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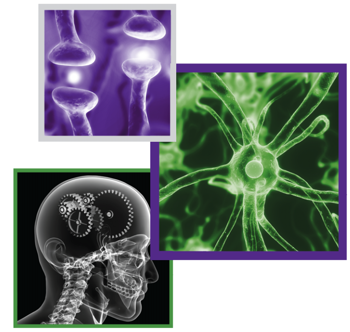

# Freezing of Gait Boot Camp: feasibility, safety and preliminary efficacy of a community-based group intervention

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**Aim:** In this pilot study, we evaluated the feasibility, safety and preliminary efficacy of a 6-week, community-based group intervention designed to reduce freezing of gait (FOG) for people with Parkinson's disease (PD). **Methods:** Seven people with PD completed 'FOG Boot Camp' provided by the St. Louis Chapter of the American Parkinson Disease Association. We recorded attendance, participant's acceptance of the intervention and adverse events during classes. Pre and post-tests included measures of freezing, balance, motor severity, quality-of-life and gait speed. **Results:** No falls or injuries occurred and attendance was high. Participants had favorable feedback and showed reduced freezing and improvements in balance and gait. **Conclusion:** Preliminary data suggest the FOG boot camp was feasible, safe and effective.

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**Keywords:** freezing of gait • Parkinson's disease • pilot study

Parkinson's disease (PD) is a common neurodegenerative disease characterized by alterations of the motor system including bradykinesia, or slowness of voluntary movement, unilateral or bilateral tremor of the extremities, overall kyphotic (or stooped) posture, postural instability, gait perturbations such as shuffling, reduced stride length and arm swing, and rigidity [1,2]. Between 20 and 60% of the 1.5 million people diagnosed with PD will eventually experience freezing of gait (FOG), a motor perturbation where people with PD are transiently unable to produce effective stepping despite the intention to move [3–5]. FOG episodes can occur at the initiation of walking, during walking or while turning and last from a few seconds to a few minutes. FOG episodes are also correlated with certain triggers such as walking through a doorway or in narrow spaces [1,4,5]. Determining methods to reduce or overcome FOG episodes is important for preventing falls. Falls are a serious medical challenge associated with reduced mobility, independence and quality of life and FOG is a leading risk factor for falls among people with PD [6–8]. In this study, we examined the feasibility, safety and motor benefits of an educational and performance-based training program designed and delivered by physical therapists knowledgeable about PD and FOG, with the goal of improving familiarity and strategies to minimize FOG episodes. Specifically, we presented the definition, pathophysiology, triggers and fall risk of FOG, and provided education and training in methods to overcome FOG.

While current efforts to understand the causes and correlates of FOG are numerous and ongoing, exact mechanisms are still unknown. One line of research suggests FOG may be related to cognitive overload, or difficulty with attending to many tasks at once [1]. However, FOG can also occur when a person is focusing intently on their walking [9]. Smulders and colleagues [10] suggest the occurrence of FOG is related to difficulties with switching motor activities, for example, gait initiation or turning. It is clear that both cognitive and motor domains are affected in PD and contribute to FOG, but how these domains are interrelated and progress during the disease process is still being researched [3,5,11]. Moreover, evidence states FOG remains in the presence of optimal medical (levodopa) treatment and can persist or emerge after surgical (deep-brain stimulation) treatment, thus, other strategies are needed to address this motor impairment [1,3–5,12,13].

Previous studies have investigated auditory, visual, or somatosensory cues and found these cues are generally effective, although some are difficult if the individual is alone [14–20]. Occupational therapy sessions addressing FOG may include rearranging home spaces or taking different paths to promote wider turns, use of walking aids such as a wheeled walker or concentrating on gait during dual tasking [4,21]. Other methods used for breaking the FOG cycle include self-initiated strategies that require conscious attention, such as sideways walking, lifting one leg higher, moving one foot backward before walking, making wider turns, counting backward rather than forward as applied with the 3-2-1-Go method, shifting weight prior to moving forward, and imagining a clock on the ground to help with turning [14,22,23]. More recently, investigators paired auditory cueing and use of an attentional strategy to reduce freezing. However, generalizability is limited because only five of 28 participants exhibited freezing during the baseline protocol [24]. Currently, little is known about how education concerning FOG in a group-setting can improve gait dysfunction in people with PD, with reviews of current approaches for freezing remarking that best practices have yet to be found [4,5]. Here, we wanted to build upon previous research on cueing by investigating the feasibility, safety, acceptability and effectiveness of a program that combines education about FOG with practice of several strategies to reduce FOG. Our goal for individuals experiencing FOG was to empower them with knowledge of FOG within an inclusive and supportive environment where they could learn and practice these strategies.

Our aims for this pilot study was to evaluate whether the multi-component intervention was feasible, safe and provided both subjective and objective benefits for the participants. Specifically, we hypothesized the intervention would not cause any falls or injuries, attendance would be high and feedback positive. We also expected improvement, primarily on a measure of FOG, as well as gait speed, balance and quality of life before and after the community-based group FOG educational program.

## Materials & methods

### Participant inclusion & exclusion criteria

We included participants with idiopathic PD, who were over the age of 30, able to walk independently for 10 meters and reported experiencing FOG in the month prior to testing. The report of FOG was verified using the New Freezing of Gait Questionnaire (nFOG_Q) [25]. Participants were excluded if there was evidence of cognitive impairment (Mini-Mental Status Examination [MMSE] <24) [26] or a serious medical problem other than PD that would prevent participation in the research study evaluations. All assessments and the intervention took place at the Greater St. Louis American Parkinson Disease Association. This study was approved by the Institutional Review Board (IRB) at Washington University in St. Louis School of Medicine. All participants signed a written, informed consent.

### Intervention

The community-based group FOG boot camp was a 6-week program with one and a half hour classes each week designed and taught by two physical therapists (P Creel, L Templin), who are board certified specialists in neurological and geriatric physical therapy, respectively. Each class started with education and group discussion on strategies for overcoming/preventing FOG episodes. The education was provided via PowerPoint presentations (Microsoft®, WA, USA). This was followed by supervised practice of the strategies in environments designed to trigger FOG (e.g., going in and out of a doorway, walking down a narrow path, making a wide turn, turning to sit in a chair, making a narrow turn, making a figure 8, taking lateral steps to sit in a chair and making a 360 degree turn). Care partners were invited to listen in and to observe the strategies during practice. Participants set personal goals, weekly, relating to their confidence of when and where they would practice particular strategies outside of class (see Goals, Supplementary Digital Content 1). Goal setting and review of their weekly action plans were done under the supervision of an occupational therapist with expertise in PD and behavioral change. During the final session participants had the opportunity to practice their skills in a community setting during a lunch outing to a nearby restaurant.

The strategies taught and practiced were based on existing literature and included visual cueing, auditory cueing and self-initiated strategies that required executive functioning and attentional processes (see Outline, Supplementary Digital Content 2).

### Feasibility outcomes

Our main objectives in this study were to determine the feasibility, safety and acceptability of a once-weekly, community-based FOG boot camp group intervention. For feasibility, we tracked attendance and hypothesized participants would attend, on average, at least four of the six FOG weekly boot camp classes. For safety, we tracked falls and musculoskeletal injuries during the intervention classes and hypothesized there would be none. For acceptability, we hypothesized participants would report the intervention as enjoyable, challenging and helpful in reducing FOG on an open-ended questionnaire about their experience. We also examined changes on the Parkinson Disease Questionnaire – 39 (PDQ-39), a valid, reliable measure developed to assess quality-of-life in people with PD [27]. Subscales include mobility, emotional well-being, stigma, social support, cognition, communication and bodily discomfort. A total summary score (0–100) was also calculated [28]. The PDQ-39 was self-administered.

### Preliminary efficacy outcomes

Additionally, we wanted to quantify the preliminary efficacy of the once weekly FOG boot camp intervention on FOG, balance, motor severity and over ground walking among participants. Our primary outcome measure of efficacy was the New Freezing of Gait Questionnaire (nFOG_Q). A trained rater administered the nFOG_Q which includes a video with examples of FOG to ensure participants' understanding of what constitutes FOG. The questionnaire quantifies FOG episodes in terms of frequency, length and impact on daily activities and has been shown to be a reliable tool. The total possible score on the nFOG_Q is 28, with higher scores indicating greater FOG severity [25].

Motor tests were administered by trained, nonblinded physical therapists (RP Duncan, GM Earhart) and included: Mini-Balance Evaluations System Test (Mini-BESTest) with anticipatory, reactive postural control, sensory orientation and dynamic gait subscales [29]; Movement Disorder Society Unified Parkinson Disease Rating Scale motor subsection (MDS-UPDRS-III) [30]; and tests of gait speed and endurance (ten-meter walk and two-minute walk).

Pre and post-test assessments were scheduled for the same time of day to control for potential changes in medication effects. Pre-test assessments were conducted one week prior to the first boot camp session and post-test assessments were conducted two days after the last boot camp session. Raters knew participants completed the intervention but were not part of the team that conducted the intervention.

### Statistical analysis

Due to the small sample size of this feasibility study, we carefully examined normality tests and outliers for each paired analysis. Outliers were detected using the median absolute deviation method [31]. Normal baseline and post distributions were compared using paired sample t-tests, two-sided. For distributions with outliers and/or a Z score $\pm$ 1.96 for skewness or kurtosis, we report statistics from Wilcoxon Signed Rank Tests. Using a conservative approach, individual items missing on questionnaires were imputed with the pre- or post answer for rating scale items (i.e., PDQ-39). Cohen's d effect sizes are reported as estimates of the population effect size. Analyses were calculated using IBM SPSS Statistics Version 24.

Study data were collected and managed using REDCap electronic data capture tools hosted at Washington University School of Medicine [32].

## Results

Ten participants who signed up for the FOG boot camp were contacted and agreed to take part in the research study. One participant was excluded due to a low MMSE score, one participant did not complete the entire baseline evaluation nor attended post-testing and one participant started taking levodopa during the intervention. Outcomes are reported for the remaining seven participants. These seven individuals had mild to moderate PD severity as evidenced by the MDS-UPDRS-III, had moderate to severe FOG, and most were frequent fallers.

### Feasibility outcomes

During the boot camp classes there were no falls or musculoskeletal injuries. Attendance was high, with five participants attending all six classes, one participant attending five classes and one participant attending four classes. Participants were enthusiastic about the boot camp. Comments on an open-ended questionnaire about their experience included "the instructors met everyone at their own level," "it helped me," "enjoyed the class very much," "very successful" and "good to know I'm not alone." (Table 1).

### Preliminary efficacy outcomes

Baseline and post-testing summary scores and test statistics are presented in Table 2 (n = 7). Improvements were

Table 1. Baseline characteristics (n = 7).

| Categorical variables | Category | N (%) |
|---|---|---|
| Gender | Male | 4 (57.1%) |
| | Female | 3 (42.9%) |
| Falls in past 6 months | Less than 2 falls | 2 (28.6%) |
| | 2 or more falls | 5 (71.4%) |
| Living situation | With partner only | 7 (100%) |
| **Continuous variables** | **M (SD)** | **Range** |
| Age | 71.86 (4.88) | 66.00–80.00 |
| BMI | 27.91 (7.88) | 19.50–42.00 |
| Mini-mental status examination | 29.29 (1.11) | 27.00–30.00 |
| Number of years since PD diagnosis | 4.71 (4.54) | 1.00–13.00 |
| Years of education | 14.29 (2.75) | 12.00–19.00 |

BMI: Body mass index; PD: Parkinson's disease.

Table 2. Baseline and post-test outcomes for Freezing of Gait Boot Camp (n = 7).

| | Baseline | | Post | | |
|---|---|---|---|---|---|
| Variables | Mean (SD) | Med (Q1:Q3) | Mean (SD) | Med (Q1:Q3) | Significance |
| nFOG_Q | 22.57 (3.10) | 23.00 (20.00:26.00) | 19.43 (3.15) | 20.00 (16.00:22.00) | 0.052† |
| Mini-BESTest | 15.14 (6.01) | 18.00 (8.00:20.00) | 18.14 (6.34) | 21.00 (9.00:22.00) | 0.022† |
| MDS-UPDRS-III | 33.71 (10.55) | 32.00 (23.00:42.00) | 29.43 (12.00) | 31.00 (17.00:38.00) | 0.082† |
| PDQ-39 Summary index | 20.60 (6.22) | 20.89 (15.05:26.15) | 21.02 (9.49) | 20.99 (11.82:28.33) | 0.860† |
| Ten-Meter walk test (m/s) | 1.03 (0.37) | 1.18 (0.80:1.35) | 1.12 (0.33) | 1.19 (0.96:1.33) | 0.237‡ |
| Two-Minute walk test (m) | 85.24 (29.97) | 79.98 (67:60:107.90) | 101.99 (40.99) | 116.28 (59.98:139.96) | 0.048† |

†Paired Samples T-Test.
‡Wilcoxon Signed Rank Tests.
m: Meter; MDS-UPDRS-III: Movement Disorder Society Unified Parkinson Disease Rating Scale motor subsection; Mini-BESTest: Mini-Balance Evaluations System Test; m/s: Meter per second; nFOG_Q: New Freezing of Gait Questionnaire; PDQ-39: Parkinson Disease Questionnaire-39.

seen on the Mini-BESTest ($t(6) = -3.07$, $p = 0.022$, $d = 0.50$), the 2-min walk test ($t(6) = -2.476$, $p = 0.048$, $d = 0.56$) and the nFOG_Q ($t(6) = 2.42$, $p = 0.052$, $d = 1.01$). No significant changes were noted for the MDS-UPDRS-III, ten-meter walk test, or the PDQ-39 summary score. Exploratory analysis of the different subsections for the Mini-BESTest and PDQ-39 showed the most improvement in dynamic gait ($p = 0.056$) and mobility ($p = 0.062$), respectively.

## Discussion

For this intervention, we applied evidence from the literature to create an educational, community-based group program that informed people about FOG and provided a safe place to practice strategies to reduce FOG. Physical therapists knowledgeable about PD and FOG created and led the 6-week 'FOG Boot Camp' at the APDA located in a suburb of St. Louis, Missouri. We investigated the feasibility, safety and acceptability of this multicomponent intervention and our study had several key findings.

In congruence with our hypotheses, attendance was high with all participants attending four or more of the six classes, there were no falls or injuries during the program, and participants reported the content, instructors and group atmosphere were all beneficial. From the clinicians' perspectives, advancing through the program systematically, presenting multiple movement training strategies, involving the participants in the decision making process, having care partners attend, allowing practice time, and the group environment were all key components of the program. Advancing through program systematically was important for each participant in understanding which strategies would work best for them. While certain strategies received more positive feedback (3-2-1 Go, imagining a clock on the ground when turning, and walking to music), it was evident that making the participant a partner in the decision making process of determining what was effective was fundamental. The obstacle course was helpful for participants and care partners to better understand what triggers freezing episodes as they move through different environments. Involving the care partners in the process was valuable as they learned how to better support their partners with PD. The group enjoyed their time in the program with almost all commenting that they would have liked to have more time to practice and share their experiences with their peers in the group.

We also predicted improvement on motor assessments. Scores on the Mini-BESTest and 2-min walk significantly improved, with a trend toward improvement on the nFOG_Q. Participants had an average decrease of three points on the nFOG_Q; this is larger than the one point decrease seen on the nFOG_Q in a study examining the benefits of a home-based cueing program designed to address FOG and falls [33]. On the 2-min walk test, participants improved on average by 55 feet. This over ground walking test was 32.8 feet long and required participants to make turns at each end of the walkway. The increase in amount of ground covered is likely related to a reduced number of freezing episodes, particularly during turns. The ten-meter walk test did not show significant differences between baseline and post-test evaluations, however, an increase of 0.09 meters per second aligns with the clinically significant milestone of 0.10 meters per second. In addition, while better scores on the Mini-BESTest were present across all four subsections, the most improvement was in dynamic gait. The improvements on these walking tests likely correspond to strategies discussed and practiced during boot camp.

Changes on the MDS-UPDRS-III and the quality of life measure did not support our hypotheses. A 4-month study looking at the sensitivity of change for the PDQ-39, noted 4 months is a short period of time to expect change in the overall PDQ-39 score while they did see mobility decline within this short time period [34]. This is in keeping with our results, showing impact on the mobility subscore but no change in overall PDQ-39 in this short, 6-week study.

### Limitations

This study is not without limitations. First, our sample size is small and the statistical tests need to be replicated in a larger sample. However, this pilot study and the raw effect sizes suggest the intervention should be investigated further. Second, a source of bias for our motor assessments may include nonblinded raters on the motor tests. The ratings on the standardized motor tests were done by trained physical therapists who knew the participants signed up for the FOG boot camp. They were not, however, knowledgeable about the participant's efforts or attendance during the program, nor the details of the program as the classes were taught by different physical therapists. Third, variability in response to anti-PD medication could have affected participants' performance. In an effort to control for this, we kept appointment times consistent between time points. Future studies should consider testing participants off anti-PD medication to better control for this limitation. Lastly, all participants scored high on the MMSE, a measure of global cognition. While many cognitive tasks show no differences between people with PD and healthy controls indicating potential to learn new techniques and understand FOG mechanisms, some studies suggest persons with FOG have more cognitive deficits than persons without FOG [11]. Thus, this educational program should be tested in people with a wider range of cognitive abilities before being generalized to people who experience FOG as a whole.

This study also identified areas where modifications to study design could be helpful for future investigations. A future hypothesis-driven study examining the educational program should be powered to detect clinically meaningful changes in gait speed, FOG and permit exploration of how different presentations of freezing (i.e., severity of FOG, duration, shuffling versus trembling) respond to certain strategies [1]. Future work could also include a control group with education only to better understand the importance of the practice component. It would also be useful to track falls before, during and after the intervention and monitor gait throughout the study via activity monitors in the real-world.

Modifications to the program itself should consider feedback from our participants. While they enjoyed the content, instructors and group, they wanted more sessions and more time to practice the strategies. It is also important to offer community-based options led by experts knowledgeable of PD so individuals with PD feel comfortable and supported rather than embarrassed about their condition, and are able to exert autonomy [7,35].

## Conclusion

In this study we sought to understand the feasibility of an educational program addressing transient episodes of freezing in a community group setting. Attendance was high, there were no adverse events, and our participants benefited from learning about their symptoms, practicing strategies to overcome freezing episodes and being with other people with PD. Moreover, we saw improvements on balance and walking tests and reduced freezing after the 6-week FOG boot camp. Future work is needed to determine the effectiveness of this program which could easily be adopted by physical therapists in community settings.

## Future perspective

If future studies examining this intervention continue to yield positive results we anticipate providing educational materials to professionals in order for these practices to be implemented in other communities.

### Summary points

- Freezing of gait (FOG), an episodic inability to produce effective stepping, is highly debilitating for people with Parkinson's disease (PD).
- Empowering individuals experiencing FOG with education and practical strategies to overcome freezing may promote independent living and reduce falls.
- 'FOG Boot Camp' was designed and led by qualified rehabilitation professionals and included education and group discussions about FOG, introduction to strategies to overcome FOG, and in-class practice once a week for 6 weeks.
- In this pilot study, we examined feasibility, acceptability, safety, as well as preliminary efficacy using the New Freezing of Gait Questionnaire (nFOG_Q), Mini-Balance Evaluations System Test, motor subsection of the Movement Disorder Society-Unified Parkinson Disease Rating Scale (MDS-UPDRS-III), Parkinson Disease Questionnaire-39 and gait speed measures before and after the 6-week intervention.
- Class attendance was high and there were no falls or injuries. Participants reported they enjoyed the class and being with others who had similar symptoms.
- We saw improvements in gait and FOG measures.
- Future work should address this type of intervention in larger samples of people with PD who experience FOG and examine optimal dose of the intervention as well as durability of its effects.

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### Author contributions

KS Rawson: acquisition, analysis and interpretation of data, drafting and revising the work, final approval, agreement to be accountable for all aspects of the work. P Creel: substantial contribution to conception and design, drafting and revising the work, final approval, agreement to be accountable for all aspects of the work. L Templin: substantial contribution to conception and design, revising the work, final approval, agreement to be accountable for all aspects of the work. AP Horin: substantial contribution to the design, acquisition of data, revising the work, final approval and agreement to be accountable for all aspects of the work. RP Duncan: substantial contribution to conception and design, acquisition and interpretation of data, revising the work, final approval and agreement to be accountable for all aspects of the work. GM Earhart: substantial contribution to conception and design, acquisition, analysis and interpretation of the data, drafting and revising the work, final approval and agreement to be accountable for all aspects of the work.

### Financial & competing interests disclosure

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No writing assistance was utilized in the production of this manuscript.

### Ethical conduct of research

The authors state that they have obtained appropriate institutional review board approval or have followed the principles outlined in the Declaration of Helsinki for all human or animal experimental investigations. In addition, for investigations involving human subjects, informed consent has been obtained from the participants involved.

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