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High-Intensity Exercise in Community-Based Boxing Improves Functional Limitations in Individuals with Parkinson's Disease

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ABSTRACT

International Journal of Exercise Science 17(3): 1493-1503, 2024. Various exercise types may slow disease progression and improve physical function for people with Parkinson's disease (PWP), including community-based boxing programs (CBP). Recent research suggests that high-intensity exercise may result in greater benefits for PWP. Participants in CBP, which are typically self-paced, may not be reaching this optimal intensity. This study examines if it is feasible and beneficial for PWP to perform high-intensity exercise in a CBP. Seven subjects diagnosed with Parkinson's disease participated in a multimodal CBP twice a week for six weeks while wearing heart rate (HR) monitors to help maintain an HR of 70-85% of the age-predicted maximum. Subjects completed pre- and post-testing, including Functional Gait Assessment (FGA), Five Time Sit to Stand (5xSTS), Timed Up and Go (TUG), and Activities-Specific Balance Confidence Scale (ABC). Data were analyzed using descriptive statistics, and paired-sample t-tests were used to evaluate improvements ($p < 0.05$) from baseline. Both Cohen's d and minimally clinically important difference (MCID) were used to evaluate effect size and efficacy. Subjects completed 37.99±8.20 minutes of high-intensity interval training (HIIT) exercise. Results demonstrated significant improvement in FGA, TUG, and 5xSTS with large effect sizes and surpassing the MCID for the FGA and 5XSTS. It is feasible for PWP to perform high-intensity exercise in a CBP, which may improve balance and functional strength.

KEY WORDS: Group training, physical therapy, community exercise

INTRODUCTION

Parkinson's disease (PD) is a neurological disorder with progressive motor and non-motor symptoms (31). The primary pathological features of PD are the loss of dopamine-producing neurons in a part of the brain called the substantia nigra, which controls movement, as well as the presence of Lewy bodies, which are clumps of abnormal proteins (2, 11). Around 1 million Americans have PD, making it the second most common neurodegenerative disorder (9). With the increasing age of the general population, this number is expected to double in the next twenty years (9). PD currently has no cure, and no disease-modifying treatments are currently available (9, 31). The combination of increased prevalence, along with a lack of disease-modifying treatments, may mean that PD is an emerging socio-economic burden and public health challenge (9).

PD symptoms may include bradykinesia, tremor, rigidity, cognitive dysfunction as well as gait and balance impairments (31). These symptoms may be alleviated with surgical procedures, such as deep brain surgery or medications, including dopaminergic replacement; however, they may have complications, and their efficacy may wane over time (11, 18, 31). Physical exercise is emerging as an effective treatment to slow disease progression and alleviate symptoms for people with Parkinson's disease (PWP) (11, 19, 26). Physical exercise interventions may focus on increasing muscular strength and aerobic capacity, as well as improving balance, gait, and functional mobility (11, 19, 26). Physical exercise may lead to neurobiological changes in PWP, including inducing neuroplastic changes and releasing neurotrophic factors (11). Clinically, this may manifest as improved functional capabilities, including improved balance, gait, strength, and activities of daily living (11).

One popular exercise modality for PWP is non-contact, community-based boxing programs (CBP), which specifically have been shown to safely improve motor impairments, mobility, gait, and quality of life in PWP (7, 19, 24). As these are typically group exercise programs, PWP may also benefit from the social interaction afforded by these programs and the functional effects of exercise (11). Although exercise (including CBP) is recommended for PWP, little literature exists regarding the optimal dosage of exercise for PWP (1, 19, 20, 29). Recently, the American College of Sports Medicine (ACSM) and the Parkinson's Foundation created exercise recommendations for PWP, recommending a minimum of 90 minutes of moderate to vigorous aerobic exercise a week, as well as 2-3 days of strength training targeting all the major muscle groups (27). Additionally, the exercise recommendations included 2-3 days of balance, agility, and multi-tasking training, as well as at least 2-3 days of flexibility training (27).

Previous literature has demonstrated that some forms of aerobic exercise, including treadmill walking and stationary cycling, showed that supervised higher-intensity exercise improved outcomes for PWP (23, 30). Evidence suggests that higher intensity exercise (above 70% of maximal oxygen uptake {VO2}) may result in greater levels of neuroplasticity and have larger effects in delaying motor dysfunction when compared to low (37-45% VO2) and moderate intensity (45-63% VO2) exercise (12, 19, 30, 32). CBPs are typically self-paced and utilize Ratings of Perceived exertion (RPE) to gauge intensity (24). Recent research suggests that solely relying on self-reports on perceived exertion may not be accurate for PWP (19). Therefore, CBP participants may not exercise at an optimal intensity and thus may not reap the full benefits from this mode of exercise (19). Currently, no studies have examined the effect of higher-intensity exercise in CBP (23, 30). This study sought to determine if it is feasible and beneficial for PWP to perform high-intensity exercise in a CBP. We hypothesize that high-intensity exercise would be feasible in this exercise setting, and that it would lead to improved outcomes for PWP, specifically gait and balance.

METHODS

Participants

An a priori power analysis with G*POWER 3.1 (Universitat Kiel, Germany) revealed that 8 participants were needed for a power of 0.80, an alpha level of 0.05, and an effect size of 1.0, which was previously reported in the literature for the outcome measures of interest in this study (5, 13). Initially, 8 subjects were recruited to participate in the study. One subject did not participate in at least 9 of the sessions, and that subject's data was excluded from the final analysis. Inclusion criteria included a clinical diagnosis of mild-to-moderate Parkinson's disease, being at least 21 years of age, ability to speak English fluently, having reliable transportation to the classes, able to participate in classes twice weekly for the duration of the study (6 weeks), available to participate in at least 80% (9) of the exercise sessions, able to stand/walk for 10 consecutive minutes, be able to ambulate independently (without any physical assistance) in the home, with or without an assistive device; be able to follow at least 3-step verbal commands. Subjects were excluded from the study if having undergone surgery in the past 6 months, receiving physical or occupational therapy services at the time of the investigation, currently pregnant, taking medications that interfere with heart rate response to exercise, any other significant comorbidity that would preclude safe exercise participation. Subjects were recruited by word-of-mouth communication and paper flyers distributed throughout the community and at local medical centers. This research was carried out in full accordance with the ethical standards of the *International Journal of Exercise Science* (25). It was reviewed and approved by the Institutional Review Board of DeSales University. Descriptive data on the seven participants who completed the study in its entirety is included in Table 1.

Table 1. Descriptive characteristics (n=7)

Age	73.8 ± 8.6 yrs
Height	174.4 ± 7.1 cm
Body Mass	72.5 ± 12.5 kg

Protocol

Subjects were screened for the ability to provide consent using the University of California San Diego Brief Assessment of Capacity to Consent (UBACC). If the participant did not meet the scoring criteria included on the Modified UBACC, the participant was not enrolled in the study. Additionally, every subject completed an informed consent. After completing informed consent, subjects completed a physical activity readiness questionnaire (PAR-Q) to screen for any risk factors that would preclude them from safe participation in the study. If a subject answered yes to any of the initial seven questions on the PAR-Q, the subject was then asked follow-up questions about their medical conditions. If the subject answered no to all the follow-up questions, they were determined to be cleared to participate in physical activity and were enrolled in the study. If a subject answered yes to any of the follow up question, then they would have been instructed to follow up with their physician for approval to participate in the study; however, no subjects answered yes to any of the follow-up questions.

All subjects were tested before beginning (pre-test) and after (post-test) completing the 6-week exercise intervention. Testing sessions were completed on different days from the exercise sessions to avoid fatigue, and all tests were completed on the same day. Subjects taking medications for PD had testing conducted about one hour after their medication to increase patient safety. The pre- and post-testing used the following battery of tests: Functional Gait

Assessment (FGA), Five Time Sit-to-Stand (5TSTS), Timed Up and Go (TUG) test, and the Activities-Specific Balance Confidence Scale (ABC); all were performed in accordance with standardized guidelines and instructions. The TUG is a valid and reliable assessment of balance and functional mobility, with Parkinson's specific scores to determine an individual's risk of falls (3, 4, 21). The ABC is a subjective measure of an individual's confidence in their balance while performing various functional walking activities and has been shown to predict future falls in PWP (21). The 5TSTS is a valid and reliable measure of functional lower extremity strength and determines fall risk in PWP (10). The FGA measures postural stability and an individual's ability to perform multiple motor tasks during ambulation and has been shown to be valid and reliable in PWP (33, 34). Testing sessions lasted for approximately 30 minutes. The pre- and post-testing, as well as all of the exercise classes were conducted at the DeSales University Community Wellness and Physical Therapy Clinic. The exercise classes were not established at this site prior to the start of the study.

After assessing the capacity to provide consent, informed consent, screening, and pre-intervention testing were completed, and subjects participated in a community-based boxing program. The program itself was designed to meet current exercise guidelines for PWP (27). Sessions were held twice weekly for the 6-week duration of the study. Exercise sessions lasted approximately 60 minutes, including a 10-minute warm-up, 30 minutes of boxing drills, 10 minutes of strength and endurance exercises, and a 10-minute cool-down. The warm-up included multi-planar movements involving ranges of motion used in the subsequent portions of the workout, dynamic stretches, and agility activities. The boxing drills were informed and executed in accordance with the protocols previously described in the literature (7, 8). Both the warm-up and boxing portion utilized activities to improve balance, agility, and multi-tasking abilities, including multi-directional stepping, weight shifting, large amplitude movements, functional agility, and cognitive drills (27). The strength and endurance exercises utilized all major muscle groups and involved 10-15 repetitions of each exercise (27). Each exercise session was led by at least one licensed physical therapist with additional advanced clinical certifications. Boxing drills included jabs, hooks, and uppercuts, coupled with cognitive activities. Participants wore boxing gloves but did not contact others. The cool-down portion of the workout included walking to gradually decrease heart rate, prevent blood pooling, and improve venous return. The cool-down also involved static stretching for all major muscle groups, held for 30 seconds, with two repetitions of each exercise completed (27).

Participants heart rate was monitored using Polar Heart rate sensors (Polar Electro Oy, Kempele, Finland) and an iPad (Apple Inc, Cupertino, California) application, the Polar Team app, that allowed the researchers to monitor the heart rates of the participants in real-time. After the warm-up, exercise intensity was monitored by investigators throughout the session such that participants maintained a heart rate (HR) of 70-85% of age-predicted-max HR (MHR). Investigators verbally encouraged participants to increase exercise intensity as needed to maintain target exercise intensity. If a participant's HR exceeded target HR range, participants were instructed to rest or decrease exercise intensity. Additionally, the application tracked the amount of time that participants spent in each of the estimated maximal heart rate zones, with zones defined as zone 1: 50%-60% MHR; zone 2: 60%-70% MHR; zone 3: 70%-80% MHR; zone

4: 80%-90% MHR; zone 5: 90%-100% MHR. The class was structured using protocols for high-intensity interval training (HIIT), which involves high-intensity exercise intervals interspersed with rest periods (15). Participants completed the boxing drills in 1:1 work rest (1-minute work 1-minute rest) or 1-minute work to 45 seconds of rest. During the strength and endurance exercises, a 1:1 work-to-rest ratio was achieved, with 1 minute of work and 1 minute of rest. The overall intent of the high-intensity portion of the workout was to complete 20-30 minutes of moderate to vigorous exercise (14) with at least 30 minutes of continuous or intermittent exercise per session (27).

Statistical Analysis

Heart rate data recorded by the Polar Team app were exported to Microsoft® Excel® (Version 2408, Redmond, WA: Microsoft Corporation). All data were analyzed using Intellectus Statistics® (version 4.8.23, Clearwater, FL: Intellectus369). All descriptive data are reported as mean (M) ± standard deviation (SD). Descriptive data for the heart rate responses were evaluated using descriptive statistics, including percentages of time spent in individual heart rate zones. Data normality was assessed using the Shapiro-Wilk test, skewness, and kurtosis. After meeting the assumptions of normality, paired-samples t-tests were used to determine if there were statistically significant differences in the pre-test scores of the outcome measures (FGA, 5xSTS, TUG, ABC) compared to the post-test scores. An a priori level of significance was set at $\alpha = 0.05$. Effect size was calculated using Cohen's d and was interpreted as follows: 0.2 small effect size, 0.5 medium effect size, greater than or equal to 0.8 large effect size (6). Additionally, the minimally clinically important difference (MCID), the score that reflects the smallest difference in an outcome measure that the subject perceives as beneficial, was used to evaluate the efficacy of the intervention (17).

RESULTS

Time (weekly averaged minutes) spent in each heart rate zone during the intervention is summarized in Table 2, including a combined time spent in zones 3-4, and zones 2-4. The percentage of the class (weekly averaged minutes) spent in each heart rate zone is displayed in Figure 1, including cumulative time spent in zones 3, 4, and 5 (moderate to high-intensity training) and zones 2-4 (included rest times required of HIIT training). Over the course of the 6-week intervention, average class time was 58.90±3.71 minutes.

Table 2. Time spent in each heart rate zone (M±SD)

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zones 3+4+5	Zones 2+3+4+5
Time in Zone	20.92 ±7.58	22.42 ±6.41	12.78 ±5.47	2.63 ±1.87	0.15 ±0.33	15.57 ±6.17	37.99 ±8.20

The results (means and SD) for the pre-tests (measured prior to the start of the 6-week intervention) and post-tests (measured at the completion of the 6-week intervention) for each outcome measure and the paired samples t-test results are summarized in Table 3. There were statistically significant changes between the pre- and post-tests for all outcome measures except the ABC. A large effect was also seen for these tests. Additionally, participants demonstrated improvements surpassing the MCID for the FGA and the 5xSTS (22, 28).

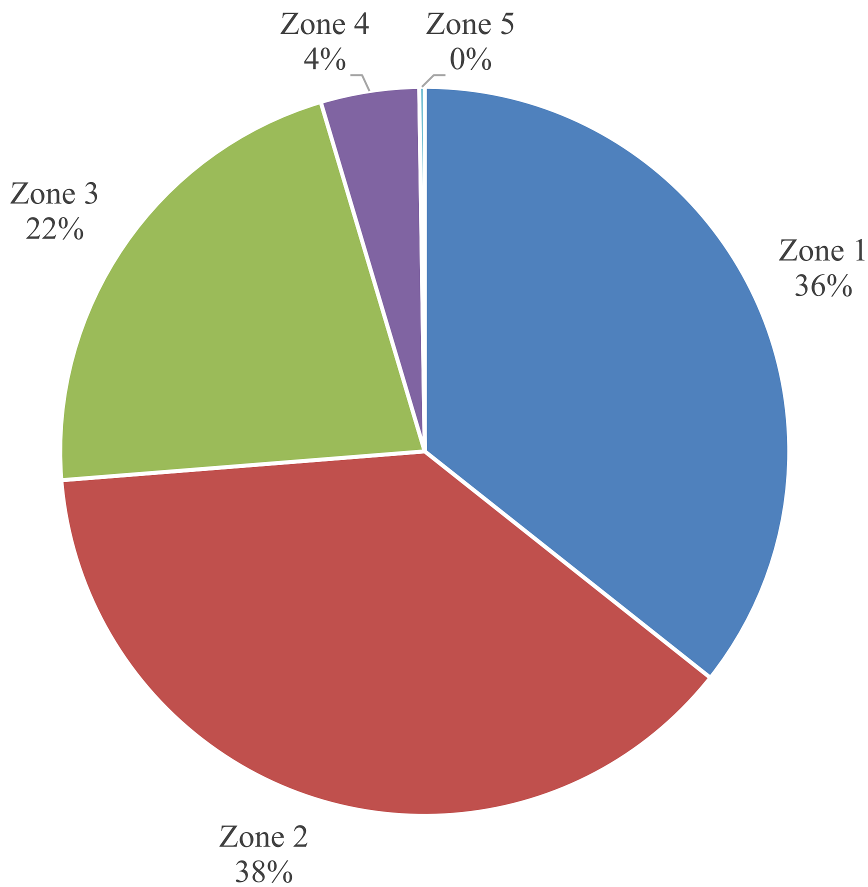

Figure 1. Percentage of total class time spent (on average) in respective heart rate training zones.

Table 3. Results of Paired Samples t-Test

FGA (Pre-test)		FGA (Post-test)				
M	*SD*	*M*	*SD*	*t*	*p*	*d*
23.17	2.86	28.67	1.21	-5.55	.003*	2.26#
TUG (Pre-test)		TUG (Post-test)				
M	*SD*	*M*	*SD*	*t*	*p*	*d*
8.68	1.15	7.25	0.99	3.98	.011*	1.63#
5xSTS (Pre-test)		5xSTS (Post-test)				
M	*SD*	*M*	*SD*	*t*	*p*	*d*
10.67	2.42	8.17	2.40	3.50	.017*	1.43#
ABC (Pre-test)		ABC (Post-test)				
M	*SD*	*M*	*SD*	*t*	*p*	*d*
87.66	4.44	92.18	4.22	-2.45	.058	1.00

* denotes significant result. # denotes large effect size. FGA = Functional Gait Assessment. TUG = Timed Up and Go Test. 5xSTS =Five Time Sit-to-Stand Test. ABC = Activities-Specific Balance Confidence Scale.

DISCUSSION

The purpose of this investigation was twofold. First, it sought to determine whether it was clinically beneficial for PWP to perform high-intensity exercise in a CBP, and second, whether it is feasible for PWP to perform high-intensity exercise in a CBP.

Results suggest that the CBP benefited PWP, as there were increases from baseline for all outcome measures. These increases were statistically significant for the 5xSTS, TUG, and FGA, with large effect sizes seen for these outcome measures, indicating that the improvement in lower extremity strength, balance, and functional mobility were large in magnitude. Additionally, increases for the 5xSTS and FGA surpassed the MCID for these tests, indicating clinically significant improvements in lower extremity strength and stability while walking to a point where the subject can perceive these changes as beneficial. These results are consistent with other studies that have shown improvements in functional ability with CBP, particularly balance (7, 19, 24). Parkinson's is a neurodegenerative disease, with functional losses in balance, lower extremity strength, and gait expected as the disease progresses. Subjects were not only able to maintain but, in fact, demonstrated significant improvements despite the progressive nature of Parkinson's disease. The only outcome measure that did not have a statistically significant increase was the ABC, which is a subjective measure of an individual's confidence in their balance during various walking scenarios. It has been reported previously that there may be a ceiling effect for this measure, with scores over 80 being unlikely to improve their balance confidence after completing physical activity programs (16). In the present study, at baseline participants scored 87.66±4.44, well above this upper limit for improving balance confidence. Future studies may consider using a different measure of balance confidence and fear of falling to better assess improvements in this domain.

During the study, no adverse events occurred. Participants completed 15.57±6.17 minutes of training at the moderate to vigorous intensity levels. When adding in the rest periods (Zone 2 training) required of HIIT style exercise programs, participants exercised for 37.99±8.20 minutes. When accounting for time spent in Zones 2-4, participants did meet exercise recommendations for PWP, which is at least 30 minutes of continuous or intermittent exercise per session (27); however, they were not able to accumulate the recommended 20 minutes of moderate to vigorous intensity exercise (14). These results demonstrate that it is feasible for PWP to perform high-intensity exercise in a CBP. Participants may not have met the recommendations for moderate to vigorous exercise because most participants were not performing regular exercise prior to the start of the study. It is recommended to start at moderate intensity exercise, and as fitness and tolerance to higher intensities increases, that exercise is then progressed to vigorous intensities when it is physiologically appropriate and safe to do so (27). Future studies may examine if more high-intensity exercise can be accumulated by following subjects over periods of time longer than the 6-weeks duration of this study. Despite not meeting the recommended amount of vigorous exercise, participants did benefit from the program, as described above. The program was designed using current exercises recommendations for PWP, including incorporation of multiple types of training, including high intensity interval, resistance, balance, and flexibility. The improvements seen in lower extremity strength, balance, and walking ability can likely be accredited to the multimodal nature of the program, as participants did meet exercise recommendations for the other forms of training.

This study is not without limitations. One of the main limitations is that this study lacked a control group. Future studies examining the effects of high-intensity exercise in a CBP should include a control group exercising at a self-paced intensity level to determine if the benefits of high-intensity exercise in this setting exceed the benefits seen with self-paced exercise. There was a single female participant in the study, and all participants were high functioning; thus, the results should be interpreted with caution and not be extrapolated beyond this population. Additionally, this study is slightly underpowered due to attrition, as one subject did not complete the required nine sessions, and the data from this subject was excluded from the final analysis. This study only examined the effects of the CBP over six weeks. Future studies should examine how a CBP may benefit PWP over a longer time by potentially helping to slow the decline in quality of life as the disease progresses.

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