BJMB
Brazilian Journal of Motor Behavior

Special issue:
"Control of Gait and Posture: a tribute to Professor Lilian T. B. Gobbi"

# Effect of long-term locomotion and balance exercise on functional mobility considering the Parkinson's disease subtypes: a pilot study

VICTOR S. BERETTA[1,2] | DIEGO ORCIOLI-SILVA[2] | DIEGO A. R. JAIMES[3] | BEATRIZ R. LEGUTKE[2] | THIAGO M. SIRICO[2] | PEDRO L. GONÇALVES[2] | LILIAN T. B. GOBBI[2] (in memoriam)

[1] São Paulo State University (Unesp), School of Technology and Sciences, Physical Education Department, Presidente Prudente, Brazil
[2] São Paulo State University (Unesp), Institute of Biosciences, Posture and Gait Studies Laboratory (LEPLO), Rio Claro, Brazil
[3] Faculty of Human Sciences and Education, Los Llanos University, Villavicencio, Colombia

Correspondence to: Victor Spiandor Beretta Ph.D., São Paulo State University (Unesp), School of Technology and Sciences, Physical Education Department, Rua Roberto Simonsen, 305 Zip code: 19060-900 - Presidente Prudente/SP, Brasil.
email: victor.beretta@unesp.br
https://doi.org/10.20338/bjmb.v17i4.360

## HIGHLIGHTS

- Exercise improves functional mobility in dual-task conditions in both PD subtypes.
- Both PD subtypes increase lower limb functional strength after 16 weeks of exercise.
- The PIGD subtype improves functional mobility after 16 weeks of physical exercise.
- The severity of motor symptoms and cognitive condition were not improved by exercise.

## ABBREVIATIONS

| | |
|---|---|
| DT | Double-task |
| H&Y | Hoehn & Yahr scale |
| MMSE | Mini-Mental State Examination |
| PD | Parkinson's disease |
| PIGD | Postural Instability and Gait Difficulty |
| post-test | Post-intervention |
| pre-test | Baseline |
| PwPD | People with Parkinson's disease |
| ST | Single-task |
| TD | Tremor Dominant |
| TUG | Timed Up and Go test |
| UPDRS | Unified Parkinson's Disease Rating Scale |

## PUBLICATION DATA

Received 17 04 2023
Accepted 17 06 2023
Published 20 06 2023

**BACKGROUND:** Different clinical subtypes (i.e., Postural Instability and Gait Difficulty -PIGD and Tremor Dominant -TD) have been highlighted in Parkinson's disease (PD). Although physical exercise improves motor symptoms in PD, the knowledge about the effect of physical exercise considering the PD subtype is limited.
**AIM:** To compare the effects of long-term locomotion and balance exercise on lower limb functional strength and functional mobility in PD subtypes.
**METHOD:** Eight individuals PIGD and 10 TD participated in this study. All individuals participated in the interventions with exercises focused on improving locomotion and balance. 48 sessions of exercise were performed three times per week for 60 minutes each session. Functional Mobility was analyzed by the Timed Up and Go test (TUG) in a single (ST) and double-task (DT – i.e., subtraction by three). Lower limb functional strength was analyzed by the 30s sit-to-stand test. Both tests were performed at baseline (pre-test) and post-intervention (post-test). Statistical analysis was performed by two-way ANOVA, with Group (PIGD vs. TD) and Moment (pre vs. post-test) factors, with repeated measures for the second factor.
**RESULTS:** PIGD decreased the time to perform TUG_ST in the post-test compared to the pre-test ($p=0.001$). Both groups decreased the time in TUG_DT and increased the number of repetitions in sit-to-stand test in the post-test in relation to the pre-test ($p<0.05$).
**CONCLUSION:** Long-term locomotion and balance exercise programs can improve functional mobility mainly in PIGD. A possible explanation is due to the greater room for improvement of PIGD subtypes and exercise specificity.

**KEYWORDS**: Physical activity | Rehabilitation | Exercise | Postural Instability and Gait Difficulty | Tremor dominant

## INTRODUCTION

The decrease of dopaminergic neurons in the basal ganglia, characteristic of Parkinson's disease (PD), promotes dysfunction in several cortical and subcortical structures involved in the control and execution of voluntary movements and cognitive resources [1]. This dysfunction causes motor deficits in people with PD (PwPD) such as bradykinesia, rigidity, resting tremor, gait impairments, and postural instability [2]. In addition to motor symptoms, PwPD demonstrates non-motor symptoms such as cognitive impairments, anxiety, and depression [2]. Although the PD symptoms are well-characterized, the prevalence of each one is variable.

PD is recognized as a heterogeneous neurodegenerative disease with different clinical features [3]. Due to the PD heterogeneity, PwPD has been classified into two subtypes according to different clinical characteristics: postural instability and gait difficulty (PIGD) and tremor dominant (TD) [4]. PIGD is characterized by the presence of severe gait impairments, postural instability, bradykinesia, and muscle rigidity [3,4]. Also, PIGD subtype has faster disease progression, late-onset, and higher fall risk [5]. TD subtype has slower disease progression and a predominance of tremor symptoms [2–4].

Medication intake is the most common treatment for PD. Pharmacotherapy relieves the signs and symptoms of the disease, but the impairments in some gait parameters and postural control are persistent [6]. Also, continuous use of the medication can bring several side effects and diminish their effects over time. Thus, physical exercise has been increasingly explored in PD as a complementary intervention to pharmacotherapy [7,8]. Physical exercise improves neurophysiological aspects (e.g., dopamine concentration and release) [9], improve motor symptoms in PwPD, and reduced the risk of falls [10]. The exercises focused on balance and locomotion in PwPD have improved balance and gait function and reduced falls in PwPD [11,12].

Studies investigating the characteristics and the effects of different interventions considering the PD subtypes are relevant to advance the knowledge and propose optimized interventions for each condition in this population. A previous study highlighted the need for personalized medicine in PD considering its subtypes (e.g., development of genotype-specific therapies) due to the development and characteristics of each clinical subtype [13]. Although a short-term multidisciplinary exercise program (i.e., two weeks) improved motor symptoms severity, balance, and functional mobility in both PD subtypes, the benefits in motor symptoms were superior in PIGD subtype [14]. However, to the best of our knowledge, there is a lack of information regarding the effects of a long-term exercise intervention in PIGD and TD subtypes [15].

Thus, this pilot study aimed to compare the effects of 48 sessions of locomotion and balance exercise on functional mobility in PwPD considering the PIGD and TD subtypes. We expected that both PD subtypes would improve functional mobility after the exercise program. We also expected that this improvement would be greater in the PIGD subtype due to the exercise specificity of the proposed intervention considering the exacerbated deficits that could impact balance and gait performance in this subtype [14].

## METHODS

### Participants

Eighteen PwPD participated in this pilot study and were distributed into two groups according to the PD subtype (eight PIGD and ten TD). The participants were selected through a database from the Program of Physical Activity for People with Parkinson's disease (PROPARKI). For inclusion criteria, PwPD should be diagnosed based on UK Brain Bank criteria, age > 50 years, took PD medication, should present a score between one and three in the adapted Hoehn & Yahr scale (H&Y), and independent locomotion. Exclusion criteria were: i) cognitive decline (score<24 in Mini-Mental State Examination – MMSE) [16]; ii) musculoskeletal, vestibular, or visual impairments that made it impossible to participate in experimental procedures; and (iii) failing to attend at least 70% of the sessions. Study approval was obtained from the research ethics committee at São Paulo State University (Unesp) (n. 1058). All participants gave their signed informed consent before their participation.

### Experimental procedures

The experimental protocol was conducted over four months. All experimental procedures (i.e., assessments of clinical characteristics, cognition, lower limb functional strength, and functional mobility and the physical exercise sessions) were performed at Unesp Rio Claro. Clinical and cognitive characteristics, lower limb functional strength, and functional mobility were collected before and after 16 weeks of the physical exercise program.

### Clinical, cognitive, and functional mobility assessment

For clinical, cognitive, and functional mobility characteristics, participants attended the Posture and Gait Studies Laboratory (LEPLO) at the same University in two different times (before and after physical exercises). A specialist researcher applied the Unified Parkinson's Disease Rating Scale (UPDRS) and the H&Y scale adapted version to evaluate the severity of the symptoms and the stage of PD, respectively. Also, the UPDRS was used to classify the individuals according to the PD subtype [4]. For that, we calculated the ratio of the mean UPDRS tremor scores (i.e., eight items) to the mean UPDRS PIGD scores (i.e., five items). The PIGD group included individuals with ratios ≤1, while the TD group included individuals with ratios ≥1.5[4]. individuals with ratios between 1 and 1.5 were classified as indeterminate and were excluded from the study. MMSE was performed to assess global cognition.

Functional mobility was evaluated by the Timed Up and Go test (TUG). The TUG involves standing up from a chair, walking three meters, turning around, walking back to the chair, and sitting down as quickly and safely as possible without running. Participants performed three trials of the TUG under two conditions: single-task (ST) and dual-task (DT). In DT, participants completed the task described above while counting backward by 3's from the pre-selected number (i.e., 30, 42, and 51). The time to perform the test was measured using a stopwatch and the average of the three trials was considered as the functional mobility performance for each condition.

Lower limb functional strength was assessed by the 30-second sit-to-stand test. Participants were instructed to stand up (completely) and sit down from a chair as quickly as possible for 30 seconds. The number of repetitions was registered and considered as the performance of lower limb functional strength.

### Physical exercise intervention

The physical exercise program was performed for 16 weeks, three times a week, totalizing 48 sessions, and included exercises focused to improve the locomotion, balance, and cognition of PwPD. All sessions lasted 60 min (10 min of warm-up, 40 min main part, and 10 min cooldown) [7]. The main part was composed of locomotion and balance exercises that manipulated the step length, velocity, and width, the sensorial conditions (i.e., visual, vestibular, and somatosensory systems), proprioception stimulus, and the task conditions (i.e., different support bases and direction). The progression was performed every eight sessions by increasing the exercise complexity (i.e., manipulating the surface, such as walking or standing on a firm or on a foam surface; manipulating the base of support, such as walking on top of a rope, or on a low or high balance beam, standing in two or one legs; manipulating the vision, such as standing with eyes open or closed) and intensity (i.e., increasing the velocity of movement execution or the number of exercises).

In addition, we included activities with DT to increase motor and cognitive function during the exercise, hence increasing the exercise complexity. We added motor (e.g., throwing a ball/balloon in the air, touching a ball, or moving the arms and hands in different ways) or cognitive secondary tasks (e.g., doing mathematical calculations or naming countries, animals, and objects) to the first task (i.e., walking or balance maintenance). The DT activities were performed in the last 40 sessions of the intervention. Sixteen sessions focused mainly on cognitive DT and the other 24 on cognitive and motor DT activities. The individuals were encouraged to take their usual PD medication during the intervention [7].

### Statistical analysis

Statistical analyses were performed by SPSS 22.0 software (SPSS, Inc.). The significance level was maintained as $p<0.05$. Normality and homogeneity were verified by Shapiro-Wilk and Levene tests, respectively. Clinical and cognitive sample characteristics of each subtype at pre-test were compared by Student t-test for independent samples or Mann-Whitney U test. Two-way ANOVA, with Group (PIGD vs. TD) and Moment (pre vs. post-test) as factors, with repeated measures for the second factor was conducted to analyze the effect of long-term exercise on lower limb functional strength, functional mobility, PD symptoms severity, and cognitive condition. Bonferroni post hoc test with was applied when interaction between the factors and main effect of the moment were indicated in the analysis.

## RESULTS

Statistical analysis indicated that both groups were similar in the demographic characteristics, UPDRS motor section (p=0.722), UPDRS total (p=0.098), and MMSE (p=0.298) at the pre-test (Table 1).

**Table 1.** Characteristics of PD subtypes at pre-test. Parametric variables are displayed as mean ± standard deviations and non-parametric variables (scales and non-normally distributed data) as medians (quartiles).

| | PIGD (n=8) | TD (n=10) | p-value |
|---|---|---|---|
| **Age (years)** | 69.88±11.28 | 71.00±6.46 | 0.793 |
| **Sex (M/F)** | 3/5 | 7/3 | --- |
| **Body Mass (kg)** | 72.18±9.82 | 72.19±13.09 | 0.998 |
| **Height (cm)** | 160.88±7.45 | 163.75±10.02 | 0.510 |
| **H&Y stage (1.5/2/2.5/3)** | 0/4/3/1 | 1/7/2/0 | --- |

ANOVA revealed Group*Moment interaction for the TUG in ST condition ($F_{1,16} = 5.647$; p=0.030; $\eta_p^2=0.261$) (Figure 1). Post hoc tests indicated that PIGD individuals decrease the time to complete the TUG at the post-test compared to the pre-test (p=0.001). In addition, ANOVA revealed main effect of moment for TUG in DT condition ($F_{1,16} = 10.382$; p=0.005; $\eta_p^2=0.394$) and lower limb functional strength ($F_{1,16} = 5.120$; p=0.038; $\eta_p^2=0.242$) (Figure 1). The ANOVA indicated that individuals, independent of PD subtype, decrease the time to complete TUG in DT condition (delta = -1.65 seconds) and increase the number of repetitions in 30s sit-to-stand test (delta = 2.39 repetitions) at post-test in relation to pre-test.

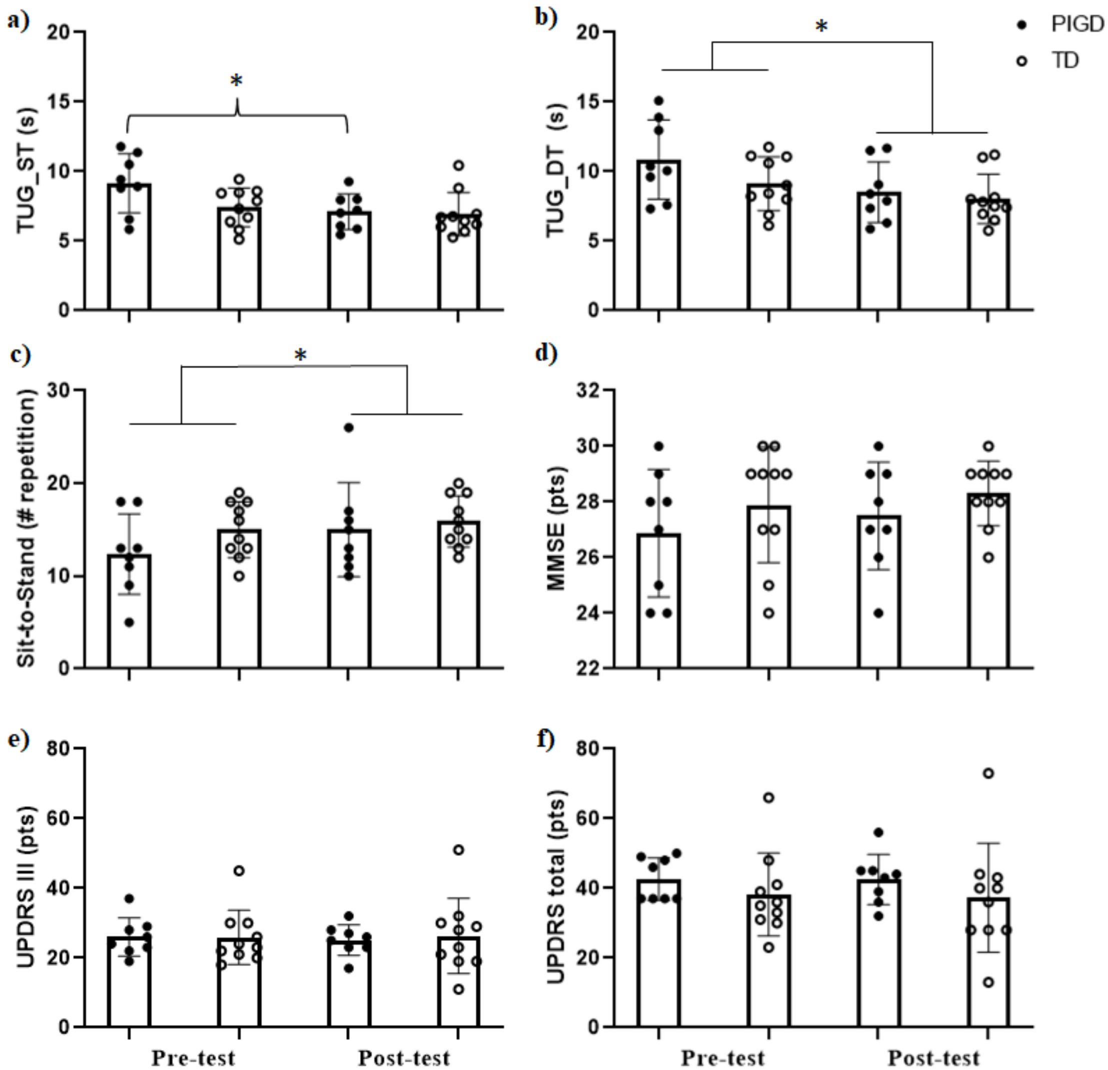


**Figure 1.** Mean and standard deviation of functional mobility in (a) single task (ST), and (b) dual task (DT) conditions, (c) lower limb functional strength, (d) MMSE, (e) UPDRS motor section, and (f) UPDRS total. * Indicates a significant difference between pre and post-test moments.

## DISCUSSION

Our study investigated the effects of long-term exercise programs on lower limb functional strength and functional mobility in PD subtypes. As expected, the locomotion and balance exercises program improves functional mobility and lower limb functional strength in both subtypes. However, the improvement in functional mobility in the ST condition was evidenced mainly in the PIGD subtype, likely due to a greater room for improvement and due specificity of exercise considering the subtype characteristics (i.e., the prevalence of gait and balance deficits in PIGD).

Although physical exercise is a well-established complementary therapy for PwPD due to the several motor and non-motor improvements [7,8,17], the benefits of physical exercise may be influenced by the PD subtype. Our results corroborate, at least in parts, with a previous study that indicated greater improvement in the PIGD subtype after physical exercise than TD [14]. PIGD individuals decrease more motor symptoms after two weeks of multidisciplinary intensive rehabilitation in relation to TD [14]. However, this short-term program improves equally functional mobility, locomotion, and balance in both subtypes [14]. A possible explanation is the program characteristics such as the type of exercise. Chen et al. [14] proposed a two-week exercise program focused on improving motor relearning with external and internal cues. On the other hand, our physical exercise program was focused on locomotion and balance activities with some cognitive tasks for 16 weeks. Taken together, these studies are relevant in identifying the specific effects of physical exercise considering each subtype of PD.

The superior benefits of our exercise program in PIGD individuals may be congruent with the common characteristics evidenced in this subtype. In general, individuals of the PIGD subtype have worse locomotion, postural control, bradykinesia, and cognition than TD [18]. The deficits in locomotion and postural control exacerbated in PIGD seem to be related to decreased functional connectivity within the prefrontal–parietal network [19], which could improve after physical and cognitive program [20]. Thus, the locomotion activities of our program such as walking in different environments and conditions (e.g., ramps, stairs, narrow and soft floors, crossing obstacles with different characteristics, increasing gait speed, changing directions, and when performing additional cognitive and motor tasks) and the activities to maintain the static and dynamic balance in several task conditions may have improved the motor and cognitive deficits exacerbated in PIGD subtype. The deficits related to the gait parameters and balance exacerbated in the PIGD subtype directly impact functional mobility performance and are related to an increased risk of falls in this population [5]. Also, although the lack of statistical difference between the PD subtypes at the pre-test, due to the greater severity of aspects that influence functional mobility (e.g., bradykinesia, balance, and locomotion), PIGD individuals have greater room for improvement than TD after an intervention, which facilitates the observation of changes in this subtype. Despite the lack of statistical difference between the PD subtypes at the pre-test on the functional mobility performance, PIGD individuals demonstrate a slightly greater time to complete the TUG test than TD at the pre-test. The slightly superior benefits of physical exercise on functional mobility in PIGD should be considered cautiously since these benefits were evidenced only in one of six parameters.

Decreased muscle strength is related to motor impairments in PD and increased risk of falls [5] which impact daily living tasks. Furthermore, deficits in functional mobility have been identified as a predictor for fall risk in PwPD. Thus, since our exercise program improved both lower limb functional strength and functional mobility during DT condition in both PD subtypes, we can speculate that our intervention may improve the motor symptoms (i.e., parameters involved in locomotion and postural control), reduce the risk of falls, improve quality of life, and independence in performing activities of daily life [17]. However, unexpectedly, our intervention did not improve statistically the general motor symptoms severity and global cognition. Although the lack of statistical significance, the intervention was able to maintain the degree of PD symptoms and global cognition. The maintenance of the severity of PD symptoms and global cognition is important since the progressive characteristics of the disease.

Current findings should be interpreted carefully as we conducted a pilot study that included small sample size and a limited number of parameters. Also, the lack of an active control group difficult to conclude that the observed improvements were exclusively due to the specific activities provided in the training program or if they were influenced by other factors such as the testing repetition. In addition, we did not analyze the cognitive performance of the DT during the TUG, which would allow us to understand better the influence of the cognitive task during the functional mobility performance in each subtype. Future randomized clinical trials are necessary to identify the characteristics of each PD subtype and the specificity of the physical program which may optimize the therapy using physical exercise for PD. Despite the small sample size, our pilot study advances the knowledge by demonstrating the effect of 16 weeks of a program with locomotion and balance exercises in each PD subtype.

## CONCLUSION

Long-term (i.e., 16 weeks) locomotion and balance exercise program improved functional mobility performed with concomitant cognitive tasks and the lower limb functional strength in both subtypes of PD. Also, functional mobility in ST was improved mainly in PIGD after physical exercise.

## REFERENCES

1. Takakusaki K, Tomita N, Yano M. Substrates for normal gait and pathophysiology of gait disturbances with respect to the basal ganglia dysfunction. *Journal of neurology*. 2008;255 Suppl:19-29. doi:10.1007/s00415-008-4004-7
2. Jankovic J. Parkinson's disease: clinical features and diagnosis. *J Neurol Neurosurg Psychiatry*. 2008;79(4):368-376. doi:10.1136/jnnp.2007.131045
3. Jankovic J, Carter J, Gauthier S, et al. Variable expression of Parkinson's disease: a base-line analysis of the DATATOP cohort. The Parkinson Study Group. *Neurology*. 1990;40(0028-3878 (Print)):5.
4. Stebbins GT, Goetz CG, Burn DJ, Jankovic J, Khoo TK, Tilley BC. How to identify tremor dominant and postural instability/gait difficulty groups with the movement disorder society unified Parkinson's disease rating scale: comparison with the unified Parkinson's disease rating scale. *Movement Disorders*. 2013;28(5):668-670. doi:10.1002/mds.25383
5. Pelicioni PHS, Menant JC, Latt MD, Lord SR. Falls in Parkinson's Disease Subtypes: Risk Factors, Locations and Circumstances. *International journal of environmental research and public health*. 2019;16(12). doi:10.3390/ijerph16122216
6. Curtze C, Nutt JG, Carlson-Kuhta P, Mancini M, Horak FB. Levodopa Is a Double-Edged Sword for Balance and Gait in People With Parkinson's Disease. *Movement Disorders*. 2015;30(10):1361-1370. doi:10.1002/mds.26269

7. Gobbi LTB, Pelicioni PHS, Lahr J, Lirani-Silva E, Teixeira-Arroyo C, Santos PCR dos. Effect of different types of exercises on psychological and cognitive features in people with Parkinson's disease: A randomized controlled trial. *Annals of Physical and Rehabilitation Medicine*. 2021;64(1):101407. doi:10.1016/j.rehab.2020.05.011
8. Abbruzzese G, Marchese R, Avanzino L, Pelosin E. Rehabilitation for Parkinson's disease: Current outlook and future challenges. *Parkinsonism & related disorders*. 2016;22 Suppl 1:S60-4. doi:10.1016/j.parkreldis.2015.09.005
9. Sacheli MA, Neva JL, Lakhani B, et al. Exercise increases caudate dopamine release and ventral striatal activation in Parkinson's disease. *Movement Disorders*. 2019;34(12):1891-1900. doi:10.1002/mds.27865
10. Goodwin VA, Richards SH, Taylor RS, Taylor AH, Campbell JL. The effectiveness of exercise interventions for people with Parkinson's disease: a systematic review and meta-analysis. *Movement disorders : official journal of the Movement Disorder Society*. 2008;23(5):631-640. doi:10.1002/mds.21922
11. Feng YS, Yang SD, Tan ZX, et al. The benefits and mechanisms of exercise training for Parkinson's disease. *Life Sciences*. 2020;245:117345. doi:10.1016/j.lfs.2020.117345
12. Shen X, Wong-Yu ISK, Mak MKY. Effects of Exercise on Falls, Balance, and Gait Ability in Parkinson's Disease: A Meta-analysis. *Neurorehabilitation and neural repair*. 2016;30(6):512-527. doi:10.1177/1545968315613447
13. Marras C, Chaudhuri KR, Titova N, Mestre TA. Therapy of Parkinson's Disease Subtypes. *Neurotherapeutics*. 2020;17(4):1366-1377. doi:10.1007/s13311-020-00894-7
14. Chen KK, Jin ZH, Gao L, et al. Efficacy of short-term multidisciplinary intensive rehabilitation in patients with different Parkinson's disease motor subtypes: a prospective pilot study with 3-month follow-up. *Neural Regeneration Research*. 2021;16(7):1336. doi:10.4103/1673-5374.301029
15. Mak MK, Wong-Yu IS, Shen X, Chung CL. Long-term effects of exercise and physical therapy in people with Parkinson disease. *Nature reviews Neurology*. 2017;13(11):689-703. doi:10.1038/nrneurol.2017.128
16. Brucki SM, Nitrini R, Caramelli P, Bertolucci PH, Okamoto IH. Suggestions for utilization of the mini-mental state examination in Brazil. *Arquivos de Neuro-psiquiatria*. 2003;61(3b):777-781. doi:https://doi.org/10.1590/S0004-282X2003000500014.
17. Ernst M, Folkerts AK, Gollan R, et al. Physical exercise for people with Parkinson's disease: a systematic review and network meta-analysis. *Cochrane Database of Systematic Reviews*. 2023;2023(1). doi:10.1002/14651858.CD013856.pub2
18. Ren J, Hua P, Li Y, et al. Comparison of Three Motor Subtype Classifications in de novo Parkinson's Disease Patients. *Frontiers in Neurology*. 2020;11:1803. doi:10.3389/FNEUR.2020.601225/BIBTEX
19. Zhang L, Li TN, Yuan YS, et al. The Neural Basis of Postural Instability Gait Disorder Subtype of Parkinson's Disease: A PET and fMRI Study. *CNS Neuroscience & Therapeutics*. 2016;22(5):360-367. doi:10.1111/cns.12504
20. Leocadi M, Canu E, Sarasso E, et al. Physiotherapy with Dual-Tasks Improves Cognition and Resting-State Functional Connectivity in Parkinson's Disease with Postural Instability and Gait Disorders (P1-1.Virtual). In: *Neurology*. Vol 98. ; 2022:1327.

## ACKNOWLEDGMENTS

The authors would like to thank all members of the Program of Physical Activity for People with Parkinson's disease (PROPARKI), Unesp, Câmpus de Rio Claro-SP, Brazil, for the intervention and data collection assistance.

**Citation:** Beretta VS, Orcioli-Silva D, Jaimes DAR, Legutke BR, Sirico TM, Gonçalves PL, Gobbi LTB. (2023). Effect of long-term locomotion and balance exercise on functional mobility considering the Parkinson's disease subtypes: a pilot study. *Brazilian Journal of Motor Behavior*, 17(4):103-108.

**Funding:** This study was supported in part by the São Paulo State University (UNESP) [Edital 13/2022/PROPe), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, Brasil (CAPES) [Finance Code 001], and by Brazilian National Council for Scientific and Technological Development, Brazil (CNPq) [grant numbers #142057/2017-7; #309045/2017-7].
**Competing interests:** The authors have declared that no competing interests exist.
**DOI:** https://doi.org/10.20338/bjmb.v17i4.360