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Effects Of Mat Pilates On Range Of Motion, Balance, Flexibility And Functional Mobility In People With Parkinson's: A Randomized Controlled Trial

Efectos Del Mat Pilates En La Amplitud De Movimiento, El Equilibrio, La Flexibilidad Y La Movilidad Funcional En Personas Con Parkinson: Un Ensayo Controlado Aleatorio

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Abstract. This study is a two-arm randomized controlled trial that analyzed the effects of Mat Pilates on range of motion, balance, flexibility and functional mobility in people with Parkinson's. 23 individuals were randomized in Mat Pilates group and control group, pre and post-intervention data collection were made evaluating shoulder amplitude (Absolute Axis 360); balance (Mini-BESTest); flexibility (Sit and reach test); and functional mobility (TUG). The results showed significant intragroup differences in Mat Pilates group on balance ($p<0.001$), functional mobility ($p=0.011$), range of motion of the right shoulder in abduction ($p=0.002$) and left shoulder in abduction ($p=0.006$), although, in flexibility there were no significant differences. There were no intergroup differences and the intragroup presented worsening results in right shoulder flexion ($p=0.008$). A Mat Pilates protocol can be a complementary treatment to improve balance, functional mobility and shoulder range of motion in abduction in people with Parkinson's disease.
Keywords: Physical exercise; Rehabilitation; Neurodegenerative diseases; Pilates.

Resumen. Este estudio es un ensayo controlado aleatorio de dos grupos que analizó los efectos del Mat Pilates sobre la amplitud de movimiento, el equilibrio, la flexibilidad y la movilidad funcional en personas con Parkinson. Se aleatorizaron 23 individuos en el grupo de Mat Pilates y en grupo de control, y se recopilaron datos antes y después de la intervención, evaluando la amplitud del hombro (Absolute Axis 360); el equilibrio (Mini-BESTest); la flexibilidad (Prueba de sentarse y alcanzar); y la movilidad funcional (TUG). Los resultados mostraron diferencias significativas dentro del grupo de Mat Pilates en el equilibrio ($p<0.001$), la movilidad funcional ($p=0.011$), la amplitud de movimiento del hombre derecho en abducción ($p=0.006$), aunque no hubo diferencias significativas en la flexibilidad. No se observaron diferencias entre los grupos y dentro del grupo se observó un empeoramiento en la flexión del hombro derecho ($p=0.008$). Un protocolo de Mat Pilates puede ser un tratamiento complementario para mejorar el equilibrio, la movilidad funcional y la amplitud de movimiento del hombro en abducción en personas con enfermedad de Parkinson.
Palabras clave: Ejercicio físico; Rehabilitación; Enfermedades neurodegenerativas; Pilates.

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Introduction

Parkinson's disease (PD) is one of the most common neurodegenerative diseases in the world and there is still no medicine capable of stopping its progression (Xu, Fu, & Le, 2019). PD is characterized as a movement disorder, and it's a neurodegenerative and chronic disease which affects motor control, its main motor symptoms are tremor, rigidity, bradykinesia-akinesia and postural instability (Balestrino & Schapira, 2019). PD affects directly functional mobility, balance, flexibility and range of motion, and worsens physical capabilities which are associated with bradykinesia-akinesia and postural instability (Cabreira & Massano, 2019).

According to the technical brief of the public health approach to Parkinson's disease published by the World Health Organization (2022), pharmacological treatment for PD includes the use of Levodopa, which has been shown to be the most effective drug for the management in PD treatment, and it is used in early stages of the disease, however, it is not effective in preventing the appearance of motor complications, and higher doses of the medicine are related to a greater risk of complications and motor fluctuations that People with Parkinson's disease (PwP) have to live and deal with on a daily basis (Saba et al. 2021). As PD progresses there is a need to take more medications to treat the symptoms that arise as a result of the disease itself and with the use of these medications people with PD may suffer from adverse effects such as dry mouth, agitation, dyskinesia, among others. The Pharmacological treatment can improve the motor symptoms of PD, but over time the effect of the dopaminergic treatment can gradually decrease, therefore it is unable to prevent the disease progression (Feng et al. 2020).

One of the alternatives to the use of medication is non-pharmacological rehabilitation therapy, which showed significant effectiveness in PD treatment. Physical exercise is one of the most used non-pharmacological treatment for PwP and a controlled training program showed improvement in both motor and non-motor symptoms of PD. (Ferreira, et al. 2018) Therefore, it is crucial to emphasize the significant potential of exercise, including Pilates, as a complementary approach for individuals with PD. Physical activity, according to Xu, Feng & Le (2019), not only counteracts the clinical symptoms of PD, but also supports brain maintenance and plasticity through neurogenesis, synaptogenesis, metabolism enhancement, and angiogenesis. It works by inhibiting oxidative stress, repairing mitochondrial damage, and stimulating growth factor production. Importantly, regular exercise can mitigate side effects like dyskinesia, which often arises from anti-PD medications. Moreover, several studies showed that low-volume resistance training not only improves the physical capacity of elderly people with PD but is also beneficial for elderly individuals without Parkinson's disease (Pucci, Neves, Santana, Neves, & Saavedra, 2021), enhancing aspects such as gait speed, muscle mass gains, muscle strength, and functional mobility (Barbalho, Monteiro & Costa, 2019; Leal, et al, 2019). This type of training promotes overall physical health and well-being in the elderly population. In a related study by Speck, Schamne, Aguiar, Cunha, and Prediger (2018), an intensive physical exercise program was found to significantly decrease dyskinesia and improve Unified Parkinson's Disease Rating Scale scores (UPDRS) in patients with PD.

Along with resistance training, there are other exercise methods that are also a viable option for PD. Pilates method has been shown to be an ally treatment for PwP (Roeder, Costello, Smith, Stewart, & Kerr, 2015; Cancela, Cardalda, Ayán, & de Oliveira, 2018). A systematic review showed that Pilates method resulted in beneficial effects on physical conditioning, balance, flexibility, autonomy, functional mobility and also showed greater gains in lower body function in PwP, indicating that the Pilates method can be safely prescribed for PwP, which indicates the importance of carrying out more studies correlating Pilates and PD (Suárez-Iglesias, Miller, Seijo-Martínez, & Ayán, 2019).

The results of this study may demonstrate the relevance of prevention, treatment, reduction and control of motor symptoms of this disease through the Pilates method, encouraging new research aimed at this population, seeking to bring clarifications and a better guide to the treatment such as improving the routine of people and family members who live with PD daily. Therefore, the primary objective of this article is to analyze the effects of mat Pilates on the range of movement and balance of people with Parkinson's and the secondary objectives are, respectively, to analyze the flexibility and functional mobility of the group.

Methods

Study design

This study is a two-arm randomized clinical trial developed in accordance with the recommendations of the CONSORT 2010 (Consolidated Standards of Reporting Trials), which followed the guidelines of the Helsinque declaration, approved by the Research Ethics Committee (CEPSH) of Santa Catarina State university UDESC (4.602.029) and registered on REBEC platform (Brazilian Registry of Clinical Trials) number 3.613.483. The participants' consent was obtained in written form.

Participants

The study consisted of 23 individuals diagnosed with PD (61,7±7,5) of both sexes recruited through the Santa Catarina Parkinson's Association (APASC); in addition, to recruit other participants, advertisements were made in newspaper, social media pages such as Instagram and Facebook and on the university's website and electronic mail. The study was also advertised in healthcare institutions. Recruitment was carried out from October 2021 to January 2022 and baseline data was carried out in February 2022. The intervention lasted 12 uninterrupted weeks between March and May 2022 and the post-intervention data was carried out from June to July 2022. The collection and intervention were carried out in a public institution of higher education in a city in the South of Brazil (Florianópolis and São José), without any charges to the study participants, the class sessions (intervention) were also held in the university.

Exclusion and inclusion criteria

For this study the following inclusion criteria were defined: a) clinical diagnosis given by a neurologist, following the criteria of Movement Disorder Society (Postuma et al., 2015); b) both sexes; c) local residents; d) with stable doses and with no change in levodopa medication in the last four weeks (ON medication state), because PwP when treated with this specific medication tend to present two distinct states, ON/OFF, with the ON state being characterized by the use and effect of the medication, indicating a significant improvement in the motor symptoms of PD (García Amor, 2020); e) aged 45 or over; f) without practicing any type of physical exercise in the month prior to data collection; g) classified in stage 1 to 4 of the disease (Hoehn & Yahr, 1967). And the exclusion criteria: a) those who did not reach the cutoff point of the MoCA instrument, considering 22 points (Sarmento,2009); b) classified in stage 5 of the disease (Hoehn & Yahr, 1967); c) who did not complete all stages of the study; d) who performed another practice of physical exercise concomitantly; e) who were not present in up to 75% of the classes.

Intervention

Participants were randomized and separated into two groups, a) Control Group (CG) n=12 participants, and b) Mat Pilates Group (MPG) n=11 participants.

Intervention protocol- Mat Pilates Group

The Mat Pilates intervention was carried out in a large room with the materials and conditions necessary for the practice, such as Swiss balls, elastic bands, non-slip mats, etc. Research participants, allocated in the MPG, participated in a training program based on Mat Pilates that was designed specifically for PwP and applied over a period of 12 weeks (Moratelli, et al., 2022). The program was prepared following the SPIRIT recommendations (Standard Protocol Items: Recommendations for Interventional Trials), moreover, the intervention was taught by a Physical Education professional trained in the Pilates method, accredited in Santa Catarina.

The Classes lasted 60 minutes and were held twice a week in the afternoon, divided into: a) initial warm-up (fifteen minutes) with the purpose of warming up the body and prepare the joints to perform Pilates exercises safely. In the warm-up, basic Mat Pilates movements were explored, such as breath control, hip release, spinal rotation, cat stretch, hip rolls, scapula isolation, elevation and depression, arm circles e head nods; b) Main part (forty minutes), more intense exercises developed muscle strength, and joint mobility of lower and upper body was included as well, also core strength exercises were made, such as: breasts stroke (hand by hips), shell stretch, preparation abdomen, half roll back, roll up, single leg stretch, one leg circle, shoulder bridge, hell squeeze prone, side kick e spine twist. Each week the difficulty degree and number of the exercises were increased; c) Final part (five minutes) was destined to final relaxation, self-stretching exercises with a ball, self-massage and myofascial release were performed. Songs were used during the classes according to the class preference to increase the participation and adherence of the participants.

Control Group

After initial data collection, participants were randomized into the control group and instructed to maintain their usual daily activities and lifestyle; they were also advised not to engage in any other form of physical training during the 12 weeks of the intervention. Control group was invited to attend an educational session focused on self-care and the relevance of incorporating physical exercise into their daily lives. Additionally, they attended seminars about health care in their daily routines. Monthly, the researchers provided guidance on physical exercise and motivational messages, through phone calls to the participants, which where scheduled previously on the first day of the month at a time defined by the researchers.

At the end of the study, the CG was invited to continue participating in classes in another physical exercise project developed at the university where the study was carried out, so that they would not lose adherence or the habit of practicing physical exercise which they acquired during this period.

Outcome measures

The main primary outcome of this study was balance, and the secondary outcomes were range of motion, flexibility and functional mobility of the PwP.

The questionnaires were applied pre and post intervention in the form of individual interviews applied by researchers and staff from the laboratory Research in Leisure and Physical Activity (LAPLAF/CNPq). The questionnaire for physical aspects consisted of: (1) Shoulder range of motion test; (2) The Mini-BESTest: balance test; (3) Lower limb flexibility test: The sit and reach test; (4) Mobility test: Timed Up & Go (TUG), and the following outcome measures were also used as collection instruments; (5) Sociodemographic and clinical information and (6) Hoehn and Yahr Disability Stage Scale (HY).

(1) Shoulder range of motion: shoulder flexion and abduction movements (Ammitzboll et al., 2017). In the abduction test, the individual was positioned sitting with his back turned to the researcher with the palm of the hand facing the trunk. The fixed arm of the goniometer is placed on the posterior axillary line of the trunk and the movable arm of the goniometer is positioned on the lateral surface of the humerus. For the shoulder flexion test, the measurement was performed with the individual in the supine position, the fixed arm of the goniometer was positioned along the midaxillary line of the trunk and the movable arm was positioned on the lateral surface of the body of the humerus. Each position was tested only once on both arms, and the angular measurement in degrees was used to record the results.

(2) Mini-BESTest for balance: This test has 14 items, which measures dynamic balance and specifically assesses changes in direction, postural responses, sensory orientation and the individual's dynamic gait. The application of the test takes up to 15 minutes and allows a quick follow-up of changes in the individual's balance. The score is accounted by the sum of the points, which can reach 28 points, each item is scored from (0-2); a score of 0 indicates that the person is unable to perform the task, while a score of 2 indicates normality (Bambirra, Magalhães, & Paula, 2015).

(3) Lower limb flexibility test - The Sit and Reach Test: This test aims to check the flexibility of the lower limbs. Positioning the individual sitting on a chair one leg with the knee flexed at approximately 90 degrees, and the other foot resting on the floor with the knee lying down. The individual makes a slight inclination forward, taking the fingers towards the foot; the measurement is taken between the distance of the middle fingers of the hand and the tip of the foot. It is considered a negative score when the fingers will not touch the tip of the foot, alternatively, it is considered a positive score when the fingers pass the tip of the foot. Three attempts were made and the final value was taken by the average of the attempts (Wells, K. F. & Dillon, E. K., 1952).

(4) Mobility test - Timed UP & Go (TUG): is a screening tool used to calculate fall risks among the elderly. With the main objective of evaluating functional mobility. The TUG measures the time it takes an individual to performs some functional activities, such as standing up, walking and walking and sitting. The score is calculated as follows: a) less than 20 seconds (low risk of falls), b) 20 to 29 second (medium risk of falls), c) 30 seconds or more (high risk of falls). (Podsiadlo, et al. 1991).

(5) Sociodemographic and clinical information: this information was used to map the study subjects with regard to age, gender, marital status, education, initial symptoms of the disease, side of the body most affected and body mass index (BMI) according to the guidelines of the WHO (2016).

(6) Hoehn and Yahr disability scale: developed and validated by the authors (H&Y), it indicates the general state of PwP and it comprises five stages, classifying indi-

viduals to assess the severity of PD. It also encompasses global measures of signs and symptoms that allow the classification of the individual according to the degree of disability in which he/she presents. Patients classified as I, II and III had mild to moderate disability, while those with IV and V disability had more severe disability and a higher stage of the disease (Hoehn & Yahr, 1967).

Data collection took place in two moments, in the period prior to the beginning of the intervention, called the baseline (T0) and in the moment after the intervention stage, which took place after 12 weeks (T1). The questionnaire application was carried out in the form of face-to-face and individual interviews in a public institution of higher education in Southern Brazil by three well trained researchers who are members of LAPLAF. Data collection took around 45 minutes and was previously scheduled and the intervention was offered free of charge to all participants in this study.

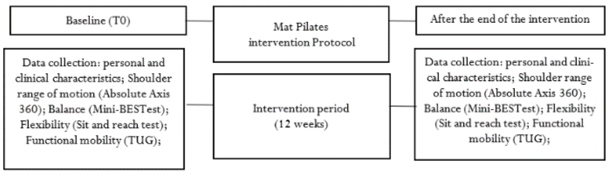

Figure 1. Development of the study stages. (Source: Produced by the author, 2023)

Sample Calculation

For the sample calculation, the primary outcome (balance) was considered through the software G*Power 3.1.9.2, assuming an effect size 0.28 (medium effect), (Paul, Canning, Song, Fung, & Sherrington, 2013). With a significance level of 5%, test power of 95% and sample loss of 20% according to (Cohen, 1988). Thus 11 participants obtained for the MPG and 12 for the CG, totaling 23 participants.

Randomization

Randomization was conducted through the website (http://www.randomization.org/), by the 1:1 method by the researchers J.M and K.H.A., in order to divide the participants into two groups: (1) MPG and (2) CG. For this study, it was not possible to blind the participants or researchers who carried out the intervention in relation to group allocation, as it was an intervention with physical exercise.

Adherence to the protocol

Adherence to classes was determined by the percentage (%) obtained throught the number of prescribed sessions fulfilled/sessions x 100. During all sessions, the presence of participants was recorded. By the end of the study, participants completed 79.4% of intervention activities.

Statistical analysis

Statistical data were recorded in an electronic spreadsheet in the Excel XP program, and transferred to the IBM SPSS statistical package version 20.0. Descriptive statistics, including mean, standard deviation, and percentage, were calculated to analyze the data, using the chi-square test and Fisher exact test, furthermore, the Shapiro-Wilk test was used to investigate the normality of the sample. The one-way ANOVA was utilized to examine the average age of the participants and to analyze the comparisons between the results of the MPG and CG groups after the intervention period. Additionally, to analyze alterations in both pre- and post-intervention intra-group comparisons, the two-way ANOVA test with repeated measures and Sidak Comparison were employed at a significance level of 5%. This approach allowed for the examination of variations within both intervention and control groups as well as between them (intra- and intergroup analyses).

It was not possible to perform the intention-to-treat analysis because the participants who did not complete the study ended up not returning for post-intervention data collection.

Results

85 PwP were initially recruited, however, 34 participants were subsequently excluded from the study for various reasons: 6 did not meet the inclusion criteria, 14 did not respond to follow-up calls, 11 declined to participate, and 3 failed to attend the baseline data collection. Consequently, 51 participants remained eligible for the study. Of these, 17 were allocated to another study conducted by the same researchers during the same period. The remaining participants (n=34) were then randomly assigned to either the MPG or CG.

Table 1.
Sociodemographic and clinical characteristics of the study participants in the baseline period (n=23).

	Mat Pilates (n=11) n (%)	Control (n=12) n (%)	Total (n=23) n (%)	P-value
Gender				0,214
Male	8 (72,7)	5 (41,7)	13 (56,5)	
Female	3 (27,3)	7 (58,3)	10 (43,5)	
Echolarity				0,241
Elementary School	5 (45,5)	2 (16,7)	7 (30,4)	
High School	3 (27,3)	3 (25,0)	6 (26,1)	
University education	3 (27,3)	7 (58,3)	10 (43,5)	
Marital status				0,193
With partner	9 (81,8)	6 (50,0)	15 (65,2)	
Without partner	2 (18,2)	6 (50,0)	8 (34,8)	
H&Y Modified				0,437
Low	7 (63,6)	6 (50,0)	13 (56,5)	
Moderate	2 (18,2)	5 (41,7)	7 (30,4)	
Severe	2 (18,2)	1 (8,3)	3 (13,0)	
Total affected side				0.090
Right	8 (72,7)	5 (41,7)	13 (56,5)	
Left	3 (27,3)	7 (58,3)	10 (43,5)	
Past physical activity history				0,667
Yes	8 (72,7)	7 (58,3)	15 (65,2)	
No	3 (27,3)	5 (41,7)	8 (34,7)	
BMI				0,293
Normal weight	6 (54,5)	4 (33,3)	10 (43,5)	
Overweight	5 (45,5)	8 (66,7)	13 (56,5)	

Note. CG = Control Group; IG = Intervention Group; n= attendance; Fisher's exact test; H&Y= Hoehn and Yarh; BMI: Body mass index.

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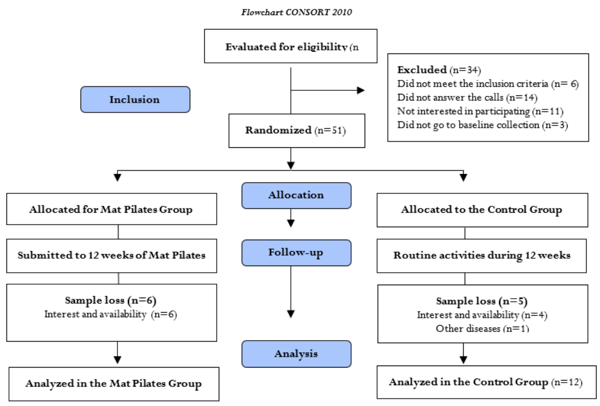

Figure 2. Flowchart of the study participants. (Source: Produced by the author, 2023)

Table 1 shows the sociodemographic and clinical characteristics in the baseline period and it is clear that there are no statistical differences between the groups, what demonstrates that it is a notable sample. The mean age of the CG was 61,6±8,9 years and the MPG 61,8±5,9 years, no significant differences were presented in the pre-intervention moment of the analyzed variables, thus showing that the sample was homogeneous. In table 2 significant differences can be observed namely in the intragroup variables of the Mat Pilates in balance ($p<0.001$), in functional mobility ($p=0,011$), in the range of motion of the shoulder in the right shoulder in abduction ($p=0,002$) and left shoulder in abduction ($p=0,006$).

There was no significant difference in the intergroup variables and the intragroup CG showed worsening in right shoulder flexion ($p=0,008$). There was no significant difference in the intergroup variables and the intragroup CG showed worsening in right shoulder flexion ($p=0,008$).

Table 2.
Effect of 12 weeks of Mat Pilates intervention compared to the control group on motor variables (n=23).

Variables	Mat Pilates (n=11)			Control Group (n=12)			
	Pre Ẋ (dp)	Post Ẋ (dp)	p*	Pre Ẋ (dp)	Post Ẋ (dp)	p*	p#
Shoulder range of motion							
Right abduction	138,7 (10,4)	150,5 (7,0)	0,002	149,7 (9,0)	145,9 (5,6)	0,517	0,574
Left Abduction	141,1 (8,0)	154,4 (6,8)	0,006	147,7 (7,7)	150,1 (6,5)	0,556	0,655
Right Flexion	146,3 (6,1)	153,0 (5,9)	0,161	157,0 (5,8)	143,8 (5,7)	0,008	0,278
Left Flexion	150,8 (5,1)	156,2 (5,1)	0,051	148,2 (4,9)	147,4 (4,8)	0,755	0,226
Balance	24,8 (2,1)	28,3 (2,1)	0,000	25,6 (2,0)	24,4 (2,0)	0,135	0,203
Flexibility of the lower limbs							
Right Leg	0,09 (2,8)	1,4 (2,8)	0,619	-9,5 (2,7)	-5,7 (2,7)	0,153	0,085
Left leg	,12 (3,0)	0,36 (2,4)	0,867	-10,7 (2,8)	-6,7 (2,3)	0,067	0,052
Functional mobility	1,4 (0,2)	1,1 (0,1)	0,011	1,3 (0,1)	1,3 (0,1)	1,000	0,515

Note. X = mean; sd = standard deviation; *p value for comparison between the baseline and post-intervention periods of the CG AND IG; p# value for comparison between GC and GI in the post-intervention period. Anova two-way with repeated measures and Sydak comparison test. Significant p values ($p < 0.05$) in bold.

Discussion

This study aimed to analyze the effects of Mat Pilates on range of motion, balance, flexibility and functional mobility on people with Parkinson's. There were positive intragroup effects on Mat Pilates group for balance, functional mobility and range of motion of the shoulder in the right abduction and left abduction variables, the variables that did not show significant improvements were the range of motion of the right and left shoulder in flexion and worsening in the CG in right shoulder flexion.

In this study, the range of motion variable had positive effects on the right and left shoulder abduction within the MPG, demonstrating the 12-week effectiveness of the Mat Pilates protocol. This finding is consistent with Bazyar, Marandi, and Chitsaz (2022), providing evidence of the benefits of Pilates for this population. Additionally, it aligns with the study of Geremia, Iskiewicz, Marschner, and Lehnen (2015), which associated Pilates practice with significant improvements in shoulder mobility among the elderly. Axial motor impairments impacts directly on the functional status of PwP, since the range of motion in PwP should be prioritized for daily well-being, as it is directly linked to the effective performance of household tasks such as eating, hygiene and sleeping (Cano de la Cuerda et al., 2020). The balance variable in this study also obtained positive results and great statistical relevance, mainly in the Mat Pilates intragroup similar to the study of Çoban, Belgen Kaygısız, and Selcuk (2021), who verified the effects of clinical Pilates on balance and postural control in PwP and noticed significant results in the balance variables in the group that performed Pilates. In another study by Cardalda, Machado, & Ayán, (2023), Mat Pilates demonstrated improvements in dynamic balance for the same population. It is known that balance is an important variable to be studied because as PD progresses the risk and history of falls increase and the fear of falling is a constant concern in the lives of PwP. Furthermore, balance impairment while performing functional activities and the reduced walking ability negatively affect the quality of life in this population (Silva, Alvarez, Nunes, Silva, & Santos, 2022; Scalzo, Flores, Marques, Robini, & Teixeira, 2012).

Moreover, flexibility was not effective in this study. In the study by Rahmati, Behzadipour, Schouten, Taghizadeh, and Firoozbakhsh, (2020), flexibility related measures reached significance only at the end of the program and in the case study carried out by Do Carmo, Boas, Do Vale, and Pinheiro (2018), the Pilates method was effective in flexibility in 3 out of 4 patients whit PD. Considering that flexibility is a more sensitive variable to be measured with PwP (Barbieri et al, 2011), a larger volume with more weeks of intervention may be necessary for this variable to show positive results. It is noted that flexibility is directly associated with balance, considering that advanced muscle stiffness caused by PD, the muscle reaction mechanism of Pwp is delayed which generates an inability to adjust balance regulatory mechanisms according to the environment demands, increasing the risk of falls. Thus, it is crucial to maintain good balance and flexibility results to prevent falls (De Carvalho et al, 2021, Barbieri et al, 2011).

Even so, functional mobility in this study presented good parameters in the Mat Pilates group after an intervention, corroborating with the study of Çoban, et al, (2021), which obtained significant post-intervention results in the Pilates group. Additionally to that, another study of Carmo et al, (2017), had even higher values after the Mat Pilates intervention. Assessing functional mobility in PwP is crucial for mitigating the risk of falls, enhancing performance in domestic and personal tasks, and alleviating joint pain associated with PD (Artigas, Franco, Leão, & Rieder, 2016). Given the necessity of functional mobility in daily life, such evaluations hold paramount importance.

Physical exercise has proven to be an essential component in the management of PD, helping to alleviate motor and non-motor symptoms associated with the disease, such as tremors, stiffness and bradykinesia, in addition to improving the quality of life of PwP, physical exercise has also been associated with a decrease in falls and improved cardiovascular health in PwP; furthermore, it was demonstrated that the diversification of exercise modalities and intensity levels, including aerobic exercise, strength training, specific motor training, and dancing, also enhanced both motor and non-motor symptoms of PD. These interventions exerted a more pronounced impact on the cognitive capacity of individuals affected by PD (da Silva et al, 2018, Murray, Sacheli, Eng, and Stoessl, 2014). Exercise also can show results for both short and long term aspects, for the short term exercise, it can lead to psychological satisfaction and reduce tremors and muscle stiffness, for the long term aspects, on the other hand, exercise is associated with a slower decline in motor function and with a reduction of the risks of premature disability in Pwp (Mak, Wong-Yu, Shen, & Chung, 2017).

The security of the participants is a concern that must be taken into account when dealing with PwP, some exercises may require a level of difficulty that can be challenging for PwP. In this study, the classified individuals had mild and moderate stage of PD, nevertheless, safety during classes was always a concern. The adherence to this intervention was 79.4%, a good level for this population, taking into consideration that PwP can struggle with issues like lack of motivation, fatigue, and physical limitation. Additional challenges, including low expectations of results, time constraints, and fear of falling, acted as barriers hindering the population from engaging in exercise (Ellis et al., 2013). Therefore, in this study, some strategies were implemented to improve adherence, for instance: sending motivational and positive messages to participants in a regular basis, also positive reinforcements during the intervention and the creation of a secure atmosphere for the participants.

Althought Mat Pilates has shown great results as an effective form of exercise for PwP in range of motion, balance, flexibility and functional mobility variables, there are limitations that deserve attention. The recruited participants were aware of the exercise intervention (Mat Pilates), and it is important to point out that and all of them have a mild to moderate stage of the disease (H&Y), therefore it cannot be stated whether the results of this study can be extrapolated to a more severe stage of the disease. It was not possible to perform the intention-to-treat test as the participants did not respond to the post-intervention collection and also, due to the low sample size, it is necessary to carry out future studies with larger sample sizes to confirm the results of this research. It is important, nonetheless, to highlight the strong points of this study, such as the methodological design (randomized clinical trial), and in the intervention with Mat Pilates, which showed great results. Even so, no adverse effects were reported during the intervention, demonstrating that it was safe and effective.

Finally, it is important to emphasize that Mat Pilates, as a form of physical exercise, is beneficial for the treatment of PD symptoms. This 12-week Mat Pilates program, therefore, can be a viable and safe complementary treatment for the studied variables. The findings highlight the significance of implementing this study within the public domain and providing clarity on PD and its treatment. The results have proven to be relevant for the scientific community and for PwP, aiding in the improvement of balance, functional mobility, and shoulder range of motion in abduction.

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