 3. Results

### 3.1. Feasibility

A total of 15 people with MS were eligible for and consented to participate in the study (see Fig. 1), which met the pre-determined recruitment threshold for demonstrating feasibility. Of this group, two people from Group 2 dropped out after Period 1, so did not participate in LoveYourBrain Yoga during Period 2.

All participants had Relapsing Remitting MS. Both groups had similar demographic characteristics and previous yoga and meditation experience (see Table 1).

All participants who started the LoveYourBrain Yoga program completed it, indicating high retention rates. The mean attendance was 4.7 (SD = 0.49) out of 6 classes for the LoveYourBrain Yoga program in Period 1 and 5.2 (SD = 0.98) out of 6 classes in Period 2. In terms of fidelity, each teacher successfully included the core curriculum components (i.e., specific breathing (pranayama) exercise, movement (asana) sequence, quote, meditation, and facilitated discussion prompts) in every class. There was some variation in level of challenge in the movement (asana) sequence based on the ability levels of the groups (e.g., more or less lunges, Warrior 1 and 2). Participants commonly shared in the open-text responses that the location was easy to access.

### 3.2. Acceptability

Participants reported a mean satisfaction of 9.50 out of 10 (SD = 1.4) with the LoveYourBrain Yoga program, which was similar between both groups (Group 1 mean of 10.00 (SD = 0.01) and Group 2 mean of 8.83 (SD = 1.90). The vast majority of participants (92.30%, n = 12) reported that they would 'Definitely, yes' recommend the LoveYourBrain Yoga program to a friend or family. Participants were also highly satisfied with the program components, which did not differ between groups (see Table 2). No adverse events were reported that related to the study.

In the open text responses, participants frequently shared high satisfaction with the program and that it led to a multitude of perceived benefits. As one participant shared, "I do not remember ever experiencing the level of relaxation I had at LYB Yoga ... [The instructor] led us through postures that were doable without pain (for me), and that accommodated my balance issues. I felt healthy, both physically and mentally, at the end of the class." In particular, participants often shared satisfaction with learning new skills for stress reduction, anxiety management, and overall wellbeing (e.g., ujjayi breathing, meditation, and safe movement) that some would use before going to bed or during a stressful situations at work. Also, participants commonly shared that they enjoyed the slow, mindful pacing of yoga to enhance self-awareness and focus, the specific yoga postures for improving balance, the class themes (e.g., gratitude, positive thinking, realistic optimism), and the community connection among others with shared yet diverse MS-related experiences. Specifically, nearly all participants shared that they valued the group discussion with psychoeducation for cultivating a sense of belonging, self-acceptance, and deeper understanding about the

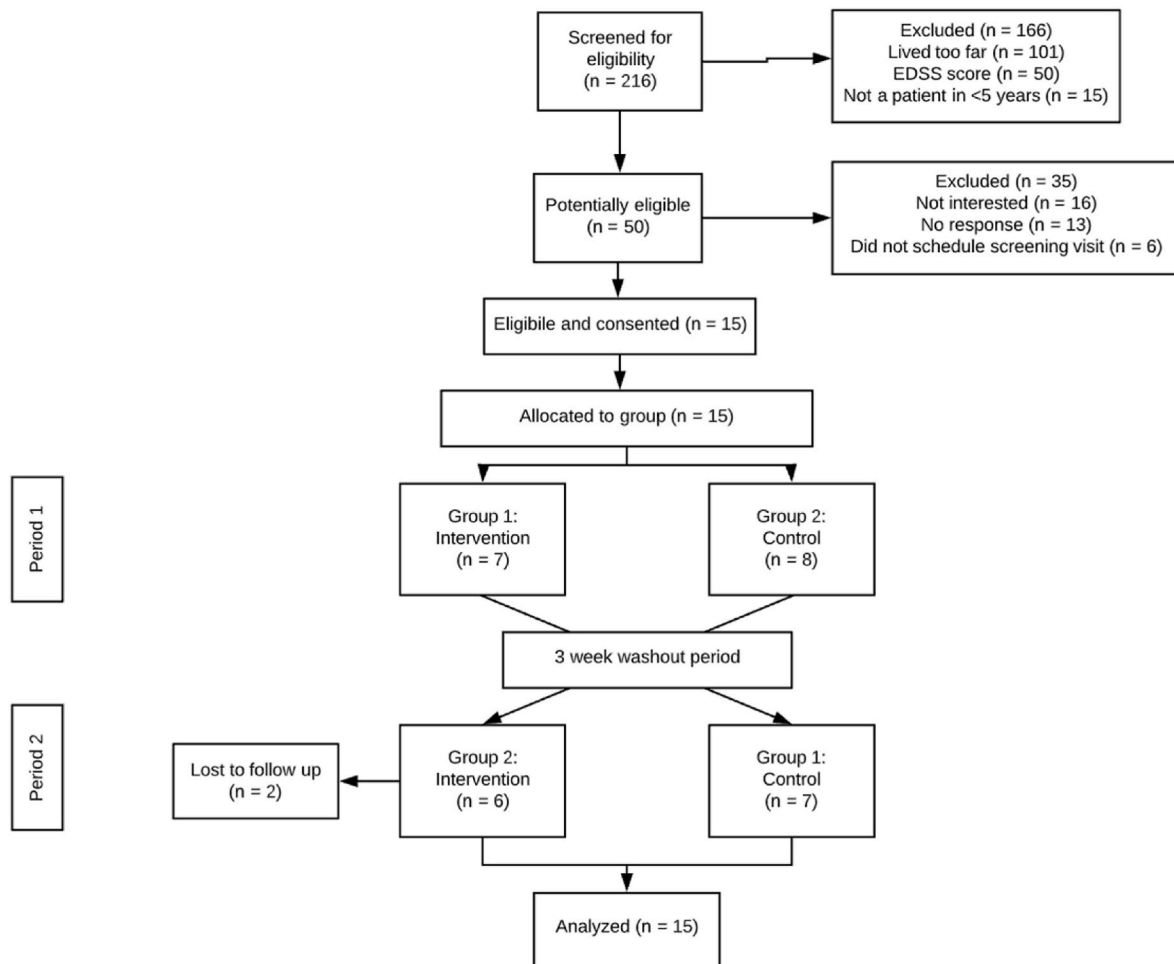


Fig. 1. Participant flow diagram.

experience of MS. For example, one participant commented that it validated where she was in her process of accepting her MS. “It was very clear that people are definitely at different levels of acceptance of their MS ... I left the last class especially feeling content with myself and where I am with my MS.” In contrast, one participant feared that talking about her MS would make her feel worse, “I enjoyed it, worked to embrace it and I dreaded it ... Almost too much attention to being a sick person. I have the sense from the group that some folks really want to talk about it, but not so much for me.”

The most common suggestions for improvement included offering it twice a week, extending the duration to 8–10 weeks, maintaining a cooler temperature in the room, and integrating more yoga postures that focus on foot drop, bladder control, and hip flexor weakness. Among the participants with previous yoga experience, a few suggested more vigorous or dynamic yoga postures and sequences even though they acknowledged that the slow, mindful pace was most appropriate to ensure all levels in the group could participate comfortably.

### 3.3. Effectiveness

When evaluating mean differences (MD) in scores after participating in the LoveYourBrain Yoga program compared to the control, significant improvements were found in Fatigue (MD -4.34, SD 5.26,  $p = 0.012$ ), Positive Affect and Wellbeing (MD 2.76, SD 3.99,  $p = 0.028$ ), and Anxiety (MD -4.42, SD 5.36,  $p = 0.012$ ) (see Table 3). No significant changes were found in other outcomes. No carryover effects were found.

Consistent with the quantitative findings, open text responses suggested participants perceived improvements in some psychological,

cognitive, and physical symptoms of MS and promoted an overall sense of wellbeing. As one participant shared, “It made me more present. Slept better. Encouraged to have met people out there like me. Less scared about future. Felt like my memory was better and so was concentration.” Notably, for some participants, the perceived benefits were maintained days after the class. For example, one participant commented, “The following days after each class seemed to be more enjoyable and I did not feel the normal sadness/depression that had seemed to be occurring since my diagnosis. I did not feel anxious as much in regards to work, social life or other things as frequently as I had been.”

## 4. Discussion

The demonstrated feasibility and acceptability of LoveYourBrain Yoga has important implications for meeting the National Society for MS’ recommendation to use yoga and other complementary therapies for disease management [31]. Research has shown a correlation between lower levels of physical activity and worsening symptoms [32], thus the high attendance and satisfaction with the LoveYourBrain Yoga program structure and delivery suggests it could be a valuable complementary, community-based therapy. Furthermore, the integration of psychoeducation was perceived, overall, to be highly valuable for promoting belonging, self-acceptance, and validation about the lived experience of MS. A controlled study of a 10-week psychoeducation program with 90 min sessions for 54 people with MS found improvements in anxiety yet not in fatigue, in contrast to our study [18]. Thus, integrating yoga with psychoeducation may provide additive benefits to certain health outcomes without undermining the feasibility and

**Table 1**  
Participant characteristics (n = 15) by total sample and group.

Characteristic	Total sample (n = 15) Freq (%)	Group 1 (n = 7) Freq (%)	Group 2 (n = 8) Freq (%)
<b>Gender</b>			
Female	13 (87.00)	7 (100.00)	6 (75.00)
Male	2 (13.00)	0 (0.00)	2 (25.00)
<b>Age</b>			
24–34 years	3 (20.00)	1 (13.00)	2 (25.00)
35–44 years	2 (13.00)	2 (29.00)	0 (0.00)
45–54 years	6 (40.00)	2 (29.00)	4 (50.00)
55+ years	4 (27.00)	2 (29.00)	2 (25.00)
<b>EDSS score median (range)</b>	2 (1.5–3)	2 (1.5–2.5)	2 (1.5–3)
<b>Race</b>			
White	15 (100.00)	7 (100.00)	8 (100.00)
Non-White	0 (0.00)	0 (0.00)	0 (0.00)
<b>Ethnicity</b>			
Non-Hispanic	15 (100.00)	7 (100.00)	8 (100.00)
Hispanic	0 (0.00)	0 (0.00)	0 (0.00)
<b>Previous Yoga Experience</b>			
None	3 (20.00)	1 (14.00)	2 (25.00)
Yes	12 (80.00)	6 (86.00)	6 (75.00)
- Less than 1 year	5 (42.00)	2 (33.00)	3 (50.00)
- 1 to 3 years	4 (33.00)	2 (33.00)	2 (33.00)
- 4 to 9 years	1 (8.00)	0 (0.00)	1 (16.00)
- More than 10 years	2 (17.00)	2 (33.00)	0 (0.00)
<b>Frequency of Yoga Practice</b>			
None	3 (20.00)	1 (14.00)	2 (25.00)
Yes	12 (80.00)	6 (86.00)	6 (75.00)
- More than once a week	0 (0.00)	0 (0.00)	0 (0.00)
- Once a week	2 (17.00)	2 (33.00)	0 (0.00)
- Once a month	2 (17.00)	1 (17.00)	1 (17.00)
- Never	8 (66.00)	3 (50.00)	5 (83.00)
<b>Previous Meditation Experience</b>			
None	6 (40.00)	3 (43.00)	3 (38.00)
Yes	9 (60.00)	4 (57.00)	5 (62.00)
- Less than 1 year	3 (33.00)	1 (25.00)	2 (40.00)
- 1 to 3 years	3 (33.00)	1 (25.00)	2 (40.00)
- 4 to 9 years	2 (23.00)	1 (25.00)	1 (20.00)
- More than 10 years	1 (11.00)	1 (25.00)	0 (0.00)
<b>Frequency of Meditation Practice</b>			
None	6 (40.00)	3 (43.00)	3 (38.00)
Yes	9 (60.00)	4 (57.00)	5 (62.00)
- More than once a week	0 (0.00)	0 (0.00)	0 (0.00)
- Once a week	2 (22.00)	1 (25.00)	1 (20.00)
- Once a month	5 (56.00)	3 (75.00)	2 (40.00)
- Never	2 (22.00)	0 (0.00)	2 (40.00)

acceptability of intervention delivery.

Another major finding of this study is that participating in the LoveYourBrain Yoga program significantly improved fatigue, positive affect and wellbeing, and anxiety without any adverse events among people with MS. Our results are consistent with other controlled studies which have found short-term effects of yoga on fatigue and mood without severe adverse events among this population [11,14,33]. Given the prohibitive costs of medications and the adverse side effects associated with certain drugs for MS, our results suggest that LoveYourBrain Yoga may be an effective symptom management approach for people with this condition [34]. Notably, MS disproportionately affects women, and yoga is most commonly practiced by women [35], so LoveYourBrain Yoga may be preferred over other similarly effective interventions (e.g., exercise [36]) for supporting MS management. However, the lack of carryover effect suggests that there may need to be sustained practice to continue to see benefits, therefore we recommend a future trial investigates the long-term effectiveness of this intervention on fatigue and mood.

The transferability of LoveYourBrain Yoga to people with MS may serve as a potential strategy for expanding access to complementary interventions for this population. LoveYourBrain Yoga currently has

**Table 2**  
Satisfaction with the LoveYourBrain Yoga program (n = 12).

LoveYourBrain Yoga program components	Freq. (%)
<b>Class time and day of the week</b>	
'Extremely' or 'very' satisfied	11 (91.67)
'Moderately' to 'not at all' satisfied	1 (8.33)
<b>Class location at the community center</b>	
'Extremely' or 'very' satisfied	10 (83.33)
'Moderately' to 'not at all' satisfied	2 (16.67)
<b>Class environment, including the temperature, lighting, and music</b>	
'Extremely' or 'very' satisfied	12 (100.00)
'Moderately' to 'not at all' satisfied	0 (0.00)
<b>Class duration of 1.5 h</b>	
'Extremely' or 'very' satisfied	11 (91.67)
'Moderately' to 'not at all' satisfied	1 (8.33)
<b>Class frequency of once per week</b>	
'Extremely' or 'very' satisfied	7 (58.33)
'Moderately' to 'not at all' satisfied	5 (41.67)
<b>Class level of difficulty</b>	
'Extremely' or 'very' satisfied	10 (83.33)
'Moderately' to 'not at all' satisfied	2 (16.67)
<b>Class structure</b>	
'Extremely' or 'very' satisfied	10 (83.33)
'Moderately' to 'not at all' satisfied	2 (16.67)
<b>Breathing practices</b>	
'Extremely' or 'very' satisfied	11 (91.67)
'Moderately' to 'not at all' satisfied	1 (8.33)
<b>Yoga movements</b>	
'Extremely' or 'very' satisfied	11 (91.67)
'Moderately' to 'not at all' satisfied	1 (8.33)
<b>Meditation practices</b>	
'Extremely' or 'very' satisfied	11 (91.67)
'Moderately' to 'not at all' satisfied	1 (8.33)
<b>Group discussion topics</b>	
'Extremely' or 'very' satisfied	12 (100.00)
'Moderately' to 'not at all' satisfied	0 (0.00)
<b>Class instructor</b>	
'Extremely' or 'very' satisfied	11 (91.67)
'Moderately' to 'not at all' satisfied	1 (8.33)
<b>Weekly email with the previous class theme and meditation recording</b>	
'Extremely' or 'very' satisfied	11 (91.67)
'Moderately' to 'not at all' satisfied	1 (8.33)
<b>Size of the group of students</b>	
'Extremely' or 'very' satisfied	12 (100.00)
'Moderately' to 'not at all' satisfied	0 (0.00)

Note. Missing data from one participant.

more than 60 community-based yoga studio partners across the United States and Canada, which presents an opportunity for widespread dissemination to people with MS. Also, given the overlapping symptoms between TBI and MS, LoveYourBrain Yoga's 20-h training could be leveraged by adding an MS-specific module to efficiently train yoga instructors in delivering the curriculum to people with MS. Such a module could address some of the areas of improvement noted by participants (e.g., cooler room temperature, and integrating more yoga postures that focus on foot drop, bladder control, and hip flexor weakness). Lastly, yoga interventions for MS have traditionally been longer in duration (e.g., 8-weeks [37,38] up to six months [36] with higher class frequency (e.g., two [37] or three classes [38] per week and home practice [36,37]), therefore, the positive results of this shorter intervention provides insights into the potential cost effectiveness of this approach if brought to scale.

This pilot study has several limitations and strengths. First, the lack of randomization limits inferences about causality and raises concerns about confounding. Although participants' demographic and MS history characteristics were comparable between groups and the crossover design treats subjects as their own control (allowing for a near perfect match of subject characteristics), nevertheless, we suggest future research uses a randomized design to more reliably assess effectiveness. Second, the study was not powered to detect differences in secondary outcomes and thus the lack of significant effect of the intervention on some outcomes may be associated with the small sample. Furthermore,

**Table 3**

Mean scores in outcomes after Period 1 and 2 by Group and mean differences in scores after participating in yoga and control conditions for the total sample.

Outcome	Group 1		Group 2		Total sample	
	Period 1 (yoga)	Period 2 (control)	Period 1 (control)	Period 2 (yoga)	Yoga vs. Control	p
	N = 7 Mean (SD)	N = 7 Mean (SD)	N = 8 Mean (SD)	N = 6 Mean (SD)	N = 13 Mean Difference (SD)	
Fatigue	52.74 (7.35)	55.30 (6.65)	57.04 (6.33)	52.02 (6.85)	-4.34 (5.26)	0.012
Positive Affect and Wellbeing	57.35 (2.71)	56.30 (3.74)	52.85 (1.83)	56.82 (3.00)	2.76 (3.99)	0.028
Anxiety	50.27 (3.16)	54.77 (4.14)	53.15 (3.28)	49.90 (5.45)	-4.42 (5.36)	0.012
Self-efficacy	39.00 (3.65)	37.29 (3.82)	33.25 (4.17)	34.50 (5.09)	1.46 (2.60)	0.066
MSIS - physical	19.64 (16.67)	16.43 (14.69)	17.75 (17.89)	12.08 (18.25)	-0.58 (6.91)	NS
MSIS - psychological	25.00 (15.04)	21.03 (17.92)	28.47 (11.18)	19.91 (11.84)	-2.99 (12.44)	NS
Pain interference	49.07 (10.43)	50.64 (7.00)	50.01 (10.36)	49.03 (10.07)	-1.15 (6.97)	NS
Cognition	32.02 (7.10)	33.30 (5.03)	29.60 (6.48)	26.48 (6.38)	-2.31 (5.30)	NS
Sleep Disturbance	47.21 (10.83)	47.79 (6.81)	53.95 (3.90)	48.87 (5.72)	-2.58 (5.68)	NS
SDMT	0.35 (1.15)	0.43 (0.91)	0.19 (1.16)	0.15 (1.02)	0.09 (0.64)	NS

Note. MSIS = Multiple Sclerosis Impact Scale; SDMT = Symbol Digit Modalities Test.

the sample was homogenous in terms of race, ethnicity, and gender, therefore the results should not be generalized to non-White, Latinx, and male groups who have varying preferences for physical activity [39, 40]. Therefore, a future trial should include a larger and more diverse sample for a robust evaluation of the effect of LoveYourBrain Yoga on a broad spectrum of symptoms experienced by people with MS. There also may have been differences in the respective yoga teacher's prosocial behavior that could have influenced participants' experience and cofounded the results, so additional methods for monitoring intervention fidelity beyond a checklist (e.g., video feedback) are recommended in future trials. The strengths of the study include using a crossover design study to increase the statistical power while allowing for a smaller sample size given the rural context. The study was also successfully implemented in a rural community-based setting, which often face recruitment and retention challenges, and thus contributes important knowledge about the potential feasibility and acceptability of yoga for harder-to-reach MS communities. Furthermore, the interventions were successfully implemented by two separate teaching teams with the use of a manualized protocol, which supports the generalizability of results while augmenting fidelity of delivery [24].

In conclusion, LoveYourBrain Yoga, a six-week yoga with psycho-education program, was perceived to be acceptable and feasible when delivered in a rural, community-based setting in the United States. It also demonstrated preliminary effectiveness in improving fatigue, positive affect and wellbeing, and anxiety among people with MS. These findings suggest that LoveYourBrain Yoga has potential to provide a viable model for complementary therapy for people with MS. A future trial with a randomized design and a larger more diverse sample is warranted.

### Funding

This research received funding from the Dartmouth-Hitchcock Neurology Department Reeves Alexander Fund, Department ID: 79215 Fund number GP026.

### Author statement

Kyla Z Donnelly: Conceptualization; Data curation; Funding acquisition; Investigation; Methodology; Project administration; Software; Writing - original draft; Writing - review & editing. Charlotte Jeffreys: Conceptualization; Data curation; Funding acquisition; Methodology; Project administration; Software; Writing - original draft, Todd MacKenzie: Formal analysis; Writing - review & editing, Lauren McDonnell: Software; Formal analysis; Writing - review & editing, Holle Black: Project administration, Martha L. Bruce: Writing - original draft, Andrew D. Smith III: Conceptualization; Funding acquisition; Investigation; Methodology; Project administration; Supervision; Writing - original draft.

### Trial registry number

The trial registry name and URL: NCT03827928 <https://clinicaltrials.gov/ct2/show/NCT03827928>.

### Declaration of interests

AS, MLB, LM, TM, and HB declare that they have no conflicts of interest. KZD is employed by the LoveYourBrain Foundation, a non-profit, for whom she led the design of the curriculum for the LoveYourBrain Yoga program. KZD is married to the Executive Director of the LoveYourBrain Foundation.

### Acknowledgements

We would like to acknowledge Shilo Zeller for her support with manuscript preparation, and Katie Cawley and Mary Allen for assisting in the yoga interventions.

### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ctcp.2022.101607>.

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