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Yoga Versus Resistance Training in Mild to Moderate Severity Parkinson's Disease: A 12-Week Pilot Study

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Abstract

Background: Yoga is a mind-body intervention which may address the motor and non-motor needs of patients with Parkinson's disease (PD).

Objective: Explore the safety and feasibility of a 12-week biweekly course of Iyengar yoga in patients with PD, and collect pilot data on efficacy compared to resistance exercise.

Method: Prospective randomized controlled single blinded study in patients with mild to moderate PD. Participants selected an urban or suburban site, and was randomized 1:1 to yoga or resistance classes.

Results: 17 participants were enrolled. Mean age 67.3 (SD 9.8) years, and mean UPDRS III score was 24.2 (SD 7.0). There were 3 withdrawals unrelated to the intervention. There were no major adverse events. 16% of yoga classes were missed compared to 8% of resistance classes (p=0.04). Significantly more classes were missed at the urban site (14.8% vs. 7.5%). Both groups improved on mean TUG time, UPDRS score, and PDQ-39 score compared to baseline, although the between-group differences were not statistically significant.

Conclusion: Attendance for yoga classes was inferior to resistance classes. Improvements in both motor and non-motor outcome measures need to be replicated with a larger study. Feasibility data will need to be taken into account in designing such a study.

Keywords: Parkinson's disease; Yoga; Exercise

Introduction

The motor and non-motor disease manifestations of Parkinson's disease (PD) are intimately connected and can lead to inactivity, loss of independence, social withdrawal, and ultimately an overall decrease in quality of life (QOL) [1-3]. Conventional interventions for PD are pharmacologic treatments aimed at improving motor symptoms. These treatments are limited as they often result in motor complications, they can become ineffective over time, and they inadequately treat some of the more troublesome non-motor symptoms of PD [4-6]. In some instances pharmacologic interventions can worsen cognitive function and fatigue which can further negatively impact QOL, especially in elderly patients [7,8]. Perhaps in light of these limitations, holistic interventions that address the motor and non-motor symptoms of disease simultaneously are gaining popularity. Surveys of outpatient PD clinics suggest that 40-50% of patients with PD in the US use some form of complementary and integrative medicine (CAIM) modality, and up to 7.5% of all adults participate in yoga [9,10]. Neurologic disorders may be particularly amenable to mind-body therapies - therapies that treat the mind and emotions as well as the physical limitations associated with a disease. Treatments like yoga involve stress-relieving practices which may be particularly relevant in neurologic conditions such as PD which are often exacerbated by stress [9]. In addition, CAIM therapies have been described as empowering to patients – making them active participants in their healthcare in ways that pharmacologic and surgical treatments cannot [9,10]. Despite the wide utilization of CAIM and yoga-based therapies there is a relative paucity of evidence in support of their use in PD and other related neurological patient samples. It has been theorized that yoga practices reduce allostatic load in the stress response system by correcting under activity of the parasympathetic and GABAergic systems through vagal nerve stimulation [11]. This in turn may impact how the brain interprets and responds to internal stress and may promote stress resilience. Yoga breathing interventions have been shown to increase heart rate variability and improve sympathetic-vagal balance [12]. Yoga has also been shown to decrease cortisol level, increase GABAergic activity, and in turn improve mood and reduce anxiety in healthy patients [13-17]. In this way, the general wellbeing associated with yoga interventions has been theorized to improve physical functioning as well.

Yoga may also be uniquely adapted to address specific physical limitations associated with PD which include posture, freezing gait, and poor balance. Zettergren et al studied the effects of an 8 week, 80 min biweekly Kripalu style yoga course on 8 healthy elderly participants and found improvements in postural control and gait speed [18]. Hip extension range of motion and stride length have also been identified as limitations that predispose aging adults to falls and which have potential to be addressed by yoga interventions [18]. DiBenedetto et al observed significant improvements in measures of hip extension and stride length in healthy elderly participants following an 8 week course of yoga which was specifically designed to target lower-body strength and flexibility [19]. There is currently only evidence from a single pilot study demonstrating the feasibility of a yoga treatment program specifically in patients with

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PD [20]. The data on the efficacy of yoga in the PD population is even more limited, and we are not aware of any studies that have compared yoga to other interventions in this population. While specific elements of effective interventions have been described, there is no published consensus guideline regarding what type of intervention is the most beneficial form of regular physical activity in PD [21]. Resistance training has been shown to be beneficial in PD, and since there is no consensus regarding what type of intervention is most beneficial in PD, it serves as an appropriate comparison [22,23]. In this current study, we aimed to explore the feasibility of a yoga intervention in patients with PD both in a busy urban setting and a suburban setting, as well as to collect pilot data on preliminary efficacy compared to traditional resistance training to support a future larger scale efficacy study.

Method

Design

This was a prospective randomized controlled single blinded study designed to assess the feasibility and safety of a gentle yoga intervention compared to traditional resistance training in patients with mild to moderate severity PD. Exploratory analysis of motor and non-motor PD outcome measures was also performed for pilot data on yoga efficacy. The study received research ethics approval from the institutional review board. Participants were recruited from the Northwestern Parkinson's disease and Movement Disorders Center and via local advertising after approval by the local institutional review board. Group yoga and resistance exercise classes took place at a Northwestern hospital-based facility located in downtown Chicago, with participation from staff at North western's Osher Center for Integrative Medicine. A second site for yoga and resistance classes was offered at an affiliated facility, Lake Forest Health and Fitness Center, located in the northern suburbs. All classes were performed under the direct supervision of licensed and trained yoga instructors (for yoga classes) and certified exercise instructors (for resistance classes).

Iyengar style yoga sessions were specifically designed and directed by a master yoga instructor with experience working with patients with PD. Iyengar yoga emphasizes precision in alignment of posture and breathe control, and can be adjusted to accommodate different levels of functional ability [19,24]. The sessions were designed to include: 1) deep breathing exercises and relaxation techniques; 2) poses targeting stretching and strengthening often using props such as pillows and belts; 3) meditation. The resistance intervention group was also directed by an instructor with extensive experience working with patients with PD, and this class followed a procedure previously designed for strengthening in older adults. This intervention was designed to provide a form of exercise and social interaction of similar frequency and duration to the yoga program, but without the mind-body benefit specifically focused on relaxation and meditation techniques, and without the tailored balance and flexibility benefits of the yoga regimen (see appendix for detailed structure of the intervention and specific poses).

Eligibility

Participants included in the study were adults with idiopathic PD as determined by UK brain bank diagnostic criteria with mild to moderate disease severity as determined by Hoehn and Yahr (HandY) stage 1-3 [25]. Participants had to demonstrate ability to walk for 2 minutes in the "ON" and "OFF" state and ability to rise from the floor independently. All participants had to be on a stable regimen of PD medications for 30 days prior to screening and throughout the course of the study. Participants were excluded if they had cognitive impairment (Montreal Cognitive Assessment score (MOCA) <24), severe depression (Beck Depression Inventory (BDI) score >17), inability to sign an informed consent, or if they participated in yoga or other physical therapy and exercise classes for the management of PD within 90 days of the study. Eligible participants selected a site (downtown or suburbs) and were then randomly assigned to one of two groups in a 1:1 ratio. Within each site one group engaged in Iyengar yoga and the other group received resistance strength training. The classes were designed to be of similar frequency, duration, and instructor engagement. A randomization block design ensured that groups were matched for age and disease severity. Blocks of 2 and 4 were listed and then randomly selected by the statistician and arranged in sequence of their selection. All sessions were 60-minute long group classes which met twice weekly for 12 weeks.

Aims/outcome measures

The primary aim of this study was to explore whether a 12-week, biweekly tailored course of Iyengar yoga was safe and feasible in a population of participants with mild-moderate severity PD. This was measured by taking attendance at classes and with scheduled phone calls at weeks 3, 6, and 9, to discuss attendance, reasons for missed classes, and discuss adverse events. Feasibility was pre-determined as 70% of participants attending at least 75% of the classes. Exploratory pilot efficacy data was obtained by comparing various pre-intervention and post-intervention outcomes. Neurological assessments including measures of motor function were performed by a neurologist at the Northwestern Movement Disorders Center who was blinded to the participant's intervention arm. These assessments occurred 1 week pre-intervention and 1 week post-intervention 3 months later. The motor outcome measures assessed by the blinded neurologist were the change in "Timed Up and Go" (TUG), the change in Unified Parkinson's Disease Rating Scale (UPDRS) parts I-IV, and the change in Berg Balance Score (BBS) [26-28]. Questionnaires were provided by a study coordinator and self-completed by participants. Freezing of gait (FOG) was assessed with the Giladi FOG questionnaire, and change in fall frequency was measured by self-report on items 12-16 on this questionnaire [29]. Fear of falling was measured with the International Falls Efficacy Scale [30]. In addition to motor assessments, participants completed several questionnaires to assess non-motor symptoms and daily function before and after the intervention. The measures assessed were the Parkinson's Disease Quality of Life Scale (PDQ-39), as well as several self-report measures from the NIH Neuro-QOL , which were developed and validated to assess health related quality of life across major neurological disorders, including Parkinson's disease [31-33]. This included short forms for fatigue, anxiety, depression, executive function, emotional and behavioral dyscontrol, stigma, positive affect and wellbeing, and sleep. All data were collected using a secure Assessment Center website and then exported to an excel spread sheet which only the study investigators, statistician, and research coordinators had access to. Exit surveys were administered to all participants at the end of the final study visit (or at the time of early withdrawal). Survey questions were on a Likert scale and asked about barriers to attendance and commitment to classes, as well as benefits and enjoyment from the classes. Three months later, participants received a phone call inquiring about on-going physical activity to assess retention.

Statistical analysis

The program Stata was used for analysis [v12.0, College Station, TX, 77845, USA, www.stata.com]. Statistical analysis was performed by the lead investigator and study statistician. We computed descriptive information on all variables of interest. This was a pilot feasibility study,

but for purposes of future efficacy studies the sample size was based on the ability to detect a 3 second difference in the after-Before "TUG" time in the "successful" group. Based on other studies that used TUG as the outcome measure, having observed SD=3 seconds, with alpha 0.05 and a one-sided alternative for sample size calculation, using PASS11 software [v11.08, Hintze, J, 2011, NCSS, LLC, Kaysville, Utah], we obtained that n=12 participants in each group would provide power over 76% to detect an effect in each treatment if it exists [13]. We calculated means and standard deviations for all outcomes and rates of events where applicable. We used Cohen's d effect size statistic to demonstrate the standardized magnitude of difference between groups, calculated by subtracting one group mean from the other and dividing by the pooled sample standard deviation. Comparisons were made using one sample or two sample non-parametric Wilcoxon rank sum test, as appropriate using SAS v 9.4 [SAS Institute Inc., Cary, NC, USA]. Change in total walking time was compared between two groups as a continuous variable using Wilcoxon test. Feasibility of the intervention is a continuous variable based on number of classes attended or missed, and was calculated using an independent t-test. All assessments were made in the medications "ON" state, and no medication changes were allowed during the course of the study.

Results

23 participants were screened and 17 met eligibility criteria. Reasons for exclusion are indicated in (Figure 1). Of the 17 eligible participants, 11 chose to participate in the downtown Chicago location and 6 chose the suburban location. Participants were then randomized within their site to yoga or resistance, with a total of 9 yoga and 8 resistance participants between the two sites. There were 3 study withdrawals (2 in the yoga group, 1 in the resistance group) unrelated to the study intervention, therefore the final dataset included 7 participants in each group, although the withdrawn participants' safety and survey response data were included (Figure 1). The groups were well matched without significant differences in any of the clinical variables of interest when comparing yoga to resistance groups as well as when comparing across sites (Table 1). None of the participants engaged in other physical therapy or exercise programs during the course of the study. The majority of the participants were white males. The mean age of the cohort was 67.3 (SD 9.8) years, and mean UPDRS part III score was 24.2 (SD 7.0).

a. Safety and feasibility

There were no serious adverse events that were considered related to the study intervention. One participant in the yoga group had to withdraw because of sepsis from a urinary tract infection. Another participant in the yoga arm made a suicide attempt requiring a visit to the emergency room, but ultimately continued and completed the study. Milder adverse events reported during scheduled phone calls

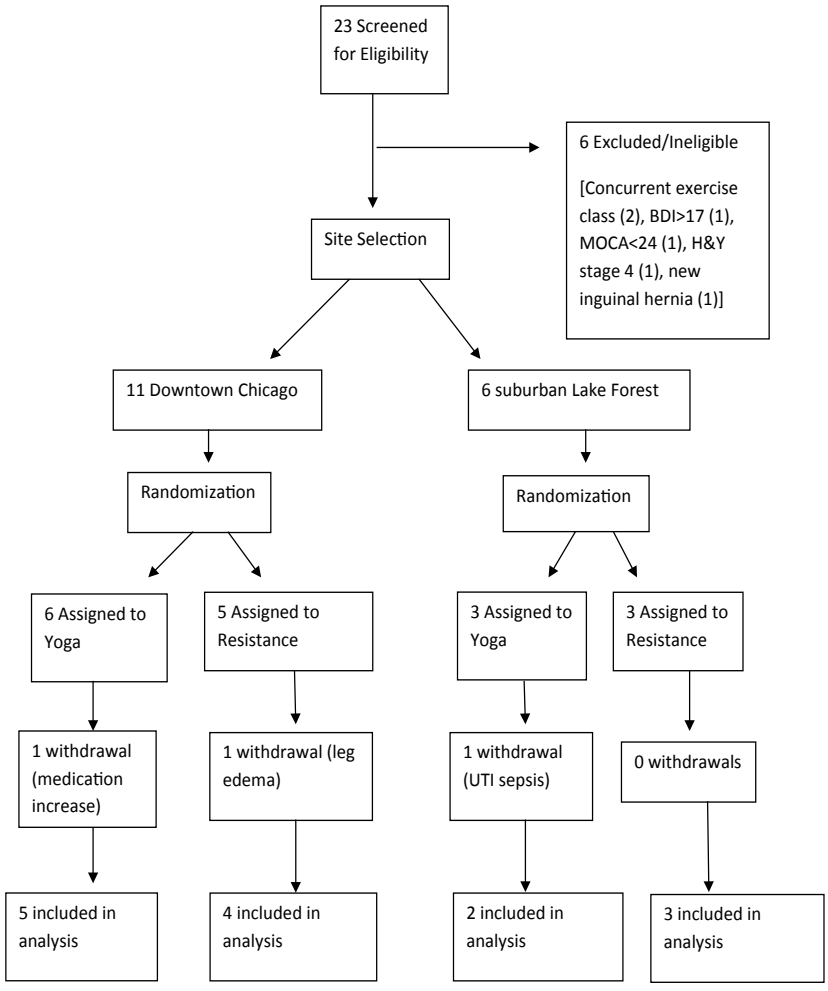

Figure 1: Flow diagram.

Variable	Yoga (n=7)	Resistance (n=7)	p-value	Chicago (n=9)	LF (n=5)	p-value
Age (yrs)	67.9 (SD 10.9)	66.7 (SD 9.3)	0.83	65.4 (SD 10.0)	70.6 (SD 9.6)	0.37
Gender (M/F)	5/2	6/1	n/a	6/3	5/0	n/a
Race (White/Non-white)	6/1	5/2	n/a	7/2	4/1	n/a
Baseline H&Y	2.3 (SD 0.4)	2.4 (SD 0.5)	0.61	2.3 (SD 0.5)	2.4 (SD 0.5)	0.83
Baseline LED	328 (SD 255)	486 (SD 478)	0.46	369.4 (SD 196.4)	476 (SD 614.0)	0.72
Baseline MOCA	26.8 (SD 1.77)	26.8 (SD 1.77)	1	26.5 (SD 1.6)	27.4 (SD 1.9)	0.43
Baseline BDI	4.57 (SD 4.54)	7.57 (SD 3.35)	0.18	6.2 (SD 4.6)	5.8 (SD 3.4)	0.85
Baseline TUG (sec)	9.86 (SD 2.11)	10.04 (SD 1.17)	0.85	9.7 (SD 1.7)	10.4 (SD 1.5)	0.47
Baseline BBS	52.28 (SD 2.92)	52.71 (SD 2.69)	0.78	53.2 (SD 2.28)	51.2 (SD 3.2)	0.25
Baseline UPDRS III	25.85 (SD 6.91)	22.57 (SD 7.23)	0.4	24.1 (SD 6.5)	24.4 (SD 8.7)	0.95
Baseline UPDRS Total	36.43 (SD 9.94)	35.49 (SD 8.69)	0.84	35.3 (SD 8.9)	37.0 (SD 10.0)	0.77
Baseline PDQ-39	20.00 (SD 22.55)	21.14 (SD 9.47)	0.9	23.1 (SD 18.1)	16 (SD 14.1)	0.43
Baseline FES-1	23.14 (SD 6.06)	21.85 (SD 4.33)	0.65	22.0 (SD 5.8)	23.4 (SD 4.0)	0.61
Baseline FOG	2.71 (SD 2.62)	3.14 (SD 3.43)	0.79	3.0 (SD 2.8)	2.8 (SD 3.5)	0.91
Baseline FF	1.28 (SD 1.38)	0.86 (SD 0.89)	0.51	1.2 (SD 1.3)	0.8 (SD 0.8)	0.47

Table 1: Baseline demographics.
There are no significant differences in baseline clinical characteristics between yoga and resistance groups or between Chicago and Lake Forest groups. The majority of the participants were white males.
H&Y=Hoehn & Yahr; LED=Levodopa Equivalent Dose, calculated based on the formula reported by Tomlinson et al [36]; MOCA=Montreal Cognitive Assessment; BDI=Beck Depression Inventory; TUG=Timed-Up-And-Go; BBS=Berg Balance Scale; UPDRS=Unified Parkinson Disease Rating Scale; PDQ-39=Parkinson Disease Questionnaire; FES-1=Falls Efficacy Scale; FOG=Giladi Freezing of Gait Scale; FF=Fall Frequency Scale

Variable	Yoga (n=7)	Resistance (n=7)	Direction Indicating Improvement	p-value
Δ TUG (sec)	-0.94 (SD 2.24)	-0.34 (SD 0.88)	↓	0.95
Δ BBS	1.3 (SD 2.2)	0.6 (SD 2.4)	↑	0.8
Δ UPDRS I	-0.43 (SD 1.27)	0.57 (SD 1.81)	↓	0.63
Δ UPDRS II	-2.71 (SD 3.59)	-0.28 (SD 1.89)	↓	0.69
Δ UPDRS III	-3.9 (SD 6.33)	-1.3 (SD 4.42)	↓	0.56
Δ UPDRS IV	-0.57 (SD 1.40)	0 (SD 1.53)	↓	0.34
Δ UPDRS total	-7.6 (SD 9.6)	-1 (SD 5.60)	↓	0.18
Δ FES-1	-0.71 (SD 2.69)	0.28 (SD 3.86)	↓	0.47
Δ FOG	-1.00 (SD 2.00)	0.28 (SD 1.11)	↓	0.21
Δ FF	-0.14 (SD 0.37)	0.14 (SD 1.34)	↓	0.94
Δ PDQ39	-0.6 (SD 4.93)	-1.4 (SD 10.19)	↓	0.41
Δ NQ (Upper Ext) t-score	-0.68 (SD 8.48)	0.26 (SD 4.06)	↑	0.61
Δ NQ (Lower Ext) t-score	-2.1 (SD 3.9)	-1.0 (SD 5.7)	↑	0.7
Δ NQ (Fatigue) t-score	-1.4 (SD 5.1)	0.54 (SD 4.1)	↓	0.56
Δ NQ (Anxiety) t-score	-1.4 (SD 3.3)	4.3 (SD 4.0)	↓	**0.0297**
Δ NQ (Depression) t-score	-3.27 (SD 5.14)	1.14 (SD 5.47)	↓	0.14
Δ NQ (Exec Fxn) t-score	2.38 (SD 4.51)	-1.26 (SD 3.02)	↑	**0.073**
Δ NQ (Emotional Behav Dysreg) t-score	-2.67 (SD 3.84)	2.98 (SD 4.60)	↓	**0.015**
Δ NQ (Stigma) t-score	-2.3 (SD 3.7)	1.67 (SD 4.16)	↓	0.17
Δ NQ (Pos Affect Wellbeing) t-score	-1.41 (SD 4.26)	-0.3 (SD 4.63)	↑	0.56
Δ NQ (Sleep) t-score	-0.75 (SD 3.8)	1.18 (SD 2.63)	↓	0.4
Δ Dementia Card Sort national percentile	4.70 (SD 10.53)	-15.9 (SD 20.88)	↑	**0.035**
Δ Flanker national percentile	2.78 (SD 8.45)	-5.00 (SD 8.43)	↑	0.2

Table 2: Change in outcome variables over 12 weeks (Pre to post intervention) comparing yoga to resistance groups.
Both groups improved on all motor measures and multiple non-motors when post-intervention scores were compared to pre-intervention scores. The magnitude of improvement for each of the motor measures favored the yoga group, although the differences were not statistically significant for any of these variables. Total UPDRS score change favored the yoga group but was not statistically significant (p=0.18). There was a significant difference in the neuro-QoL anxiety score (p=0.0297) and emotional dyscontrol score (p=0.015) both of which favored the yoga group.

include muscle cramps and back ache in the yoga group, and fatigue and dizziness in the resistance group. Each of these occurred once and may or may not have been related to the study intervention. The pre-determined feasibility outcome was met with at least 70% of participants attending at least 75% of the classes. Only 4 out of 17 participants failed to meet this feasibility standard. However, attendance was poorer than expected with a total of 27 (16%) missed yoga classes compared to 14 (8%) missed resistance classes (p=0.04). Significantly more classes were missed at the downtown campus (32 total classes missed, 19.2%) compared to the suburban campus (9 total classes missed, 9.4%). Reasons for missed classes included work conflicts, medical appointments, family obligations, and trouble with travel arrangements.

b. Exploratory outcomes related to motor and non-motor function

Both yoga and resistance groups improved on all motor measures of interest (BBS, TUG, and UPDRS part III) when post-intervention scores were compared to pre-intervention scores. The magnitude of improvement for each of these measures favored the yoga group, although the differences were not statistically significant for any of these variables and the standard deviations were large (Table 2). Total

UPDRS score improved by an average of 7.6 points in the yoga group compared to 1.0 point in the resistance group, but this too was not statistically significant (p=0.18). There were no significant differences in motor outcomes between sites.

Both yoga and resistance groups also demonstrated improvement on multiple non-motor measures. There was no significant between-group difference in the main non-motor outcome which was the PDQ-39 total score (p=0.41), although there was a significant difference in the Neuro-QoL anxiety score (p=0.0297) and emotional and behavioral dyscontrol score (p=0.015) both of which favored the yoga group. Yoga had a strong preventative role on anxiety not worsening over the course of the study (d=0.99), while the resistance group's anxiety scores increased over time (d=-1.5). The magnitude of difference between yoga and resistance groups on the emotional score was also large (d=1.3). While the resistance group's emotional scores increased to a large extent over the course of the study (d=0.60), the yoga group's emotional scores decreased to a moderate extent (d=0.45). The only outcome variables which differed by site were the Neuro-QoL sleep score (p=0.035) and the PDQ-39 total score (p=0.045), both of which favored the Chicago site (e.g., sleep and overall QOL improved).

c. Exit survey responses

With the exception of one yoga participant, all participants expressed that they benefited from and enjoyed the classes (Figure 2). Given the opportunity, all but one participant said that they would continue the intervention beyond 12 weeks and recommend the intervention to other individuals with PD if given the opportunity. Two of the Chicago participants found the commitment to 24 classes over a 12 week period to be difficult, while the majority of the study participants did not (Figure 2). At months after study completion, 100% of the resistance participants were still practicing resistance exercise on their own, and half of them described their activity level as more active than before the study, while the other half described it as the same. In the yoga group, only 55% (5/9) of participants continued to practice yoga at 3 months after study completion. Among these participants, only 1 felt their activity level was greater compared to before the study and the other 8 felt it was unchanged.

d. Follow-up data

A phone call three months after completion of the study demonstrated that 5 out of 9 yoga participants were still practicing

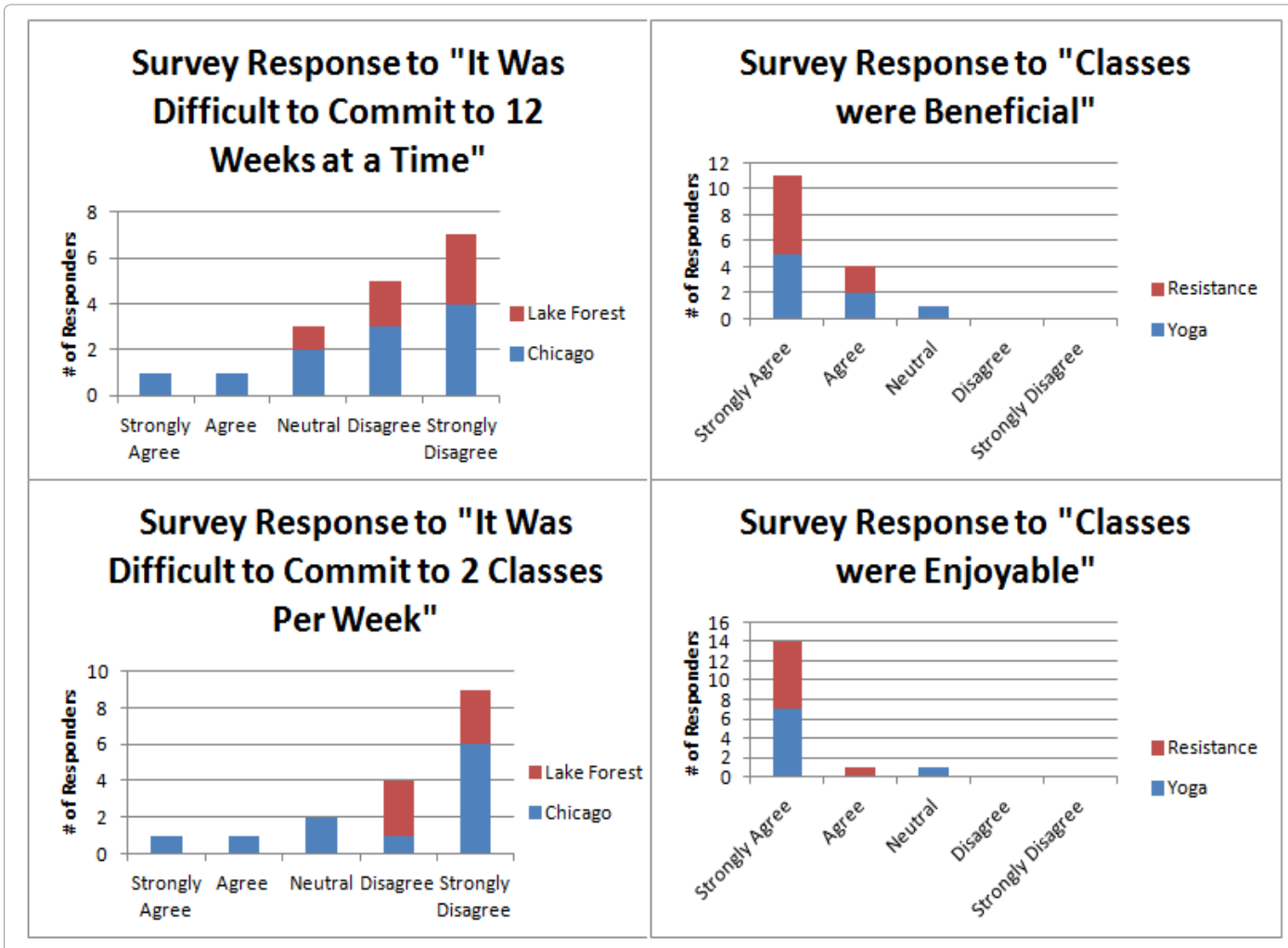

Figure 2: Survey responses.
Top Left and Bottom Left: 2 of the Chicago participants found the commitment to 24 classes over a 12 week period to be difficult, while the majority of the study participants did not.
Top Right and Bottom Right: With the exception of 1 yoga participant, all participants expressed that they benefited from and enjoyed the classes.

yoga, while all 8 of the resistance participants were still practicing resistance exercises. 8 out of 9 of the yoga participants described their current level of activity as "the same" as before the study intervention began, while 1 person endorsed being "more active". In the resistance group, 4 out of 8 participants described their current level of activity as "the same" as before the study intervention, while the other 4 stated they were "more active".

Discussion

This small pilot study demonstrated that both yoga and resistance exercise modalities were safe and well-tolerated in mild-moderate PD. The feasibility of a 12-week group yoga intervention in this cohort was somewhat limited, with better attendance seen for resistance classes. This was true despite nearly universally positive responses regarding enjoyment and perceived benefit of the classes. While most participants responded that commitment to 2 classes per week over 12 weeks was not difficult, this was not reflected in their attendance. Barriers to attendance, which included trouble with travel arrangements, work conflicts, and medical appointments, may be related to the fact that classes all occurred during daytime work hours. The suburban location was associated with significantly better compliance compared to the downtown Chicago location that may be related to proximity and ease of reaching the center. This has applicability to future exercise interventions in this population in general. Future studies may improve success by providing transportation or organizing classes in local community centers rather than metropolitan academic centers.

The 3-month follow-up data also shows that yoga had poorer maintenance than resistance exercise. While all of the resistance class participants were still practicing their exercises, only half of the yoga participants continued to practice. While this may reflect a difference in perceived benefit from the classes, both groups rated their perceived benefit highly. Instead, it may be that yoga practice is more dependent on instruction, and participants may not feel as comfortable with the techniques on their own compared to resistance training. Likewise, yoga instruction may be seen as a class-based intervention which is dependent on going to a facility at a set time, whereas resistance exercise may be more amenable to self-practice at home. Future studies may consider providing home-practice content such as instructional DVDs. Refresher courses, such as through telecommunication or local community center courses may also be necessary. Finally, loosening eligibility criteria for exercise studies may also be helpful as most PD patients are participating in some form of activity or physical therapy and end up excluded from such studies.

The previous study by Colgrove et al. demonstrated that yoga practice improved total UPDRS score among PD patients, but it was compared to a control group of no intervention, and non-motor outcome assessments were limited [20,34]. Resistance exercise has repeatedly been shown to improve strength and motor signs of Parkinsonism, although data on non-motor benefits is less clear [35,36]. Our pilot exploratory efficacy outcome data suggest comparable improvement in motor and non-motor outcome measures in both yoga and resistance groups, but this needs to be replicated with a larger well-powered study particularly given the wide variability we observed from participant to participant. Despite the relatively small sample size, our study did point to a small signal of superiority for the psychological benefits of the yoga intervention (e.g., reduced anxiety and emotional and behavioral dyscontrol), which is noteworthy since one would not expect to detect statistically significant differences of this magnitude without a larger, more adequately powered sample. Considering the degree of interest in yoga and the significant utilization of yoga practice in the community, evidence based data is important in allowing health care provides to communicate facts rather than beliefs.

In daily practice, yoga may not be ready to replace conventional exercise, but whether it is an appropriate adjunctive therapy for patients with PD is an important question to answer in future studies. Yoga can be adapted to suit participants with different abilities as well as to meet different goals from flexibility, to strength, to postural alignment, to relaxation. Future studies may wish to consider designing a specific home-based yoga regimen for PD based on the unique needs of this population. Future studies should also assess the specific impact of yoga and yoga-breathing on the body's stress response using biochemical markers [11]. While our small pilot study found no cognitive benefits, future studies should continue to investigate whether yoga can improve cognitive function through enhanced neuroplasticity.

The major limitation of this study is the small sample size. Future studies looking at efficacy will need to be larger, but given the widespread acceptance of the importance of physical activity in PD, finding participants who are not engaged in other activities is challenging and may require more flexible eligibility criteria. Future studies should also be mindful of the limitations of location and time of day with regard to such interventions, and consider local community centers as locations for studies rather than metropolitan academic centers. E-Health-enabled yoga programs may also be beneficial for this population. Finally, strategies for home practice should be considered to improve retention and maintenance of material. The design of the study is limited in that the comparison exercise group was a general resistance class for elderly individuals rather than a PD-focused resistance class. Future studies comparing efficacy of yoga will need to compare it to exercise classes that are designed specifically for PD, and should include yoga poses specifically designed for PD as well. Additionally, the intensity of resistance was not measured in this study, and it was not possible to control for intensity between the yoga and resistance classes given the nature of these different interventions.

Disclosures

The authors have no relevant conflicts of interest to disclose.

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