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Yoga improves balance and low back pain, but not anxiety, in people with Parkinson's disease

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Abstract

Introduction: Individuals with Parkinson's disease (PD) experience postural instability, low back pain (LBP), and anxiety. These symptoms increase the risk of falls, as well as decrease quality of life. Research shows yoga improves balance and decreases LBP and anxiety in healthy adults, but its effects in PD are poorly understood.

Methods: All participants were part of a larger intervention study. Participants received pre-test and post-test evaluations, including completion of the Balance Evaluation Systems Test (BESTest), Beck Anxiety Inventory (BAI), and Revised Oswestry Disability Index (ROSW). Total scores for each measure, as well as individual balance system section scores from the BESTest (Biomechanical constraints, stability limits/verticality, transitions/anticipatory, reactive, sensory orientation, and stability in gait) were compared within group pre- to post-test. Participants in the yoga group (n=13) completed a twice weekly, 12-week yoga intervention, while controls (n=13) continued their usual routines for 12 weeks.

Results: Both the yoga ($Z=-3.2$, $p=.001$) and control ($Z=-2.1$, $p=.04$) group improved on the BESTest total score. The control group showed no changes in individual balance systems whereas the yoga group improved in stability limits/verticality ($Z=-2.3$, $p=.02$), transitions/anticipatory ($Z=-2.5$, $p=.01$), reactive ($Z=-2.7$, $p=.008$), and sensory orientation ($Z=-2.3$, $p=.02$) systems. ROSW decreased in the yoga group only ($Z=-2.1$, $p=.03$). BAI did not change in either group.

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Conclusions: Yoga is a non-pharmacological intervention that can improve balance and LBP in people with PD. This study demonstrated that yoga is feasible for people with PD, and participants reported high levels of enjoyment and intent to practice yoga after the study.

Keywords

Parkinson disease; Yoga; Postural instability; Low back pain; Anxiety

Introduction

People with Parkinson's disease (PD) suffer from balance and postural deficits, which increase the likelihood of debilitating falls (Horak, Dimitrova, & Nutt, 2005). Specifically, people with PD can have insufficient responses to external forces or perturbations, leading to loss of balance (Smithson, Morris, & Iansek, 1998). Limb stiffness (Grimbergen, Munneke, & Bloem, 2004) and a flexed posture (Khlebtovsky et al., 2017) may also contribute to the risk of falls, and these symptoms become worse as the disease progresses. Additionally, increased flexed posture may contribute to low back pain (LBP), a symptom often untreated in PD (Watanabe et al., 2015). Non-motor symptoms in people with PD are also present. Increased anxiety is a common non-motor symptom, which can affect up to 55% of individuals with PD (Broen, Narayen, Kuijf, Dissanayaka, & Leentjens, 2016). The combination of increased motor disability (Shulman et al., 2008) and anxiety negatively impacts the quality of life of individuals with PD (Broen et al., 2016). While antiparkinsonian medications can decrease postural instability (Beuter, Hernández, Rigal, Modolo, & Blanchet, 2008), the medications may also impact the pathogenesis of anxiety in PD (Walsh & Bennett, 2001), increasing symptomatology. Therefore, non-pharmacological interventions warrant exploration for long-term management of both motor and non-motor symptoms in PD.

Yoga has been explored in multiple populations (Huang, Jenny, Chesney, Schembri, & Subak, 2014; Kaur et al., 2018; Wimberly, Engstrom, Layde, & McKay, 2018), and it has been shown to improve balance (Jeter, Nkodo, Moonaz, & Dagnelie, 2014). Many yoga postures challenge balance by placing the individual's body in unstable positions, which cannot be maintained without the appropriate muscular activation to stabilize the joints (Bolgia et al., 2018). Likely, individuals learn how to appropriately activate their muscles, resulting in balance improvements. In people with PD, yoga significantly improved measures of overall balance (Colgrove, 2012; Ni et al., 2016). However, as assessed by the Balance Evaluation Systems Test (BESTest) (Horak, Wrisley, & Frank, 2009), people with PD have deficits in all six systems of balance (biomechanical constraints, stability limits/verticality, transitions/anticipatory, reactive, sensory orientation, and stability in gait), and it is unclear which systems are most affected by yoga interventions. Yoga has other beneficial effects, such as decreasing LBP (Cramer, Lauche, Haller, & Dobos, 2013) and anxiety (Li & Goldsmith, 2012) in non-PD populations. Improvements in LBP are likely related to physical aspects of yoga, while changes in anxiety could relate to both the breathing and meditative aspects of yoga (Goyal et al., 2014; Li & Goldsmith, 2012; Sharma, Barrett, Cucchiara, Gooneratne, & Thase, 2017); however, these benefits have not been explored in PD.

The aims of this study, therefore, were to determine both the feasibility and the effect of a 12-week yoga intervention on the specific systems of balance as well as LBP and anxiety. We developed a yoga program that incorporated breathing, meditation, and physical postures, with a focus on postural transitions, such as getting up and down from the floor. Importantly, each posture was instructed from the ground up to ensure participants had a stable foundation. Additional layers to any posture, such as arm placement or gaze were provided as options. Once a pose was established, the transition to the next pose was instructed to maximize safety for all participants. The goal was for participants to learn to be mindful of how to move from one position to the next. As falls are a result of loss of balance, we felt this to be integral to the success and safety of all participants. Further, the design of our yoga program was intended to affect postural instability in people with PD by improving joint stability in static and dynamic positions. For this reason, our assessment of balance employed the full BESTest (Horak et al., 2009) to examine changes in each system of balance. We also used the Beck Anxiety Inventory (BAI) [22] to measure changes in anxiety and the Revised Oswestry Disability Index (ROSW) [23] for changes in LBP. We hypothesized that people with PD would show more improvements in BESTest, BAI, and ROSW scores after a yoga intervention than a control group receiving no intervention. Further, based on the transition-focused nature of the yoga program, we expected to see improvements in the biomechanical constraints, stability limits/verticality, and transitions/anticipatory systems of balance in the BESTest.

Methods

Participants

All participants were part of a larger intervention study with the following inclusion criteria: 1) clinical diagnosis of Parkinson's disease, 2) able to stand for at least 30 minutes, 3) normal peripheral function, 4) no history of vestibular disease, and 5) Mini Mental State Exam (MMSE) score ≥ 24 (Folstein, Folstein, & McHugh, 1975). Exclusion criteria included 1) diagnosis of any other major medical condition, 2) having deep brain stimulation or neural implants, 3) diagnosis of peripheral neuropathy, 4) use of neuroleptic or dopamine-blocking medications, and 5) has a current, regular yoga practice. Participants were randomized into one of three groups: controls, yoga, and mobile health. Only the control and yoga groups are included in the present analysis; however for clarity, the mobile health group participated in a 12-week program which utilized a smartphone application intervention (Horin et al., 2019). All participants provided written informed consent, and this study was approved by the Human Research Protection office of Washington University in St Louis.

Evaluations

Participants received a pre-test evaluation consisting of a behavioral assessment and questionnaires, followed by a 12-week intervention or control period. Controls were asked to continue their usual daily routines during the 12 weeks, which began the day after their pre-test evaluation, and the yoga group participated in the yoga program for 12-weeks. Pre-test evaluations for the yoga group occurred within four weeks of starting the yoga program. All post-test evaluations occurred within two weeks of completing the yoga program or control

period. The behavioral assessment included the full BESTest (Horak et al., 2009), which consists of 36 items, divided into six sections. Each section evaluates a different system of balance (biomechanical constraints, stability limits/verticality, transitions/anticipatory, reactive, sensory orientation, and stability in gait), and section scores add together for a total score. The individual section scores, as well as the total score, are valid for group comparisons (Horak et al., 2009) and were used here to evaluate changes in balance systems and overall balance in each group. Disease severity was measured using the Movement Disorder Society Unified Parkinson's disease Rating Scale, motor symptom subscale (MDS-UPDRS III) (Goetz et al., 2008). BESTest and MDS-UPDRS III were videotaped and scored by a rater blinded to group. To minimize effects of medications, evaluation time remained consistent for both evaluations within each participant.

Participants received questionnaire packets electronically or through the mail one week before their scheduled evaluations and were asked to complete the entire packet before their evaluations. The packet of questionnaires included a demographics sheet, the BAI (Beck, Epstein, Brown, & Steer, 1988), and the ROSW (Hudson-Cook, Tomes-Nicholson, & Breen, 1989). The BAI is a self-report measure of anxiety that asks the participant to rate how much they are bothered by each of 21 items on a scale of 1 (not bothered at all) to 3 (severely, it bothered me a lot), for a maximum possible score of 63. The ROSW asks whether the participant experiences LBP chronically or when engaging in a list of ten different activities. Each activity has a possible answer of 0 (no disability) to 5 (severe disability), giving a maximum possible score of 50. ROSW scores are multiplied by two to provide a percentage of total disability. The BAI and ROSW were used to measure anxiety and LBP, respectively, before and after the intervention or control period. As part of the post-test questionnaire packet, participants in the yoga group also completed an exit questionnaire to evaluate their perceptions of the effectiveness of, and to elicit feedback on, the yoga program.

Yoga Intervention

Participants in the yoga intervention were assigned to one of two class sections (Monday/Wednesday mornings or Tuesday/Thursday afternoons) depending on their personal schedules. Classes had 7-9 participants, and 3-5 research team members, including two certified yoga instructors, were present at each class to assist participants when necessary. This guaranteed that there were enough staff on hand to help all participants when necessary without significantly slowing down the pace of the class. Instructors alternately taught classes to ensure all participants had equal exposure to both instructors, and the instructors discussed class format prior to the classes to ensure content and difficulty were maintained across class sections. Participants were required to attend at least 20/24 classes for inclusion in the present analysis. Of the 15 enrolled participants, 13 completed enough classes for inclusion. Two participants discontinued participation in the study, one due to leg pain unrelated to the intervention and one due to employment conflicts.

All classes maintained the following format: 5 minutes introduction with relaxation and guided meditation, 10 minutes gentle spinal movements, 30-35 minutes standing poses, 5-10 minutes cool down, and 5 minutes rest and relaxation. Standing poses focused on balance and stability and included poses such as Warrior I and II, Crescent Lunge, Downward Dog,

and Tree. Participants were encouraged to work on safely transitioning between poses, with or without assistance from research staff. All poses were instructed with breath cues to encourage breath with movement, and the simplest, most accessible form of a pose was taught first, with more advanced variations offered as skill levels improved. During the final five minutes of every class, participants lay in savasana, a final resting pose where one lies supine on the floor with eyes closed in meditation. Instructors provided a brief leg or neck adjustment to maximize relaxation and comfort to all participants during this time.

The yoga intervention was designed to build upon itself. The intervention began with basic spinal movements and integration of breath and movement, and incrementally built up to a beginner vinyasa class (Figure 1). As individuals with PD often contend with bradykinesia, or a slowness in movement, classes were slow but evenly paced to accommodate all levels. Further, as participants were not familiar with yoga poses, the instructors chose to avoid Sanskrit names, favoring English translations or descriptions instead. All participants were provided with a yoga mat (68x24in), high density foam blocks (9x6x4in), and a cloth strap (1x120in). Foam blocks and straps were used to assist participants in poses. Chairs were available upon request should a participant need to rest but were not part of the yoga class. There were no adverse events such as falls or muscular injuries during the classes.

Statistical Analyses

Statistical analyses were conducted using IBM SPSS statistics (version 24, IBM, Armonk, NY, USA). For the 13 yoga participants who completed the study, we used propensity score matching to identify 13 age-matched control participants. Analyses reported include the 13 yoga completers and these 13 age-matched controls. Due to the small group sample sizes and data skewness, non-parametric tests were used. Mann-Whitney U tests were used to compare baseline performance for BESTest, BAI, and ROSW between groups. Wilcoxon signed rank tests were used to compare pre-test vs. post-test scores for BESTest, BAI, and ROSW within each group. Statistical significance was set at $\alpha < .05$.

Results

Participants in the yoga group attended an average of 22 classes, with a range of 20-24 classes. There were no significant demographic differences between groups at pre-test (Table 1). Mann-Whitney U tests comparing pre-test performance for BESTest total, each BESTest section, BAI, and ROSW showed no significant differences between groups at pre-test.

BESTest total score and the six section scores were compared for each group. In the control group, there was a significant improvement in overall score ($Z = -2.1$, $p = .04$) but not in any of the individual sections. The yoga group showed significant improvement in overall score ($Z = -3.2$, $p = .001$) as well as improvement in stability limits/verticality ($Z = -2.3$, $p = .02$), transitions/anticipatory ($Z = -2.5$, $p = .01$), reactive ($Z = -2.7$, $p = .008$), and sensory orientation ($Z = -2.3$, $p = .02$) sections. BAI scores at pre-test and post-test were compared for each group and showed no change in controls ($Z = -.40$, $p = .69$) or yoga ($Z = -.04$, $p = .97$). ROSW scores at pre-test and post-test were compared for each group and showed no change for controls ($Z = -.48$, $p = .63$) but a significant decrease in disability for yoga ($Z = -2.1$, $p = .03$) (Table 2; Figure 2).

Twelve of the thirteen yoga participants completed an exit questionnaire. The overall response was positive, with ten participants noting the social aspect and sense of community as being beneficial for them. Eleven responded to the question “How effective was this exercise program? Please slide the bar along the scale” (0=not effective, 50=somewhat effective, 100=very effective). The average rating was 82.5, indicating participants thought the intervention was effective for them. Ten respondents answered the question “How would you rate the physical requirements of the class? Please slide the bar along the scale” (0=too easy, 50=just right, 100=too difficult). The mean answer was 62.2, indicating the class was challenging but not overly demanding for the participants. Four participants said driving distance to the class was difficult, and four indicated a printed document illustrating the yoga poses would have been helpful. Eleven participants reported feeling physical benefits, such as improved balance, strength, and flexibility. Finally, ten participants said they planned on continuing yoga after the study, commenting that they enjoyed the program.

Discussion

Here we have shown that yoga can both improve balance and decrease LBP-related disability in people with PD. Specifically, our results indicate that after 12 weeks of yoga, people with PD were more stable and upright, better at transitions and anticipatory movements, more able to react quickly and appropriately to external stimuli, and better at sensory orientation. Additionally, people with PD reported significantly less LBP after the yoga intervention. On top of the quantitative evidence, qualitative feedback from the exit survey was highly positive with more than $\frac{3}{4}$ of the participants intending to continue yoga after the research study.

The BESTest results illuminate which specific systems of balance changed over the course of the yoga intervention. Minimal clinically important differences for the BESTest, particularly for the individual balance systems, have not been established in PD. However, people in the yoga class did report feeling physical improvements after the intervention, which may have contributed to improved performance on the BESTest. The improvement in the transitions/anticipatory balance system suggests a yoga program emphasizing transitions is effective for targeted improvements in this system of balance. Additionally, the program helped people with PD improve their responses to external perturbations (i.e., postural instability). As people with PD are highly prone to debilitating falls due to increased limb stiffness and poorly directed arm movements (Grimbergen et al., 2004), significantly improving these balance systems may help reduce fall risk. Further, the stability limits/verticality balance system improved in the yoga group, suggesting yoga may have been able to mitigate the tendency towards the flexed trunk associated with increased disease severity (Khlebtovsky et al., 2017).

The yoga group results stand in contrast to control group performance. While the controls improved in the BESTest total score, none of the individual systems significantly changed. This indicates the control group improved performance overall but improvement was random with no systematic change leading to this result. Additionally, controls were asked to continue their normal routines of physical activity, so changes in total BESTest score may

be due to improvements associated with outside routines or with a practice effect from pre-test to post-test.

The LBP improvements are noteworthy as little research has been conducted looking at LBP treatment in PD. Exercises to address stooped posture and motor function are often given as the treatment for LBP (Watanabe et al., 2015), and the multiple motor and non-motor symptoms associated with PD may impact traditional LBP treatment efficacy. Here, we show the yoga group reported both significantly reduced LBP after the yoga intervention and they enjoyed the class overall. Previous research on LBP (Fairbank & Pynsent, 2000) suggests a reduction of 10% for the ROSW is clinically meaningful. Due to our smaller sample size, it cannot be determined whether this threshold was truly met, but our data do suggest the mean change in ROSW for the yoga group was around 10% (Figure 2).

Participant enjoyment of an activity is important for activity adherence (Carraro, Gobbi, Ferri, Benvenuti, & Zanuso, 2014), and group exercise increases participant enjoyment (Hackney & Earhart, 2010). Not only did the yoga group report enjoying the classes, but ten of the thirteen participants said they planned to continue practicing yoga after the study. This suggests the benefits of the yoga class went beyond quantifiable changes in balance and LBP and indicates that yoga felt like an accessible activity to the participants. A regular yoga class would promote activity and provide a social support system, both of which are important among people with PD (Paula, Teixeira-Salmela, Faria, Brito, & Cardoso, 2006).

Surprisingly, we did not see a significant decrease in BAI in the yoga group, but this may have been due to participants reporting low anxiety at baseline with all pre-test scores less than 21, except for one participant in the yoga group (Beck et al., 1988). That participant went from a pre-test BAI score of 35 to a post-test BAI score of 18. Additionally, while relaxation and guided meditation was offered at the beginning and end of each class, our yoga program did not focus on meditation.

Though this study's sample size was small, groups were similar at pre-test, and significant differences were detected from pre- to post-test. Additionally, we showed that a transition-focused yoga program is feasible, having had no adverse events during class; and most individuals who completed the program intended to continue to practice yoga after the study because of perceived physical benefits from the intervention. Importantly, a significant amount of assistance from research team members was needed to ensure the safety of participants. The ratio of research staff to participants was never more than 1:3. This may suggest this yoga program would not be as safe and effective for individuals with more severe PD. Future research is needed to assess the implementation of a yoga program in a community setting where the ratio of instructors to participants would decrease.

It should be noted that we did not use an active control group, such as one that received a bodyweight exercise intervention, limiting our ability to compare the changes seen here to other forms of exercise. However, we have shown that a yoga practice may be an accessible alternative for people with PD who do not wish to engage in more traditional forms of exercise such as walking, biking, or weight lifting. During classes, some participants used the foam blocks to adapt poses based on their flexibility or increase stability. This introduces

variability in the received intervention, but it is standard in any yoga class to provide each participant with the necessary tools to fully participate during class in a safe and effective manner. Importantly, this yoga program did not use chairs, encouraging participants to challenge themselves and learn strategies for safe postural transitions.

Overall, our study shows that yoga is potentially beneficial for people with PD and warrants further examination. While we have shown improvements in specific systems of balance, future research should examine whether these improvements are due to improved muscle strength, changes in muscle activation patterns, or other factors. Future work may also provide further insight into why yoga impacted LBP and its relationship to different systems of balance. Additionally, yoga's impact on fall risk requires further research. While we report balance improvements, whether that translates to fall reduction is beyond the scope of this study. Nevertheless, yoga offers a non-pharmacological treatment for balance deficits in people with PD, as well as other physical and social benefits, which are important for maintaining high quality of life.

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References

- Beck AT, Epstein N, Brown G, & Steer RA (1988). An inventory for measuring clinical anxiety: psychometric properties. *Journal of Consulting and Clinical Psychology*, 56(6), 893–897. [PubMed: 3204199]
- Beuter A, Hernández R, Rigal R, Modolo J, & Blanchet PJ (2008). Postural sway and effect of levodopa in early Parkinson's disease. *The Canadian Journal of Neurological Sciences. Le Journal Canadien Des Sciences Neurologiques*, 35(1), 65–68. [PubMed: 18380279]
- Bolgia LA, Amodio L, Archer K, Estes J, Leung R, Magoni K, ... Beazley D (2018). Trunk and hip muscle activation during yoga poses: do sex-differences exist? *Complementary Therapies in Clinical Practice*, 31, 256–261. 10.1016/j.ctcp.2018.03.006 [PubMed: 29705465]
- Broen MPG, Narayan NE, Kuijf ML, Dissanayaka NNW, & Leentjens AFG (2016). Prevalence of anxiety in Parkinson's disease: a systematic review and meta-analysis. *Movement Disorders: Official Journal of the Movement Disorder Society*, 31(8), 1125–1133. 10.1002/mds.26643 [PubMed: 27125963]
- Carraro A, Gobbi E, Ferri I, Benvenuti P, & Zanuso S (2014). Enjoyment perception during exercise with aerobic machines. *Perceptual and Motor Skills*, 119(1), 146–155. 10.2466/29.06.PMS.119c15z3 [PubMed: 25153745]
- Colgrove YS (2012). Effect of yoga on motor function in people with Parkinson's disease: a randomized, controlled pilot study. *J Yoga Phys Ther*, 2.
- Cramer H, Lauche R, Haller H, & Dobos G (2013). A systematic review and meta-analysis of yoga for low back pain. *Clinical Journal of Pain*, 29(5), 450–460. 10.1097/AJP.0b013e31825e1492 [PubMed: 23246998]
- Fairbank JC, & Pynsent PB (2000). The Oswestry Disability Index. *Spine*, 25(22), 2940–2952; discussion 2952. [PubMed: 11074683]
- Folstein MF, Folstein SE, & McHugh PR (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, 12(3), 189–198. [PubMed: 1202204]
- Goetz CG, Tilley BC, Shaftman SR, Stebbins GT, Fahn S, Martinez-Martin P, ... Movement Disorder Society, U. R. T. F. (2008). Movement Disorder Society-sponsored revision of the Unified

- Parkinson's Disease Rating Scale (MDS-UPDRS): scale presentation and clinimetric testing results. *Mov Disord*, 23, 2129–2170. 10.1002/mds.22340 [PubMed: 19025984]
- Goyal M, Singh S, Sibinga EMS, Gould NF, Rowland-Seymour A, Sharma R, ... Haythornthwaite JA (2014). Meditation programs for psychological stress and well-being: a systematic review and meta-analysis. *JAMA Internal Medicine*, 174(3), 357–368. 10.1001/jamainternmed.2013.13018 [PubMed: 24395196]
- Grimbergen YA, Munneke M, & Bloem BR (2004). Falls in Parkinson's disease. *Curr Opin Neurol*, 17, 405–415. [PubMed: 15247535]
- Hackney ME, & Earhart GM (2010). Effects of dance on gait and balance in Parkinson's disease: a comparison of partnered and nonpartnered dance movement. *Neurorehabilitation and Neural Repair*, 24, 384–392. 10.1177/1545968309353329 [PubMed: 20008820]
- Horak FB, Dimitrova D, & Nutt JG (2005). Direction-specific postural instability in subjects with Parkinson's disease. *Exp Neurol*, 193, 504–521. 10.1016/j.expneurol.2004.12.008 [PubMed: 15869953]
- Horak FB, Wrisley DM, & Frank J (2009). The Balance Evaluation Systems Test (BESTest) to differentiate balance deficits. *Phys Ther*, 89, 484–498. 10.2522/ptj.20080071 [PubMed: 19329772]
- Horin AP, McNeely ME, Harrison EC, Myers PS, Sutter EN, Rawson KS, & Earhart GM (2019). Usability of a daily mHealth application designed to address mobility, speech and dexterity in Parkinson's disease. *Neurodegenerative Disease Management*, 9(2), 97–105. 10.2217/nmt-2018-0036 [PubMed: 30998100]
- Huang AJ, Jenny HE, Chesney MA, Schembri M, & Subak LL (2014). A group-based yoga therapy intervention for urinary incontinence in women: a pilot randomized trial. *Female Pelvic Medicine & Reconstructive Surgery*, 20(3), 147–154. 10.1097/SPV.0000000000000072 [PubMed: 24763156]
- Hudson-Cook N, Tomes-Nicholson K, & Breen A (1989). A revised Oswestry disability questionnaire In: Roland MO, Jenner JR, eds. *In Back Pain: New Approaches to Rehabilitation and Education* (pp. 187–204). New York, NY: Manchester University Press.
- Jeter PE, Nkodo A-F, Moonaz SH, & Dagnelie G (2014). A systematic review of yoga for balance in a healthy population. *Journal of Alternative and Complementary Medicine (New York, N.Y.)*, 20(4), 221–232. 10.1089/acm.2013.0378
- Kaur G, Prakash G, Malhotra P, Ghai S, Kaur S, Singh M, & Kaur K (2018). Home-based Yoga Program for the patients suffering from malignant lymphoma during chemotherapy: a feasibility study. *International Journal of Yoga*, 11(3), 249–254. 10.4103/ijoy.IJOY_17_18 [PubMed: 30233121]
- Khlebtovsky A, Djaldetti R, Rodity Y, Keret O, Tsvetov G, Slutzcki-Shraga I, & Benninger F (2017). Progression of postural changes in Parkinson's disease: quantitative assessment. *Journal of Neurology*, 264(4), 675–683. 10.1007/s00415-017-8402-6 [PubMed: 28154973]
- Li AW, & Goldsmith CAW (2012). The effects of yoga on anxiety and stress. *Alternative Medicine Review*, 17, 21–35. [PubMed: 22502620]
- Ni M, Signorile JF, Mooney K, Balachandran A, Potiaumpai M, Luca C, ... Perry AC (2016). Comparative effect of power training and high-speed yoga on motor function in older patients with Parkinson disease. *Arch Phys Med Rehabil*, 97, 345–354 e15. 10.1016/j.apmr.2015.10.095 [PubMed: 26546987]
- Paula F. R. de, Teixeira-Salmela LF, Faria C. D. C. de M., Brito P. R. de, & Cardoso F (2006). Impact of an exercise program on physical, emotional, and social aspects of quality of life of individuals with Parkinson's disease. *Movement Disorders*, 21(8), 1073–1077. 10.1002/mds.20763 [PubMed: 16637049]
- Sharma A, Barrett MS, Cucchiara AJ, Gooneratne NS, & Thase ME (2017). A breathing-based meditation intervention for patients with major depressive disorder following inadequate response to antidepressants: a randomized pilot study. *The Journal of Clinical Psychiatry*, 78(1), e59–e63. 10.4088/JCP.16m10819 [PubMed: 27898207]
- Shulman LM, Gruber-Baldini AL, Anderson KE, Vaughan CG, Reich SG, Fishman PS, & Weiner WJ (2008). The evolution of disability in Parkinson disease. *Mov Disord*, 23, 790–796. 10.1002/mds.21879 [PubMed: 18361474]

- Smithson F, Morris ME, & Iansek R (1998). Performance on clinical tests of balance in Parkinson's disease. *Physical Therapy*, 78(6), 577–592. [PubMed: 9626270]
- Walsh K, & Bennett G (2001). Parkinson's disease and anxiety. *Postgraduate Medical Journal*, 77(904), 89–93. 10.1136/pmj.77.904.89 [PubMed: 11161073]
- Watanabe K, Hirano T, Katsumi K, Ohashi M, Ishikawa A, Koike R, ... Shimohata T (2015). Characteristics and exacerbating factors of chronic low back pain in Parkinson's disease. *International Orthopaedics*, 39(12), 2433–2438. 10.1007/s00264-015-3011-4 [PubMed: 26440577]
- Wimberly AS, Engstrom M, Layde M, & McKay JR (2018). A randomized trial of yoga for stress and substance use among people living with HIV in reentry. *Journal of Substance Abuse Treatment*, 94, 97–104. 10.1016/j.jsat.2018.08.001 [PubMed: 30243425]

Figure 1. Yoga intervention outline. The middle column indicates the focus of each week's classes. New poses were integrated with poses from previous weeks, building up to a beginner level vinyasa class. Class outlines for weeks one, six, and twelve are shown in the boxes.

Figure 2.

Box and whisker plots for changes in outcomes from pre- to post-test. For the Balance Evaluation Systems Test (BESTest) and its system sections, a positive change denotes improvement. For Revised Oswestry Disability Index (ROSW), a negative change denotes reduced disability. For the Beck Anxiety Inventory (BAI), a negative change denotes reduced anxiety. The bottom two rows show the different balance systems within the BESTest.

+indicates mean value.

Table 1.

Demographics

Characteristic	Control (<i>n</i> = 13)	Yoga (<i>n</i> = 13)	<i>p</i> Value
Age in y, mean (SD)	65.0 (8.7)	70.5 (8.7)	0.12
Sex, No. female	5	6	0.99
MMSE, median (range)	29 (25–30)	29 (27–30)	0.73
UPDRS-III, median (range)	24 (18–42)	29 (10–49)	0.74
H&Y, median (range)	2 (2–3)	2 (2–3)	0.99

SD = standard deviation; MMSE = Mini Mental State Exam; UPDRS-III = Unified Parkinson's Disease Rating Scale, Motor Symptom Subscale; H&Y = Hohn and Yahr stage.

Table 2.Outcome Measures, Median (Range)^a

	Controls			Yoga		
	Pretest	Posttest	<i>p</i> Value	Pretest	Posttest	<i>p</i> Value
BESTest						
Biomechanical constraints	10 (4–12)	11 (5–13)	0.100	11 (7–14)	11 (9–15)	0.810
Stability limits/verticality	18 (15–21)	19 (11–21)	0.170	17 (12–20)	19 (16–21)	0.020 *
Transitions/anticipatory	14 (10–18)	13 (11–18)	0.390	15 (9–17)	16 (9–18)	0.010 *
Reactive	12(6–18)	13 (5–17)	0.660	13 (6–14)	13 (7–18)	0.008 *
Sensory orientation	13 (10–14)	13 (9–15)	0.060	13 (11–14)	14 (11–15)	0.020 *
Stability in gait	16 (10–19)	17 (13–20)	0.110	16 (10–19)	15 (10–18)	0.390
Total	84 (63–95)	86 (66–100)	0.040 *	87 (63–93)	90 (66–98)	0.001 *
Beck Anxiety Inventory	8 (0–14)	6 (1–14)	0.690	8 (1–35)	7 (1–18)	0.970
Revised Oswestry Disability Index	14 (0–40)	14 (0–40)	0.630	14 (0–46)	2 (0–22)	0.030 *

^aWilcoxon signed-rank test compared pre- and posttest within each group, separately.* Significant at $\alpha < 0.050$.