Case Report

Boxing Training for Patients With Parkinson Disease: A Case Series

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Background and Purpose. A nontraditional form of exercise recently applied for patients with Parkinson disease (PD) is boxing training. The primary purpose of this case series is to describe the effects of disease severity and duration of boxing training (short term and long term) on changes in balance, mobility, and quality of life for patients with mild or moderate to severe PD. The feasibility and safety of the boxing training program also were assessed.

Case Descriptions. Six patients with idiopathic PD attended 24 to 36 boxing training sessions for 12 weeks, with the option of continuing the training for an additional 24 weeks (a seventh patient attended sessions for only 4 weeks). The 90-minute sessions included boxing drills and traditional stretching, strengthening, and endurance exercises. Outcomes were tested at the baseline and after 12, 24, and 36 weeks of boxing sessions (12-, 24-, and 36-week tests). The outcome measures were the Functional Reach Test, Berg Balance Scale, Activities-specific Balance Confidence Scale, Timed "Up & Go" Test, Six-Minute Walk Test, gait speed, cadence, stride length, step width, activities of daily living and motor examination subscales of the Unified Parkinson Disease Rating Scale, and Parkinson Disease Quality of Life Scale.

Outcomes. Six patients completed all phases of the case series, showed improvements on at least 5 of the 12 outcome measures over the baseline at the 12-week test, and showed continued improvements at the 24- and 36-week tests. Patients with mild PD typically showed improvements earlier than those with moderate to severe PD.

Discussion. Despite the progressive nature of PD, the patients in this case series showed short-term and long-term improvements in balance, gait, activities of daily living, and quality of life after the boxing training program. A longer duration of training was necessary for patients with moderate to severe PD to show maximal training outcomes. The boxing training program was feasible and safe for these patients with PD.

Parkinson disease (PD) is a progressive neurodegenerative disorder that is characterized by tremors, postural rigidity, bradykinesia, and postural instability.[1] These motor signs can have detrimental effects on balance, mobility, and quality of life in patients with PD.[1] Increasing evidence has indicated that traditional forms of exercise, such as stretching and aerobic and resistance training, provide positive health benefits and improved quality of life for patients with PD.[2–7] Alternative, nontraditional group exercise programs implemented within community settings have also shown promise.[8–11] Nontraditional exercise programs integrate traditional exercise concepts but apply them in an alternative manner. Examples include tango dance,[8] tai chi,[11] taiji,[9] and qigong.[10] These programs have been found to increase balance,[8,11] mobility,[8,11,12] and gait endurance,[11] as well as to improve perceived physical, psychological, and social abilities.[9]

A nontraditional form of exercise recently applied for patients with PD is boxing training. Customary boxing training is designed so that boxers have sufficient endurance to last the duration of each round with enough explosive strength to throw punches and move quickly within the boxing ring.[13] In combination with fitness activities, boxing training incorporates whole-body movements, with upper-extremity punching motions and lower-extremity footwork in multiple directions. The punching actions combine high-speed arm motions with trunk rotation and anticipatory postural adjustments.[14] The actions used in boxing training incorporate motions similar to those described in previous reports, such as spinal flexibility,[15] stepping in multiple directions,[16] and movements performed faster than preferred speeds.[3,16,17] Therefore, boxing training may be an effective alternative for improving function in patients with PD.

We found only 2 studies that investigated the effects of boxing training in young adults who were healthy.[18,19] Kravitz et al[18] reported that upper-extremity boxing motions at any speed provided adequate exercise intensity to improve cardiorespiratory fitness. Bellinger et al[19] found that a 60-minute boxing training session resulted in an energy expenditure similar to that resulting from running about 9 km (5.6 miles) in 60 minutes on a treadmill. Currently, there is no evidence on the effects of boxing training in patients with PD; however, the use of boxing training as a component of an exercise program to improve agility and reduce bradykinesia in patients with PD has been suggested.[14]

In Indianapolis, Indiana, a community-based group boxing training program developed by the Rock Steady Boxing Foundation has gained remarkable popularity since its inception in 2006 by enrolling more than 80 members with mild to severe PD. Members anecdotally have reported increased ease in completing activities of daily living (ADL), decreased parkinsonian symptoms, and improved perception of quality of life after participation in the boxing training program. Therefore, the primary purpose of this case series is to describe the effects of disease severity and duration of boxing training (short term and long term) on changes in balance, gait, mobility, disability, and quality of life for patients with mild or moderate to severe PD. Because of the novelty of the intervention for patients with PD, the feasibility and safety of the group boxing training program also were assessed.

Case Descriptions

The case series included patients who inquired about the boxing training program developed by the Rock Steady Boxing Foundation. Patients had to have a diagnosis of PD; be at least 21 years of age; currently not be receiving physical therapy; be able to ambulate independently in the home, with or without an assistive device; be able to follow at least 3-step verbal commands; and be available for the entire course of the case series with self-transportation. Patients could not have preexisting neurological conditions other than PD, current musculoskeletal or cardiovascular conditions that would limit participation in an exercise program, past brain surgery or implantation of a deep brain stimulator, or current pregnancy.

Seven patients who were new to boxing training and the Rock Steady Boxing Foundation program provided informed consent before beginning the program. During an initial interview, physical therapists (S.A.C., M.D.D., and W.H.S.) collected general demographic information and administered the Hoehn-Yahr scale to categorize PD-related motor dysfunction (moderate to severe impairment=score of 3 or 4; mild impairment=scores of 0–2).[20]

Procedures

Testing took place 1 week before the beginning of the boxing training program (baseline) and 1 week after the completion of 12 weeks (12-week test) of the boxing training program.

Patients underwent further testing at 24 weeks (24-week test) and 36 weeks (36-week test) regardless of whether they continued attending the boxing training program. Physical therapists and physical therapist students (L.C., K.D., N.L., and K.S.) were extensively trained to conduct all outcome measures. Intrarater reliability and interrater reliability were established with the Berg Balance Scale (BBS) (intraclass correlation coefficient [ICC]=.998). Tests were randomized in each testing session to reduce the effects of test order bias. For patients taking medications for PD, testing was conducted approximately 1 hour after the medications were taken.

Outcome Measures

Balance

Because boxing training incorporates weight shifting from the base of support, dynamic changes in balance, and postural adjustments, we chose the following outcome measures: Functional Reach Test (FRT), BBS, and Activities-specific Balance Confidence Scale (ABC).

Margins of stability were assessed with the FRT.[21] The test-retest reliability of the FRT has been established (ICC=.73), as has a minimal detectable change (MDC) of 9 cm for patients with PD.[22] For the FRT, patients were instructed to stand with their arms raised to shoulder height and reach as far forward as possible along a meter stick without losing their balance. The average distance from 3 trials was used, with greater reaching distances indicating better performance.

The BBS was designed to measure changes in functional standing balance over time.[23] The summed total of the 14-item scale ranges from 0 to 56, with higher scores indicating improved balance. The test-retest reliability of the BBS is high (ICC=.94), and an MDC of 5 points has been established for patients with PD.[22]

The ABC was designed to measure balance confidence in various everyday activities. The mean score on the 16-item questionnaire ranges from 0% to 100%.[24] The test-retest reliability of the ABC is high (ICC=.94.), and an MDC of 13% has been determined for patients with PD.[22]

Gait and Mobility

Because boxing training includes elements of stepping in multiple directions, changes in speed, fast motions, and cardiovascular demands, we chose the following outcome measures: Timed "Up & Go" Test (TUG), Six-Minute Walk Test (6MWT), and spatiotemporal parameters of gait.

Mobility was assessed with the TUG.[25] The test-retest reliability of the TUG for patients with PD has been reported to be high (ICC=.85),[22] and the interrater reliability is high (ICC=.99) when the TUG is used during the "on phase" of the medication cycle.[25] Because the MDC of 11 seconds established previously for the TUG was not realistic or achievable for the patients in the present case series,[22] the MDC (0.67 second) for the group was calculated from 3 baseline values. Patients were instructed to stand up, walk 3 m, turn around a cone, and return to a sitting position, beginning with the instruction "Go." The average time from 3 trials was used.

Walking endurance was assessed with the 6MWT.[22] The test-retest reliability of the 6MWT is high (ICC=.96), and the MDC for patients with PD is 82 m.[22] The 6MWT was conducted along a 60-m course in a hallway, with feedback given once per minute.

Spatiotemporal parameters (speed, cadence, stride length, and step width) were assessed with a GaitRite Walkway System.* Patients were instructed to walk at a comfortable pace on the 4.88-m walkway. The average value from 5 measurement trials was used. Patients started and ended the trials 1.5 m (5 ft) beyond the GaitRite walkway to ensure a steady ambulation state. Patients did not wear orthoses or use assistive devices during the walking trials. A physical therapist or a physical therapist student walked beside patients for safety, if necessary, but no physical assistance was provided. The test-retest reliability has been established to be high for gait speed (ICC=.93), cadence (ICC=.92), and stride length (ICC=.97) measured at preferred walking paces in adults who are healthy.[26] An MDC of 0.18 m/s has been established for gait velocity in patients with PD.[22] An MDC has not been reported for other spatiotemporal parameters in patients with PD.

PD-Specific Disability and Quality of Life

Because the boxing training program was applied specifically for patients with PD, we chose the following disease-specific outcome measures: Unified Parkinson Disease Rating Scale (UPDRS) and Parkinson Disease Quality of Life Scale (PDQL). The UPDRS was designed to monitor PD-related impairments and disabilities.[27] Activities of daily living subscale II and motor examination subscale III were included in this case series. The ADL subscale measures patients' reported ability to perform everyday tasks, and the motor examination subscale measures muscular involvement of PD, indicating the severity of motor disease. Lower scores on the UPDRS signify higher levels of function. High test-retest reliability of the UPDRS (ICC=.89 for the ADL subscale; ICC=.93 for the

* CIR Systems Inc, 60 Garlor Dr, Havertown, PA 19083.

motor examination subscale) in adults with PD has been established.[22] Minimal detectable changes of 4 points on the ADL subscale and 11 points on the motor examination subscale have been established.[22]

The PDQL is a self-administered quality-of-life questionnaire that contains 37 items.[28] The PDQL total score has been found to be reliable (ICC=.94) for measuring the quality of life of patients with PD.[29] A higher total score on the PDQL indicates a higher perceived quality of life. An MDC has not been established for the PDQL.

Feasibility and Safety

Because boxing training is a relatively new exercise concept for patients with PD, feasibility and safety were assessed. Feasibility was determined on the basis of adherence to the initial 12-week training protocol (attending at least 24 sessions). In addition, adherence to the training protocol over time was measured as the number of sessions attended after the initial 12 weeks. Patient reports regarding enjoyment of the program were requested. Safety was evaluated on the basis of the incidence of adverse events.

Intervention

Immediately after baseline testing, patients completed 24 to 36 boxing training sessions at the Rock Steady Boxing Foundation during a 12-week period. Continuation of boxing training after the initial 12 weeks was optional. Patients were instructed to continue their regular exercise routines and not to alter routines during the course of the case series.

The boxing training program began with a 20-minute warm-up of breathing and stretching exercises for major muscle groups in the trunk and extremities. The warm-up was followed by a 45- to 60-minute circuit training regimen of function, endurance, and punching activities that alternated between 3-minute training bouts and 1-minute rest breaks. The functional training incorporated activities for whole-body fitness and calisthenics, such as push-ups, skipping, and jumping rope, along with boxing ring work, which focused on footwork and agility drills. The endurance training activities included walking on treadmills, cycling on stationary bikes, and running outdoors. The punching activities included punching heavy bags (heavily padded, cylindrical bags suspended from the ceiling for the practice of large punches), speed bags (small, air-filled bags suspended from an overhead platform for the practice of rhythmic, rapid punches), and focus mitts (padded mitts worn by a trainer to prompt the practice of various combinations of punches toward moving targets). The activities were advanced by encouraging patients to train as intensely as they could tolerate by striving to complete more repetitions during each training bout. The session ended with a 15- to 20-minute cool-down that emphasized core stretching and strengthening and breathing exercises (see video at ptjournal.apta.org).

The format of the training program remained constant throughout the case series, but exercises were varied across sessions. Each training session lasted approximately 90 minutes and was led by 1 or 2 professional boxers who were certified as personal trainers by the National Academy of Sports Medicine. Patients wore boxing gloves and performed many activities within a boxing ring during the workouts. Patients did not make contact with other patients while boxing. Patients could pace themselves during the training sessions, taking longer rest breaks as needed. The case series physical therapists and physical therapist students were not involved in the design or implementation of the boxing training program.

Outcomes

Six patients attended 24 to 36 boxing sessions during the initial 12 weeks and completed all 4 measurement sessions. One patient stopped attending the exercise program after 4 weeks because of a change in health status that was unrelated to the case series; therefore, data for this patient were not included in the outcomes. Of the 6 patients who completed all phases of the case series, 3 patients scored 1 on the Hoehn-Yahr scale at the baseline, indicating mild motor dysfunction, and 3 patients scored 3 or 4 on the Hoehn-Yahr scale, indicating moderate to severe motor dysfunction.[20] The demographic characteristics of the patients are shown in Table 1.

Balance

All patients increased the distance reached on the FRT by the 24-week test (Tabs. 2 and 3). As shown in Figure 1A, patients with moderate to severe PD consistently increased their reaching distances during the course of the case series, with patients 3 and 4 exceeding the MDC of 9 cm[22] at the 36-week test. Patients with mild PD showed small increases in their reaching distances over time, with only patient 1 exceeding the MDC at the 12-week test.

All patients maintained or increased their scores on the BBS at the 12- and 24-week tests, and 5 of 6 patients maintained or further increased their scores at the 36-week test (Tabs. 2 and 3). Patients 1 and 6 attained the highest scores possible at the baseline and maintained these scores at all subsequent tests. As shown in Figure 1B, patients with moderate to severe PD showed consistent improvements in their BBS scores during the course of the case series, whereas patients with mild PD showed little change over time. Two

Table 1.
Demographic Characteristics of Patients With Parkinson Disease (PD)[a]

Patient	Age (y)	Time Since Diagnosis (mo)	Hoehn-Yahr Stage	Dopamine Replacement Medication	PD Subtype[36]	No. of Training Sessions Attended During Weeks:		
						1–12	12–24	24–36
1	51	23	1	Yes	PIGD	28	19	19
2	55	11	1	No	Tremor	24	19	22
3	58	40	3	Yes	Tremor	24	11	10
4	77	73	3	Yes	ND	30	16	16
5	68	12	4	Yes	ND	36	22	30
6	52	13	1	No	Tremor	35	3	0
$\bar{X}$ (SD)	60.17 (10.26)	28.67 (24.34)	2.17 (1.33)			29.5 (5.21)	15 (6.96)	16.17 (10.32)

[a] All patients were men. PIGD=postural instability gait dominant, ND=not differentiated.

patients with moderate to severe PD (Hoehn-Yahr stage 3 or 4) reached the MDC of 5 points on the BBS by the 36-week test.[22]

Five of 6 patients maintained or increased their scores on the ABC at the 24- and 36-week tests (Tabs. 2 and 3). Patients with moderate to severe PD showed consistent improvements in their ABC scores during the course of the case series (Fig. 1C). Patient 5 in that group exceeded the MDC of 13% at the 24-week test.[22] Both patients 3 and 5 exceeded the MDC by the 36-week test. Patients with mild PD showed little change in balance confidence over time (Fig. 1C).

Gait and Mobility

Five of 6 patients decreased the time to complete the TUG at the 12- and 24-week tests, and all patients decreased the time by the 36-week test (Tabs. 2 and 3). All patients exceeded the MDC during at least 1 measurement session, with 5 of 6 patients exceeding it during the 36-week test. All patients with mild PD showed decreases in the time to complete the TUG of greater than 10% over the baseline immediately after the initial 12 weeks of boxing training (Fig. 2A). This change was not consistently shown by all patients with moderate to severe PD until the 24-week test.

Five of 6 patients increased the distance walked on the 6MWT at the 12- and 24-week tests (Tabs. 2 and 3). All 6 patients increased the distance walked on the 6MWT at the 36-week test, with 5 of 6 exceeding the MDC of 82 m.[22] Both patients with mild PD and patients with moderate to severe PD showed improvements over time, but those with mild PD showed increases in the distance walked on the 6MWT of greater than 17% over the baseline by the 24-week test. This change was not shown by patients with moderate to severe PD until the 36-week test (Fig. 2B).

All 6 patients increased gait speed by the 24-week test and maintained the increase over the baseline at the 36-week test (Tabs. 2 and 3). Patients with mild PD achieved a 23% increase in gait speed over the baseline at the 12-, 24-, and 36-week tests, even with only 1 patient (patient 6) exceeding the MDC at the 12- and 24-week tests (Fig. 2C).[22] Although patients with moderate to severe PD achieved increases in gait speed at the 24- and 36-week tests, these changes constituted only 9% and 10% increases over the baseline, respectively. Accordingly, increased cadence and stride length and decreased step width were achieved by patients with mild PD at the 12-, 24-, and 36-week tests. However, these changes in gait parameters were not achieved by patients with moderate to severe PD until the 24- and 36-week tests. Similar to the results for gait speed, the percent changes shown by patients with moderate to severe PD were smaller than those shown by patients with mild PD.

PD-Specific Disability and Quality of Life

Both patients with mild PD and patients with moderate to severe PD showed consistent decreases in scores on the ADL subscale of the UPDRS over time (Fig. 3A). Patients 1, 3, and 4 achieved an MDC of greater than 4 points on the ADL subscale of the UPDRS at the 12-week test, with patients 1 and 4 maintaining the MDC at the 36-week test (Tabs. 2 and 3).[22] On the motor examination subscale of the UPDRS, scores fluctuated (Fig. 3B); only 2 patients with moderate to severe PD (Hoehn-Yahr stage 3 or 4) achieved the MDC of 11 points by the 36-week test.[22]

Five of 6 patients had increased total scores on the PDQL at the 12-, 24-, and 36-week tests, indicating a higher self-perceived quality of life (Tabs. 2 and 3). Both patients with mild PD and patients with moderate to severe PD showed consistent improvements during the course of the case series; however, patients with

Table 2.
Individual Outcomes for Patients With Mild Parkinson Disease (Hoehn-Yahr Stage 1)

Measure[a]	Patient 1				Patient 2				Patient 6			
	Baseline	12-Week Test	24-Week Test	36-Week Test	Baseline	12-Week Test	24-Week Test	36-Week Test	Baseline	12-Week Test	24-Week Test	36-Week Test
FRT (cm)[b]	30.5 (1.8)	41.1[c] (1.6)	42.3[c] (0.3)	30.5 (1.3)	36.4 (1.5)	38.1 (3.5)	39.0 (0.7)	39.0 (1.2)	42.8 (1.0)	34.7 (0.3)	40.6 (0.5)	44.9 (0.7)
BBS[d]	56	56	56	56	55	56	56	56	56	56	56	56
ABC[b]	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)	100.0 (0.0)	91.9 (10.5)	82.5 (22.9)	95.6 (8.1)	93.8 (7.2)	95.6 (7.3)	97.5 (12.4)	85.6 (15.0)	85.6 (7.3)
TUG (s)[b]	9.89 (0.17)	7.87[c] (0.04)	7.38[c] (0.13)	8.06[c] (0.56)	6.58 (0.34)	5.93 (0.78)	4.99[c] (0.54)	4.91[c] (0.22)	6.53 (0.38)	5.50[c] (0.67)	6.03 (0.32)	5.10[c] (0.17)
6MWT[d]	395.5	510.0[c]	475.8	480.0[c]	584.0	646.8	695.2[c]	628.0	532.9	391.5	602.0	720.0[c]
Gait speed (m/s)[b]	0.98 (0.02)	1.10 (0.05)	1.08 (0.04)	1.03 (0.05)	1.14 (0.06)	1.61[c] (0.07)	1.56[c] (0.08)	1.69[c] (0.09)	1.20 (0.02)	1.41[c] (0.03)	1.42[c] (0.04)	1.36 (0.05)
Cadence (steps/min)[b]	88.1 (0.7)	93.3 (2.9)	97.0 (2.3)	92.6 (3.3)	105.6 (2.0)	118.1 (3.4)	114.9 (3.7)	118.7 (2.3)	96.2 (1.0)	102.5 (1.2)	105.4 (2.1)	101.1 (2.1)
Stride length (cm)[b]	113.8 (1.9)	141.2 (3.1)	133.6 (2.9)	133.9 (2.5)	130.3 (4.1)	163.5 (3.0)	163.1 (2.9)	171.4 (6.0)	150.0 (1.7)	165.3 (1.9)	166.8 (1.8)	161.7 (2.7)
Step width (cm)[b]	12.7 (1.0)	11.5 (0.3)	12.9 (1.3)	12.3 (1.1)	8.5 (0.6)	6.6 (1.7)	6.9 (1.7)	6.8 (2.0)	10.2 (0.2)	9.1 (1.0)	9.3 (1.6)	10.6 (1.1)
UPDRS ADL subscale[d]	13	4[c]	5[c]	3[c]	7	6	4	4	16	19	18	13
UPDRS motor subscale[d]	0	2	10	8	13	16	15	10	16	26	6	9
PDQL[d]	142	174	170	177	139	143	140	145	115	100	104	114

[a] FRT=Functional Reach Test, BBS=Berg Balance Scale, ABC=Activities-specific Balance Confidence Scale, TUG=Timed "Up & Go" Test, 6MWT=Six-Minute Walk Test, UPDRS=Unified Parkinson Disease Rating Scale, ADL=Activities of Daily Living, PDQL=Parkinson Disease Quality of Life Scale.
[b] Expressed as mean (standard deviation).
[c] The value exceeded the minimal detectable change for that measure.
[d] Expressed as total score.

Table 3.
Individual Outcomes for Patients With Moderate to Severe Parkinson Disease (Hoehn-Yahr Stage 3 or 4)

Measure[a]	Patient 3				Patient 4				Patient 5			
	Baseline	12-Week Test	24-Week Test	36-Week Test	Baseline	12-Week Test	24-Week Test	36-Week Test	Baseline	12-Week Test	24-Week Test	36-Week Test
FRT (cm)[b]	11.4 (0.0)	19.9 (1.0)	16.9 (0.7)	25.4[c] (0.5)	18.2 (0.6)	30.9[c] (1.8)	31.8[c] (0.0)	34.3[c] (0.5)	26.3 (0.3)	16.9 (1.4)	27.1 (0.3)	23.3 (0.7)
BBS[d]	46	47	51[c]	53[c]	48	50	51	53[c]	50	52	53	47
ABC[b]	63.8 (25.0)	63.8 (13.1)	65.0 (17.5)	74.4[c] (13.6)	63.1 (17.0)	39.4 (16.9)	65.6 (22.8)	65.0 (20.3)	52.8 (26.5)	53.8 (31.0)	65.6[c] (30.8)	65.0[c] (26.8)
TUG (s)[b]	11.10 (0.42)	10.03[c] (0.24)	8.73[c] (0.75)	10.47 (0.05)	14.83 (0.37)	13.37[c] (0.70)	12.37[c] (0.25)	11.55[c] (0.33)	10.37 (0.57)	12.39 (0.50)	10.68 (0.63)	9.48[c] (0.66)
6MWT[d]	307.9	323.5	324.4	389.0[c]	247.6	273.1	313.1	330.0[c]	372.8	373.7	335.3	472.0[c]
Gait speed (m/s)[b]	0.89 (0.06)	0.83 (0.06)	0.99 (0.09)	0.92 (0.04)	0.88 (0.04)	0.89 (0.04)	0.98 (0.04)	1.06[c] (0.04)	0.99 (0.03)	0.99 (0.06)	1.02 (0.05)	1.08 (0.04)
Cadence (steps/min)[b]	102.3 (3.1)	97.8 (3.0)	105.7 (3.8)	96.9 (0.7)	103.4 (1.3)	103.1 (3.4)	105.9 (2.6)	107.4 (2.0)	116.9 (2.2)	119.1 (2.1)	118.0 (4.8)	121.4 (2.8)
Stride length (cm)[b]	104.0 (3.6)	101.5 (5.4)	112.5 (6.4)	113.7 (5.0)	103.0 (3.7)	104.2 (2.6)	111.5 (3.9)	118.4 (2.9)	102.4 (1.2)	100.5 (5.2)	104.4 (2.9)	106.9 (2.7)
Step width (cm)[b]	13.7 (1.3)	13.5 (0.5)	12.9 (1.7)	12.3 (1.0)	17.3 (0.6)	18.1 (1.6)	16.2 (0.9)	17.4 (0.5)	8.9 (1.4)	7.7 (0.7)	8.2 (0.9)	9.0 (2.4)
UPDRS ADL subscale[d]	20	15[c]	20	18	24	13[c]	12[c]	8[c]	15	19	16	18
UPDRS motor subscale[d]	30	25	26	31	29	27	28	10[c]	29	35	31	18[c]
PDQL[d]	96	118	106	128	100	129	109	146	96	110	117	129

[a] FRT=Functional Reach Test, BBS=Berg Balance Scale, ABC=Activities-specific Balance Confidence Scale, TUG=Timed "Up & Go" Test, 6MWT=Six-Minute Walk Test, UPDRS=Unified Parkinson Disease Rating Scale, ADL=Activities of Daily Living, PDQL=Parkinson Disease Quality of Life Scale.
[b] Expressed as mean (standard deviation).
[c] The value exceeded the minimal detectable change for that measure.
[d] Expressed as total score.

moderate to severe PD showed greater changes than patients with mild PD (Fig. 3C).

Feasibility and Safety

No adverse events were reported during the course of the case series. The patients adhered to the training protocol, completing at least 24 sessions during the initial 12 weeks. All 6 patients chose to continue attending the boxing training program after the initial 12 weeks for a variety of reasons, including enjoyment of the program, emotional support from other group members and trainers, comfort in participation without fear of judgment, and perception of improved physical abilities (Tab. 1). Only 1 patient completed more than 24 sessions within 1 of the 12-week follow-up periods; other patients reported time conflicts as the primary reason for not attending more sessions. Patient 6 attended only 3 sessions between weeks 12 and 24 before discontinuing attendance in the program (Tab. 1). He cited travel distance, conflict with work schedule, and lack of interest in boxing as the reasons.

Discussion

All 6 patients in this case series showed improvements on at least 5 of the 12 outcome measures over the baseline at the 12-week test. Except for patient 6, all patients showed improvements in every outcome category, including balance, gait, disability, and quality of life. These positive changes may be indicative of the whole-body approach of the boxing training program, which incorporated dynamic balance activities (eg, reaching overhead when punching speed bags) and multidirectional reaching and stepping (while following a trainer's movements when punching focus mitts). In addition, agility drills within the circuit training regimen, such as jumping rope and footwork activities, focused on the initiation of movement and fast-

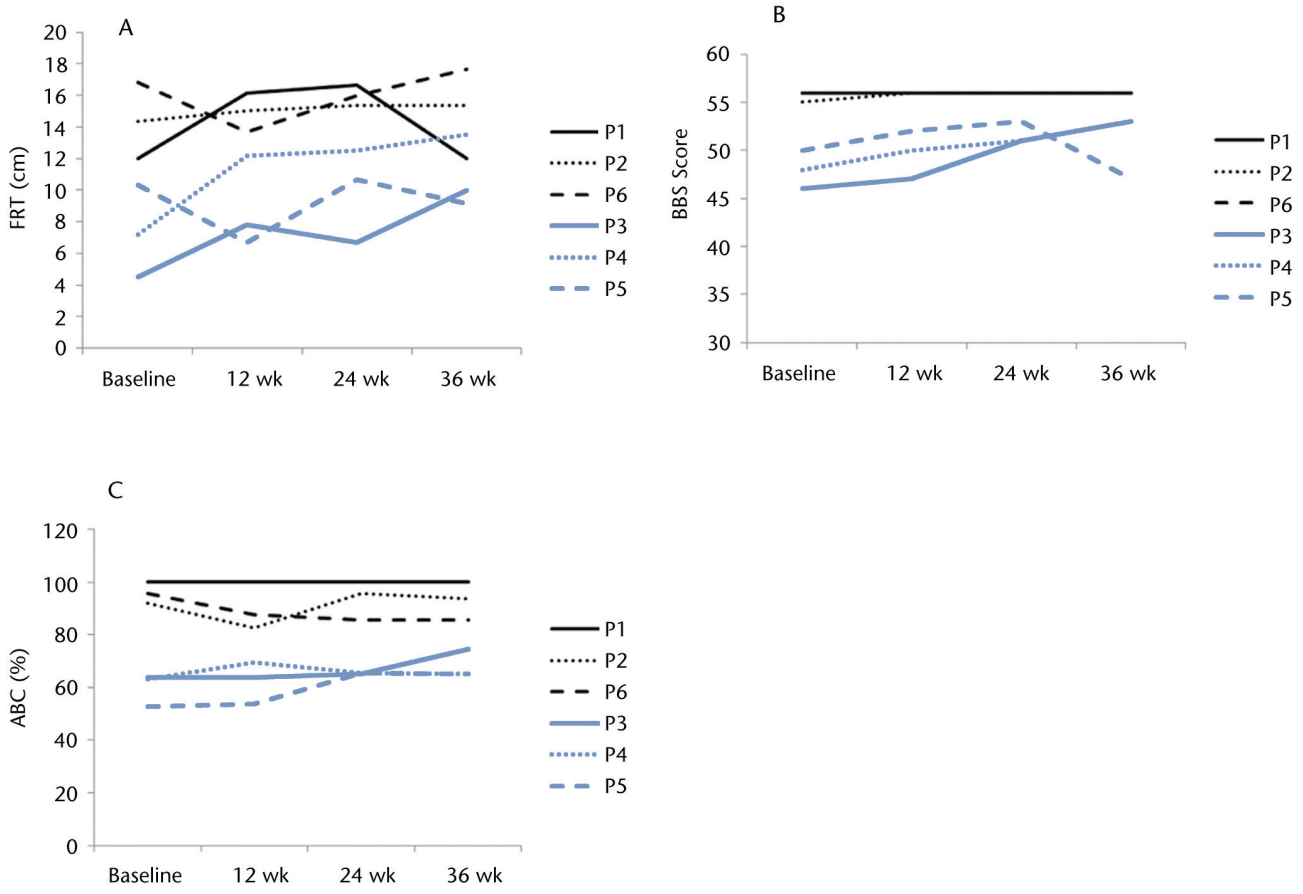

Figure 1.
Changes over time in outcomes for balance. Data for patients with mild Parkinson disease (PD) are shown in black (patients 1 [P1], P2, and P6), and data for patients with moderate to severe PD are shown in blue (P3, P4, and P5). (A) Functional Reach Test (FRT). (B) Berg Balance Scale (BBS). (C) Activities-specific Balance Confidence Scale (ABC).

paced changes in direction. The incorporation of a variety of activities that encompassed the whole body, as in other whole-body intervention programs that have shown promise,[8,11,30] may have translated to the multiple areas of functional improvements shown by the patients in this case series.

Interestingly, patients with mild PD showed improvements earlier than patients with moderate to severe PD, particularly in the gait-related outcome measures. Patients with mild PD more often showed improvements that exceeded the MDC after the initial 12 weeks of the boxing training program than did patients with moderate to severe PD. These early differences may have been due to the ability of patients with mild PD to tolerate and complete more repetitions during the circuit training regimen. This observation supports research suggesting that disease severity affects training capacity.[30] However, patients with moderate to severe PD did eventually show improvements in most outcome measures, suggesting that they required a longer training duration to acquire the necessary training capacity.

Another key observation of this case series was that all patients continued to make improvements in balance, gait, and quality of life up to the 24- and 36-week tests despite the reduction in attendance after the initial 12 weeks. The majority of changes that achieved and surpassed the established MDC values were seen at the 36-week test, indicating that long-term training may be necessary to attain maximal gains.[31] Patient 6 attended only 3 boxing sessions after the initial 12 weeks of the case series but maintained or improved scores on most outcome measures at the 24-week test, indicating a sustained benefit of the boxing training program. However, at the 36-week test, patient 6 showed a decline in scores on 5 outcome measures, perhaps because he was no longer attending boxing sessions. The 5 patients who continued to attend boxing sessions during the course of the case series showed persistent long-term bene-

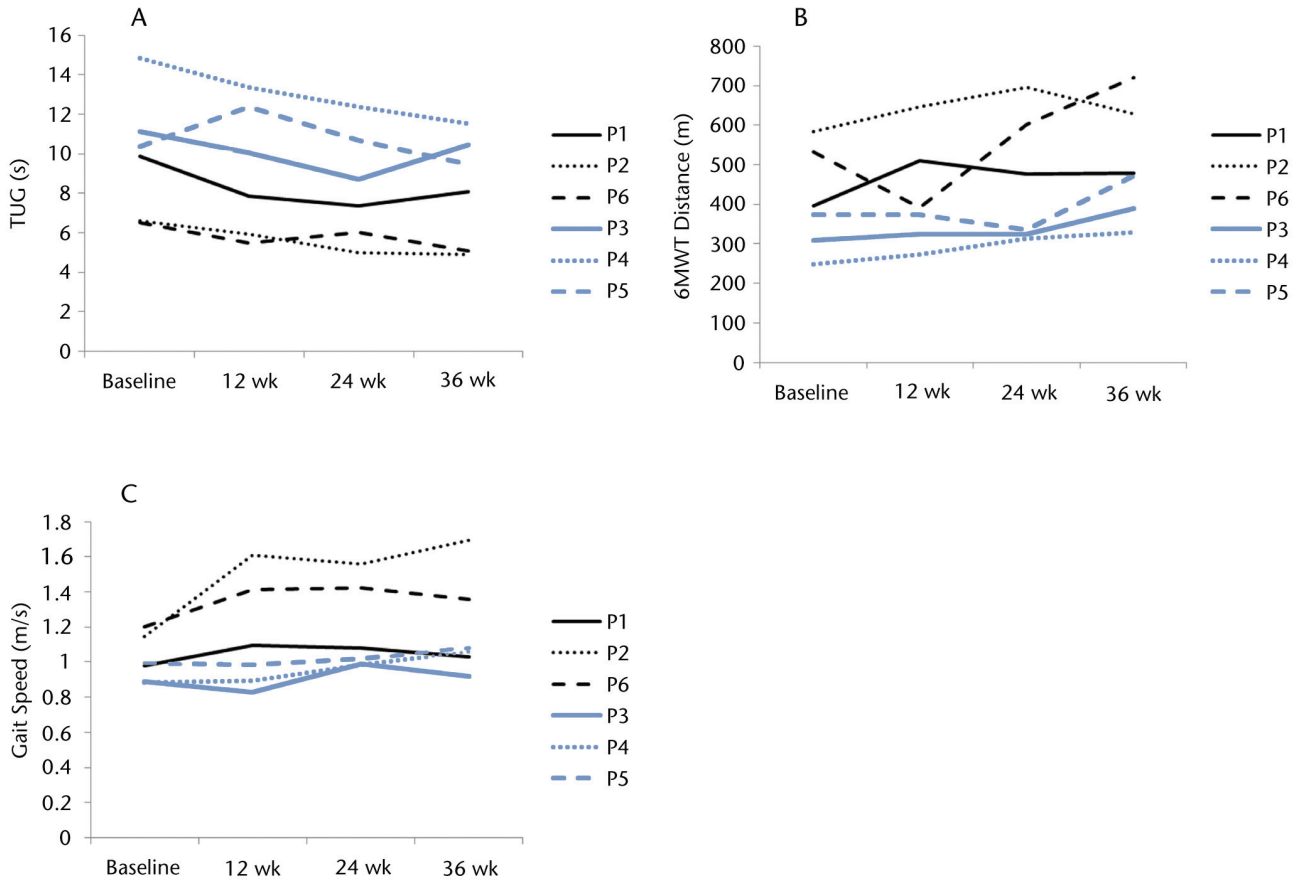

Figure 2.
Changes over time in outcomes for gait and mobility. Data for patients with mild Parkinson disease (PD) are shown in black (patients 1 [P1], P2, and P6), and data for patients with moderate to severe PD are shown in blue (P3, P4, and P5). (A) Timed "Up & Go" Test (TUG). (B) Six-Minute Walk Test (6MWT). (C) Gait speed.

fits, lending support for their continued use of the boxing training program.

We were able to demonstrate that group boxing training was feasible for patients in this case series regardless of the level of PD severity. All 6 patients tolerated the 90-minute boxing training program. The patients also were able to engage in other aspects of the training program, including donning and doffing boxing gloves and climbing through the ropes surrounding the boxing ring. The decline in the number of sessions completed after the initial 12 weeks for all patients may have reflected the typical time constraints of daily life, as well as reduced accountability.

The nature of a case series limits our ability to generalize our observations to other patients with PD and restricts our ability to compare boxing training with other rehabilitation interventions. All patients in this case series were men; therefore, the outcomes of boxing training for women are unknown. Additional limitations were that the physical therapists and physical therapist students were not masked to the design and purpose of the case series and that the balance-related tools used in the case series may have had a ceiling effect for patients with mild impairments.[21] The MDC represents a value greater than measurement error[22,32]; therefore, it may not represent clinical relevance and may limit the interpretation of outcomes. In addition, variability in the numbers of sessions attended by patients during the course of the case series may have led to differences in outcomes among patients.

This case series is the first report of the effects of boxing training in patients with PD. Provided that further reports demonstrate effectiveness, the incorporation of concepts from the whole-body boxing training regimen, such as repeated punching motions and fast-paced footwork, into traditional physical therapy

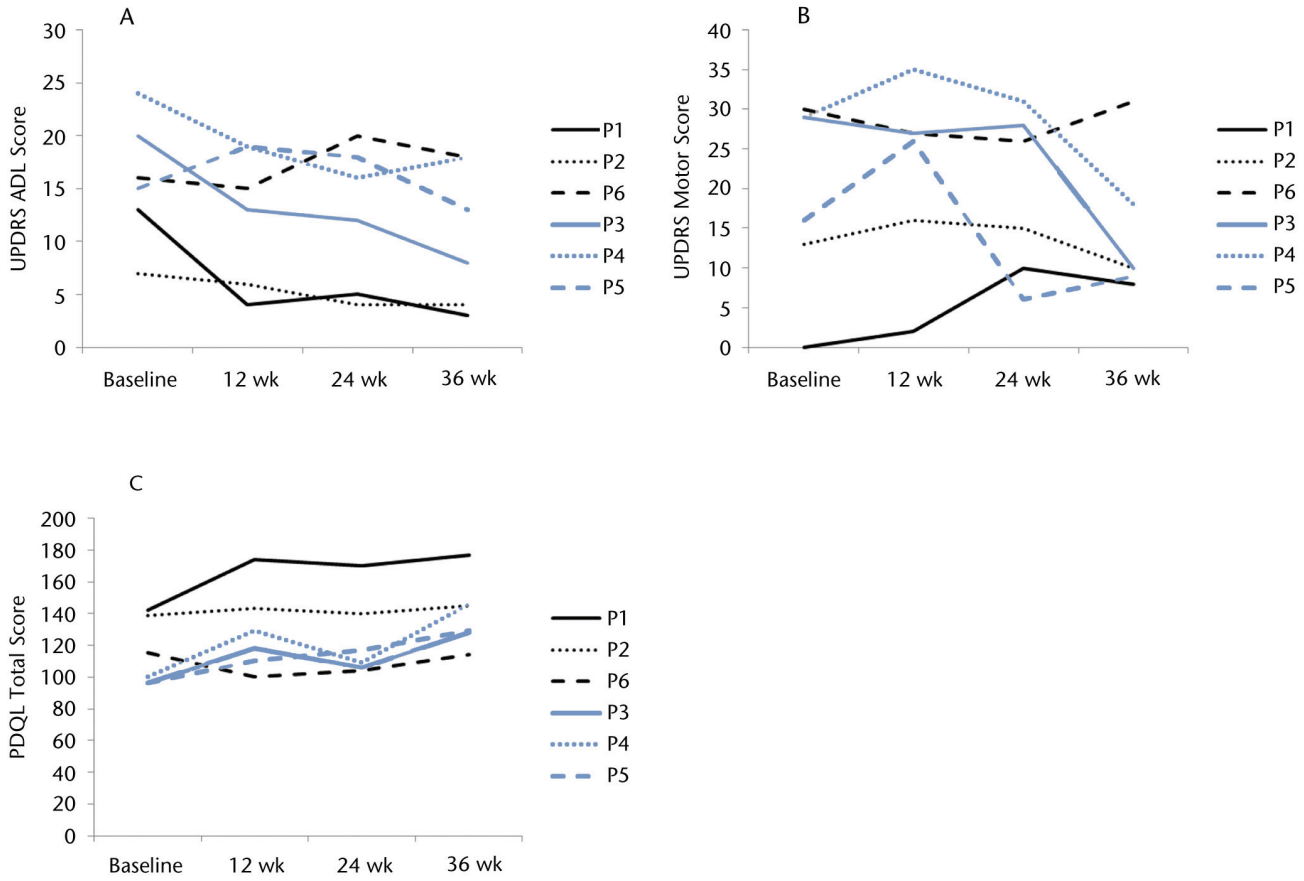

Figure 3.
Changes over time in outcomes for Parkinson disease (PD)–specific disability and quality of life. Data for patients with mild PD are shown in black (patients 1 [P1], P2, and P6), and data for patients with moderate to severe PD are shown in blue (P3, P4, and P5). (A) Unified Parkinson Disease Rating Scale (UPDRS) activities of daily living (ADL) subscale. (B) UPDRS motor examination subscale. (C) Parkinson Disease Quality of Life Scale (PDQL).

treatment plans for patients with PD may be beneficial. Finding an exercise program that meets the fitness needs of a patient and that appeals to personal interests is important for long-term exercise adherence.[33,34] Community-based boxing training programs for patients with PD may be a long-term alternative to physical therapy. Physical therapists can play an integral role in transitioning patients from traditional rehabilitation to such community-based programs by serving as consultants, facilitators, or both to maximize outcomes and promote long-term retention.[35] Comparisons of boxing training with traditional exercise techniques commonly applied by physical therapists and monitoring of levels of training intensity and repetitions are needed.

Conclusion

The promising outcomes of this case series demonstrated the feasibility of a community-based boxing training program for patients with PD. Despite the progressive nature of PD, the patients in this case series showed short-term and long-term improvements in balance, gait, activities of daily living, and quality of life after attending the boxing training program. A longer duration of training was necessary for patients with moderate to severe PD to show maximal training outcomes. The observations of this case series indicate that an examination of the effects of boxing training in patients with PD is warranted.

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This case series was approved by the Institutional Review Board at the University of Indianapolis.

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