PRDOA 6 (2022) 100137

Contents lists available at ScienceDirect

Clinical Parkinsonism & Related Disorders

journal homepage: www.sciencedirect.com/journal/clinical-parkinsonism-and-related-disorders

Associations between exercise classes and self-reported exercise by people with Parkinson's disease at Parkinson's foundation centers of excellence

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ARTICLE INFO

Keywords:
Parkinson's disease
Exercise
Physical activity
Exercise classes

ABSTRACT

Introduction: Despite evidence of the benefits of exercise, people with Parkinson's disease (PD) often exercise less than recommended. We sought to identify exercise class-related factors associated with the amount of exercise in PD communities.

Methods: We used Parkinson's Outcome Project (POP) data from 3146 people with PD at 19 participating Centers of Excellence (COEs). POP data included self-reported moderate-vigorous exercise (MVE) hours, light physical activity (PA) hours, demographic and disease severity variables. We also collected information about weekly exercise class availability, intensity, cost, and distance from class location to the COE. We examined differences between COE-based and community-based exercise classes using the Akritas test for paired and unpaired samples. We tested associations between class characteristics and exercise hours based on a two-part model: logistic regression on whether a participant does MVE or light PA and linear regression for log-transformed time of exercise.

Results: Community-based exercise classes had a significantly higher weekly availability than COE-based classes (class hours per week: 47.5 ± 25.6 vs 6.5 ± 8.6, $p < 0.001$), a higher percentage of vigorous-intensity classes (24.2 ± 17.8 vs 11 ± 14.7, $p < 0.001$), and a broader geographic distribution (miles to COE: 12.8 ± 4.6 vs 6.2 ± 5.7, $p < 0.001$). Greater weekly hours of availability, intensity, and distance to COE were associated with increased MVE and light PA hours among participants who exercised ($p < 0.01$). Of these, higher weekly class availability explained the most variability in reported exercise hours.

Conclusion: Parkinson's COEs may be able to increase exercise by facilitating a high weekly availability of exercise classes with higher intensity levels and broader geographical distribution.

1. Introduction

There is growing evidence to suggest that increasing exercise alleviates the motor and non-motor symptoms of Parkinson's disease (PD), including physical functioning, quality of life, muscle strength, balance, emotional and cognitive domains, and gait speed [1–3]. According to findings from the Parkinson's Outcome Project (POP), maintaining at least 2.5 h of exercise per week is associated with slower declines in quality of life compared to people with PD who do not exercise regularly [4]. While moderate and vigorous intensity exercise programs may have the greatest clinical impact, simply increasing levels of physical activity (PA) to meet the minimum of 2.5 h per week can improve physical health-related quality of life among people with PD [5]. Unlike exercise, which is a subset of PA that is planned, structured, repetitive, and done

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https://doi.org/10.1016/j.prdoa.2022.100137
Received 3 September 2021; Received in revised form 20 January 2022; Accepted 7 February 2022
Available online 15 February 2022

for a specific purpose to improve or maintain fitness, PA is defined more broadly as any bodily movement produced by skeletal muscles that results in energy expenditure [6]. Therefore, as a supplement to medications, medical centers treating patients with PD should be actively promoting both moderate-vigorous exercise (MVE) and any PA [2].

Despite the evidence that exercise and PA can be beneficial for PD, people who are diagnosed with PD often exercise less than recommended and have decreased muscle strength and functional ability both as a consequence of lack of exercise, and as a symptom of PD [1,2,4]. Studies examining the perceived barriers to exercise among people with PD have found that lack of time to exercise, fear of falling, disease-specific impairments, and lack of convenient locations were among the main barriers [7,8]. While there is widespread evidence of the benefits of exercise for PD, barriers to exercise continue to limit exercise engagement by people with PD.

Although there are many studies on the barriers to exercise, there is limited information on how to help people with PD to exercise more. The purpose of our study was to investigate the associations between exercise class characteristics and self-reported exercise using a combination of POP data and novel data collection on exercise classes at the COEs and within their communities. We investigate the weekly availability, intensity, cost, and location of classes sponsored directly by the COE compared to exercise classes in the surrounding community. We hypothesized that greater exercise class availability, more locations, and lower costs would be associated with higher levels of exercise.

2. Methods

The Parkinson's Foundation POP, which was launched in 2009, is an international patient registry that collects information on individual characteristics, medical history, outcomes including quality of life, as well as medical, surgical, and rehabilitation management at annual study visits [9]. The goal of the registry is to provide opportunities to measure best practices. The data considered for our project was derived from 19 out of the 29 COEs that are participating in the POP. We excluded nine COEs because they were outside of North America, and we excluded one North American COE because it was a newly designated COE and therefore did not have sufficient data collected.

We limited our data analysis to data collected from patients who were being treated in outpatient neurology clinics. We excluded patients in inpatient rehabilitation, as well as those who were missing exercise data, from analysis. Participants with PD were recruited consecutively for the POP as they came to participating COEs for an appointment [9]. Any patient receiving medical care for a PD diagnosis at a COE participating in the POP was eligible for enrollment in the POP database with no limitations for participation based on age, disease severity, or cognitive impairments [9,10]. Clinical experts in movement disorders confirmed the PD diagnosis of all POP participants [9]. The POP is approved by each site's Institutional Review Board (IRB), and all participants included in the POP database provided informed consent [9]. The present analysis was deemed exempt by the Beth Israel Deaconess Medical Center IRB.

2.1. Participant demographics

Participants were categorized into one of four disease stage categories based on where they fell on the Hoehn and Yahr scale (HY) [10]. The individuals whose data were used in our study included 195 (6.2%) Stage 1 patients, 1648 (52.4%) Stage 2 patients, 922 (29.3%) Stage 3 patients, 306 (9.7%) Stage 4 patients, and 75 (2.4%) Stage 5 patients. HY stages 4 and 5 were combined in data analysis. Our sample included a predominance of women with 2022 (64.3%) female patients and 1124 (35.7%) male patients. The average age of onset was 69 years old. The majority of participants identified as non-Hispanic/Latino (95.1%) and White (93.9%), with 4.9% who identified as Hispanic/Latino and 6.1% who identified as non-White.

2.2. Measurement

To supplement the POP data regarding reported exercise hours among people with PD, we collected data examining the weekly availability, intensity, cost and location of (1) COE-based and (2) community-based exercise classes. We contacted center coordinators to request information about how many exercise classes the COE runs for people with PD, a list of available classes including the zip codes, and the cost of the available classes. The study team also requested this same information about community-based PD exercise classes offered within a 25-mile radius surrounding each COE. The study team completed web-searches and made phone calls to community-based exercise classes when necessary to fill in information that COE coordinators were unable to provide.

2.2.1. Self-reported hours of exercise from the POP

Exercise amount and intensity within the POP dataset were collected in three categories: light activity, moderate intensity exercise, and vigorous intensity exercise. When looking at the effects of different exercise class factors on reported exercise hours, we considered two outcomes regarding reported exercise hours: 1) MVE hours and 2) light PA hours.

2.2.2. Weekly class availability

To examine the availability of exercise classes offered at and around the COEs, we created a variable taking into account the frequency with which classes were offered and the duration of the classes. Specifically, for each identified class, we multiplied the weekly frequency by the duration of the class (e.g. 45 min, three times per week equals 2.25 h per week). Then this weekly availability was summed for COE-based and for community-based classes at each center. We adjusted the weekly class availability by the size of the COE (per 1000 patients) based on estimated number of patients with PD seen per year.

2.2.3. Class intensity

To examine the effects of class intensity on reported exercise hours, we looked at the proportion of classes that are high intensity. We determined a class's intensity by comparing the description of the exercise class to the examples provided on the POP data collection forms and drawing from the clinical experience of the study team. Table 1 reports the examples provided on the POP data collection form mapped to exercise class titles. When the COE coordinator did not know the intensity of a class, and information about class intensity was not available online, a study team member attempted to contact staff from the exercise class to obtain the missing information.

2.2.4. Cost of classes

To examine the cost of COE-based and community-based classes, we categorized each class as either 'free' or 'not free.' We then looked at the proportion of all classes that were free in order to examine the effect of free classes on reported exercise hours.

2.2.5. Distance of classes to COE

To examine the geographical distribution of exercise classes, we looked at the location of each exercise class in terms of distance to the COE. We used Google Maps™ to determine distance in miles to the COE by calculating the distance between the class and COE based on their addresses.

2.3. Statistical analyses

We examined differences in weekly class availability, intensity, cost, and distance from class location to COE using descriptive statistics. These differences between COE-based and community-based classes were compared using the Akritas test, which deals with both paired and unpaired samples (5 centers had community classes but did not have

Table 1
Parkinson's outcomes project (POP) exercise data collection question: exercise intensity examples mapped to exercise class types.

POP Exercise Questions: Ask three times replacing the underlined language with each level of activity and examples: Vigorous intensity exercise, followed by moderate intensity exercise, and finally light activity: How many hours a week *(or min/day and day/week and RA calculate)* do you do vigorous activity or exercise such as running, fast biking or strenuous weight lifting? *(if patient has difficulty answering, provide additional examples that are appropriate for the patient or use pictures to explain intensity)*

Exercise Intensity	Exercise examples provided in POP data collection form	Example class types categorized in each intensity
Vigorous Intensity Exercise	• Jogging or running • Fast biking • Stair climbing for exercise • Swimming laps • Weight lifting	• Rock Steady Boxing (high intensity) • PWR! • Spin class • High Aerobic Exercise for Parkinson's
Moderate Intensity Exercise	• Fast/brisk walking pace or walking on hills • Dancing • Tai chi, yoga, Pilates • Arm or leg cycling • Pool aerobics	• Tai Chi • Dance for PD • Pedaling for Parkinson's • Strength training • Pilates
Light Activity	• Walking at a usual or leisurely pace • Chores in house or yard • Seated exercise routine	• Chair yoga • Mindful stretch • Seated exercise

COE classes) [11]. Due to the zero-inflated and skewed distribution of the exercise hours, we used a two-part model, a combination of a logistic regression model and a linear regression model, to examine the associations between our two outcomes (MVE and light PA hours) and each of our 4 independent class variables (weekly class availability, class intensity, class cost, and class distance to the COE), controlling 9 covariates (age, gender, race, HY stage, ethnicity, education, disease duration, number of comorbidities, and number of currently used medications). Specifically, logistic regression was first used to model the probability of an individual exercising any hours (exercise hours greater than 0). Then the linear regression was applied to fit all log-transformed non-zero exercise hours, which estimated the association of the independent variable with exercise duration in people who were doing some exercise. Since the exercise hour was log-transformed, smearing estimator was provided to illustrate the association between the independent variable and exercise duration on the entire sample. We then combined the results of these two models to estimate the effects of independent variables on exercise behaviors. To compare the associations of four class independent variables with exercise hours, we computed root mean squared error (RMSE) and compared RMSE by adding each independent variable separately in the baseline model adjusting for nine covariates. We then used another model comparison in which each one of the four independent class variables were deleted separately from the full model that includes all nine covariates and all four independent class variables.

3. Results

3.1. Patient characteristics and study flow

From the initial cohort of 13,200 individuals, 3454 individuals were excluded because they were patients at one of the ten excluded COEs, 750 individuals were excluded because they lacked at least 90% certainty of a PD diagnosis, 5258 individuals were excluded because they lacked records in and after 2016 when the POP started collecting self-reported exercise information, and 592 individuals were excluded due to missing covariate values (age, gender, race, HY stage, disease duration, ethnicity, and education). The remaining 3146 individuals were included in the statistical analyses. Common comorbidities in the sample included back pain (n = 1629, 52%), depression (n = 1139, 36%), osteoarthritis (n = 1087, 35%), high blood pressure (n = 970, 31%), heart or lung disease (n = 585, 19%).

3.2. Comparing COE-based exercise classes to community-based exercise classes

Table 2 presents that a higher proportion of classes were located in the community compared to those located at the COE itself. There were more community-based exercise classes offered at a high intensity than COE-based classes. There was no statistically significant difference in the proportion of free classes between COE-based and community-based exercise classes. The community-based classes had a greater distance to the COE.

3.3. Extent to which exercise class variables are associated with amount of MVE and light PA

Table 3 presents the results of two-part modeling, with a logistic regression model for adjusted odds of doing MVE or light PA (yes/no) compared to no exercise, as well as a linear regression model for log-transformed exercise time among those who exercised.

Weekly class availability was positively associated with the odds of doing any light PA, and increased hours of MVE and light PA among those who exercised. With a one hour increase in weekly class availability, there would be an increase of 1.3% (95% confidence interval (CI): 0.8% to 1.7%) in odds of doing any light PA, an increase of 0.4% (95% CI: 0.2% to 0.6%) in hours of MVE among those who did MVE, and an increase of 0.8% (95% CI: 0.6% to 1.0%) in hours of light PA among those who did light PA. With the two models combined, a one hour increase in classes per week was associated with an average increase of 0.021 (95% CI: 0.009 to 0.032) hours (1.3 min) of MVE and 0.046 (95% CI: 0.029 to 0.065) hours (2.8 min) of light PA per week.

The proportion of high intensity classes also was positively associated with the odds of doing any light PA, as well as with an 11.8 min increase in MVE and a 39.7 min increase in light PA among those who exercised. Although the proportion of free classes was negatively associated with the odds of doing any MVE and light PA, it was associated with a 4.7 min increase in MVE among those exercised. Lastly, average distance of all classes to the COE was not significantly associated with the odds of doing any MVE or light PA, but it was associated with a 9.1 min increase in MVE and a 14.9 min increase in light PA among those who exercised. Numbers for the specific effects are provided in Table 3.

Table 2
Comparing COE-based exercise classes to community-based exercise classes.

Variable	Sub-variable	COE class	Community class	Akritas test (p-value)
Weekly availability of classes	Number of different classes	5.5 ± 6	24.5 ± 11.5	<0.001
	Average frequency of times classes are offered per week	1.1 ± 0.5	1.8 ± 0.7	<0.001
	Weekly class availability (hours)	6.5 ± 8.6	47.5 ± 25.6	<0.001
Intensity	% of classes that are high intensity	11 ± 14.7	24.2 ± 17.8	<0.001
Cost of classes	% of classes that are free	49 ± 49.6	22.5 ± 27.7	≥0.05
Average distance of classes to COE (miles)		6.2 ± 5.7	12.8 ± 4.6	<0.001

Table 3
Two-part regression model demonstrating association between exercise class variables and amounts of MVE and light PA. The estimate in the logistic model presents an odds ratio of the likelihood of an individual with PD exercising at all. The linear regression estimate presents the relative risk of amount of exercise in those who exercised. The combined estimate (beta) is a smearing estimator presenting the estimated change in exercise hours per week.

Independent variables	Two-part model	MVE					Light PA				
		Estimate	Std. Error	95% CI		p-value	Estimate	Std. Error	95% CI		p-value
				Lower Bound	Upper Bound				Lower Bound	Upper Bound	
Weekly class availability per 1000 patients (hours)	Logistic (OR)	1.003	0.002	0.999	1.008	0.1381	1.013	0.002	1.008	1.017	<0.0001
	Linear (RR)	1.004	0.001	1.002	1.006	<0.0001	1.008	0.001	1.006	1.010	<0.0001
	Combined (hours)	0.021		0.009	0.032		0.046		0.029	0.065	
Proportion of high intensity classes (10% increment)	Logistic (OR)	0.993	0.033	0.930	1.060	0.8378	1.116	0.033	1.047	1.190	0.0008
	Linear (RR)	1.037	0.014	1.009	1.066	0.0095	1.113	0.017	1.077	1.151	<0.0001
	Combined (hours)	0.196		0.021	0.381		0.661		0.396	0.983	
Proportion of all classes that are free (10% increment)	Logistic (OR)	0.940	0.016	0.911	0.970	0.0001	0.950	0.015	0.922	0.979	0.0007
	Linear (RR)	1.015	0.007	1.002	1.029	0.0279	0.998	0.009	0.981	1.015	0.8346
	Combined (hours)	0.079		0.018	0.147		-0.017		-0.108	0.074	
Average distance of all classes to COE (miles)	Logistic (OR)	1.003	0.011	0.981	1.025	0.8130	1.012	0.011	0.991	1.033	0.2689
	Linear (RR)	1.029	0.004	1.020	1.038	<0.0001	1.042	0.005	1.031	1.053	<0.0001
	Combined (hours)	0.152		0.093	0.225		0.248		0.149	0.382	

3.4. Determination of which class variables were most strongly associated with exercise participation:

By investigating the overall effects of four exercise class variables on reported exercise, we found that, for both MVE and light PA hours, a two-part model had the lowest RMSE when including "weekly availability of classes" compared with the other three variables (Fig. 1A, B). This indicates that "weekly availability of classes" has the most significant association with exercise hours. This effect was present, but diminished, in the MVE outcome compared to the light PA outcome. The deletion model showed similar findings (Fig. 1C, D).

4. Discussion

Based on our study, greater weekly exercise class availability, intensity, and distance to the COE were associated with increased MVE and light PA among people with PD at Parkinson's Foundation COEs. Of these, the weekly class availability within a 25-mile radius of the COE explained the most variability in the reported exercise hours. Our findings suggest that Parkinson's Foundation COEs may want to focus on increasing the availability, intensity level, and distance to the COE of classes offered in their wider communities in order to increase exercise participation.

We found that higher weekly class availability and intensity levels of classes were associated with higher levels of reported exercise among people with PD. Interestingly, having more high-intensity classes was associated with increased odds of participants engaging in light PA, but not with increased odds of engaging in MVE. Although we did not measure long-term clinical outcomes, increased overall PA in people with PD is associated with better health outcomes and slower disease progression [1,2,12]. Furthermore, participation in higher intensity exercise has been associated with better disease severity outcomes compared to participation in light to moderate exercise in people with PD [13]. Among those who reported some exercise, their amount of MVE was associated with a higher proportion of high-intensity classes available in their communities. This finding is consistent with past studies, which have found that exercisers value the intensity of exercise programs [14]and therefore were likely to participate in vigorous classes

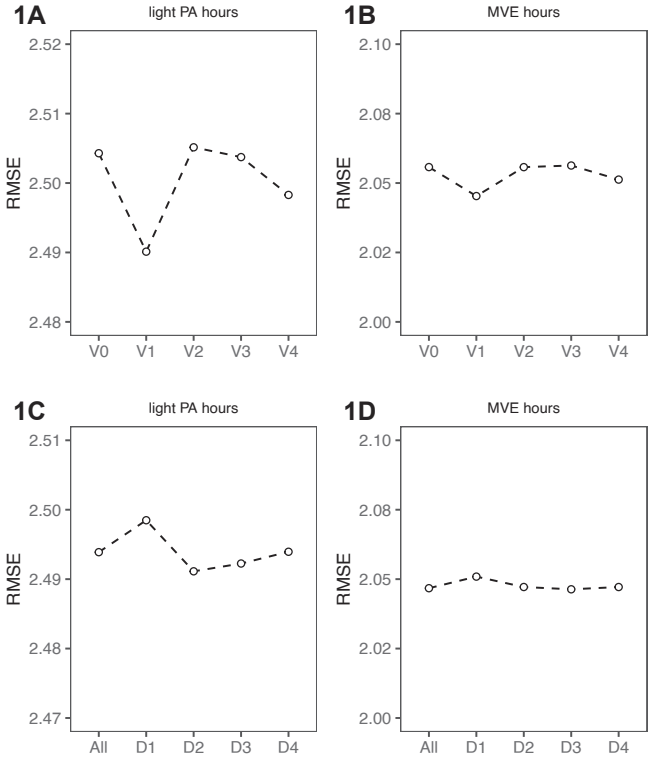

Fig. 1. Root mean squared error comparing the association of four class independent variables with exercise hours. Fig. 1A, B: V0 indicates the baseline with only 9 covariates included in the model, V1 indicates "weekly availability of classes" added to the model, V2 indicates adding "average class intensity" in the model, V3 indicates "proportion of free classes" added to the model, and V4 indicates "average distance to COE." Fig. 1C, D: D1 denotes "weekly availability of classes" deleted from the full model, D2 denotes "average class intensity" deleted from the full model, D3 denotes "proportion of free classes" deleted from the full model, and D4 denotes "average distance to COE."

offered in their area. Our findings support the idea that targeting increased availability and intensity of COE and community exercise classes may benefit the PD community.

Although cost of classes is often cited as a barrier to exercise [15][16], we found that the overall odds of engaging in exercise decreased with more free classes available at the COE and within a 25 mile radius. One explanation for this could be that cost barriers differ in different populations. Cost barriers for POP participants have not been explored, but research participants tend to have higher socioeconomic status than the overall population of patients with a given diagnosis [17]. Additionally, studies have shown associations between high socioeconomic status and increased exercise behavior, so those seeking out exercise classes in our study may perceive cost as less of a barrier [18].

For our study, greater distance of classes to the COE was associated with the presence of more classes in the surrounding communities and suburbs, rather than having all classes consolidated to the COE itself. Many studies have cited distance to exercise classes as a barrier to exercise [15][16], and our findings supported this by showing the benefits of increased exercise class distribution throughout a community. Our findings overall suggest that the average distance of classes to the COE may be a potential area to target to maximize exercise and PA among the PD population in a given community. Furthermore, the increased weekly class availability, intensity, and geographical distribution of community classes compared to COE classes highlights the important role these classes play in enhancing exercise participation in communities.

4.1. Limitations

One limitation to our study stems from the manual data collection of class characteristics for COE-based and community-based exercise classes. Because our study team was limited to publicly available information found on the internet, we recognize the risk of having missed exercise classes that were not easily found online. Additionally, we determined exercise class intensity based on online descriptions of the classes or via contact with class staff members, which allows for potential biases due to the subjective nature of this data collection.

Another limitation to our study involves the fact that we excluded COEs that were outside of North America due to differences in documentation at these COEs. This limitation reveals the potential for geographical bias and limits the generalizability of our findings to locations outside of North America. Future studies investigating the relationship between exercise class characteristics and reported levels of exercise and PA should attempt to collect data from areas outside of North America to broaden the applicability of the findings. Our use of POP data limited our available information. For example, we did not have patient outcomes such as Unified Parkinson's Disease Rating Scale scores and we do not know which people with PD participated in COE or community exercise classes. An additional limitation is that data on exercise hours was self-reported and not objectively measured. Finally, our study identified only correlations, and thus cannot conclusively determine if the identified relationships are causal.

5. Conclusion

While studies continue to examine the benefits and barriers to exercise among people with PD, our study explored exercise class characteristics associated with greater MVE and PA within this community. Our results suggest that offering a greater weekly availability of classes at a higher intensity and with a broader geographical distribution may help bridge the gap between recommended and reported exercise. These findings favor the implementation of exercise programs at and near COEs, particularly at COEs whose patients have lower than average levels of exercise. Implementation of exercise programs at and around COEs has the potential for widespread benefits among the PD community.

Funding

Research reported in this publication was supported, in part, by the Parkinson's Foundation, Miami, FL; the United States Department of Defense CDRMP Neurotoxin Exposure Treatment Parkinson's (W81XWH-19-PRP-EIRA; Rafferty); and the National Institutes of Health's National Institute on Aging (P30AG059988; Rafferty). The content is solely the responsibility of the authors and does not necessarily represent the official views of the funders.

Acknowledgements

The authors acknowledge the work of each Parkinson's Foundation POP Center Principal Investigator and Site Coordinators for their efforts in data collection and assisting our project staff to identify local exercise resources. We also thank the POP participants for their dedication to longitudinal data collections.

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