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Is high intensity Pilates exercise treatment beneficial for people with Parkinson´s disease?
¿El tratamiento con ejercicios de Pilates de alta intensidad es beneficioso para las personas con enfermedad de Parkinson?

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Abstract. Aim: to compare the effects of a therapeutic physical exercise programme based on mat Pilates method carried out at two intensities in a population with Parkinson´s disease. Method: 32 participants with Parkinson's disease were randomly assigned to the low-intensity Mat-Pilates group (n=16) and to the high-intensity Mat-Pilates group (n=16) with both interventions lasting 12 weeks. Lower limb strength (30 Second-Chair-Stand-test), gait speed (Timed-Up and Go), and feasibility were assessed. Results: A total of 29 participants attended 80% of the intervention sessions. The participation rate was 91.14% and 70.05% in the low intensity and high intensity groups, respectively. This research shows that after the intervention there was a significant increase in lower limb strength (low-intensity 8.31% *vs* high-intensity 34.25%) and gait speed (low-intensity 12.12% *vs* high-intensity 19.35%) for both groups, although the improvement in the high-intensity group was statistically greater than the low-intensity group. Conclusions: The Pilates method is evidenced as a comprehensive rehabilitation strategy in the treatment of patients with Parkinson's disease. Furthermore, an exercise regime based on the Pilates method at high intensity seems to lead to significant improvements in lower limb strength and an improvement in gait speed for this type of patient.
Keywords: Physical therapy, Neurodegenerative disorders, Older adults, Therapeutic exercise, Pilates Method, Parkinson´s disease
De 5 a 8 palabras clave

Resumen. Objetivo: comparar los efectos de un programa de ejercicio físico terapéutico basado en el método Mat Pilates realizado a dos intensidades en una población con enfermedad de Parkinson. Método: 32 participantes con enfermedad de Parkinson fueron asignados aleatoriamente al grupo de Mat-Pilates de baja intensidad (n=16) y al grupo de Mat-Pilates de alta intensidad (n=16), ambas intervenciones con una duración de 12 semanas. Se evaluaron la fuerza de las extremidades inferiores (30 Second-Silla-Stand-test), la velocidad de la marcha (Timed-Up and Go) y la factibilidad. Resultados: Un total de 29 participantes asistieron al 80% de las sesiones de intervención. La tasa de participación fue del 91,14% y 70,05% en los grupos de baja y alta intensidad, respectivamente. Esta investigación muestra que después de la intervención hubo un aumento significativo en la fuerza de los miembros inferiores (baja intensidad 8,31% vs alta intensidad 34,25%) y la velocidad de la marcha (baja intensidad 12,12% vs alta intensidad 19,35%) para ambos grupos, aunque la mejora en el grupo de alta intensidad fue estadísticamente mayor que en el grupo de baja intensidad. Conclusiones: El método Pilates se evidencia como una estrategia de rehabilitación integral en el tratamiento de pacientes con enfermedad de Parkinson. Además, un régimen de ejercicios basado en el método Pilates de alta intensidad parece conducir a mejoras significativas en la fuerza de los miembros inferiores y una mejora en la velocidad de la marcha para este tipo de pacientes.
Palabras clave: Fisioterapia, Trastornos neurodegenerativos, Adultos mayores, Ejercicio terapéutico, Método Pilates, Enfermedad de Parkinson

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Introduction

Parkinson's disease (PD) is known to be the second most common chronic neurodegenerative disorder, one which affects the central nervous system and evolves slowly. The result is a premature, progressive, and irreversible degeneration of the nigrostriatal pathway neurons. This neurological disease causes motor and non-motor disorders (Jellinger, 2015). The four cardinal signs of PD are tremor, bradykinesia, rigidity, and postural instability, resulting in a progressive loss of the patient's functional independence (Suchowersky, et al., 2006).

The bases of PD treatment are pharmacological therapy (levodopa as the drug par excellence) and surgical techniques (deep brain stimulation), although these treatments do not satisfactorily mitigate symptoms. Therapeutic exercise can be incorporated as a low-cost therapeutic alternative, without adverse effects, with the aim of increasing functional capacities (Fritz, et al., 2019). Pharmacological therapy can produce long-term side effects (Menéndez-González, et al., 2016).

Therapeutic exercise for patients with PD has positive effects on the development of conditional physical abilities, gait, balance, coordination and mood, thus improving the quality of life of this population (Ebersbach, et al., 2015; Machado, et al., 2022; Yang et al., 2022).

New proposals for intervention via physical exercise, for example using aquatic Ai Chi in PD (Pérez-de la Cruz, et al., 2016) or boxing (Suarez-González & González-Ortiz, 2019) are currently emerging, although they are not suitable for all populations. Therefore, there is a need to carry out the validation of specific therapeutic exercise protocols for people with certain pathologies such as PD. The Pilates method, in its variant of floor work, also known as Mat Pilates (MP), is an attractive kind of exercise, as it can be adapted in intensity and difficulty according to the patient's abilities and can be carried out with minimal material and space. It is a type of physical exercise that focuses on improving strength, core stability, flexibility, muscle control, posture and breathing (Bulguroglu, et al., 2017; Panhan, et al., 2019).

The main objective of the Pilates method is to improve

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coordination and control of the core muscles that contribute to optimal lumbopelvic stabilisation, which is necessary for the activities of daily living and general functionality (Queiroz, et al., 2010). In recent years, this type of exercise modality has been very well accepted by the elderly population, resulting in improvements in their physical condition, mood, and balance, decreasing the risk of falls, and improving their quality of life (Bullo, et al., 2015; Pata, et al., 2014; Rodríguez-Fuentes, et al., 2014).

Currently, there are few proposals for interventions using the Pilates method in the Parkinsonian population. Research that has used the Pilates method has obtained satisfactory results, with increases in fitness, and improving the quality of life of those subjects (Cancela, et al., 2018; Johnson, et al., 2013; Mollinedo-Cardalda, et al., 2018). Although improvements have been observed when applying this mode of therapeutic exercise, no study focussing on the Pilates method has recorded which load produces the greatest benefits. Following this line of investigation, the study by Xu et al. 2019 shows that power training is slightly more effective than conventional resistance training when used to improve physical functions in patients with PD, such as balance, walking speed and stride length, muscle strength and power. Based on the scientific evidence of the positive effects of strength training and MP on cognitive and physical aspects. This study combines both aspects, to create an MP program based on the principles of strength training. Therefore, the aim of this research was to compare the effects on lower limb strength, gait speed, and motor symptomatology of a therapeutic exercise programme based on MP, but performed at two different intensities (low *vs* high) in a population diagnosed with PD. The second objective was to know the feasibility of both MP programmes (low *vs* high).

Materials and methods

Design

A double-blind, randomized, controlled trial of Mat Pilates (low vs high intensity) in PD.

Participants

The trial was designed and implemented by four experts in therapeutic exercise and neurodegenerative diseases from the University of Vigo in Spain. Men and women patients diagnosed with PD and belonging to the "Parkinson's Association of the Province of Pontevedra" who met the following selection criteria were recruited: diagnosed with PD (diagnosed by neurologist), Hoehn & Yahr score one-three, no history or evidence of dementia and/or moderate or severe cognitive impairment (Minimental State Examination lower than 20 points)(Chou et al., 2022; Yoshitaka et al., 2022) , no evidence or history of other neurological deficits or diseases that could affect movement, and no medication and/or surgical intervention not directly related to PD that could interfere with motor function.

Fifty people attended the first screening. A total of 32 people fulfilled the selection criteria and were randomly assigned to the Low Mat Pilates Group (LMPG) and High Mat Pilates Group (HMPG) (Figure 1). Randomisation was carried out using IBM SPSS Statistics Software v21. The participants didn´t know of the differences between the two Pilates groups, and the researchers involved in data collection didn´t know to which group each participant belonged. In addition, the researcher who performed the data analysis was also unknow of the differences between the two groups.

This study was approved by the Research Ethics Committee of the Regional Ministry of Health (Xunta de Galicia), being assigned code 2015/484. Both its ethical standards and those of the Declaration of Helsinki were followed. All participants were informed of the characteristics of the study by the principal investigator and gave their written consent prior to participation.

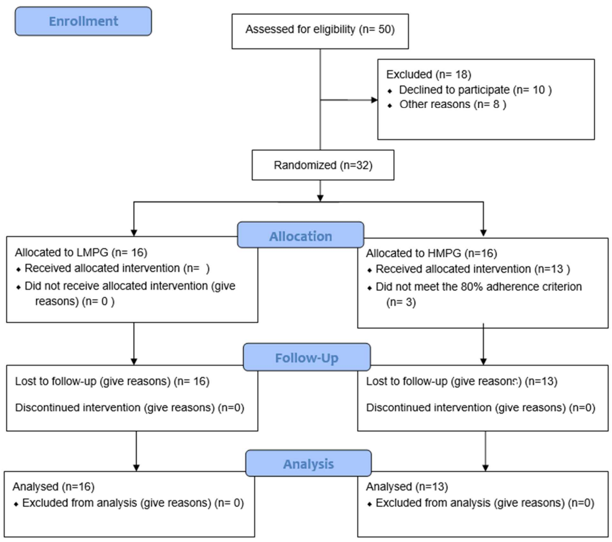

Figure 1. Flow diagram

The sample size was calculated using the statistical power analysis programme G*Power 3.1.3. The sample size calculation was performed based on the estimated Galician population diagnosed with PD (7500 people, Sergas, 2018), and the results obtained by Mollinedo-Cardalda & Cancela-Carral (2018) along lower body strength (30s chair stand; ES=0.94) in a sample of 26 Parkinsonians. A confidence level of 98% (1-Alpha) and a statistical power of 99% was assumed. Based on this information, the sample size to be achieved was 28 people diagnosed with PD. Accounting for a loss of 20%, the total sample size would be 33 persons.

Instruments

Participants were assessed at baseline (week #cero), at the end of the intervention (week #12) and four weeks after the end of the intervention (week #17) to analyze possible residual effects. The variables under analysis were as follows:

- Anthropometric measurements. The height (cm) and weight (kg) of the participants was registered while dressed in light clothing and without shoes. Their body mass index (BMI) was calculated with the formula: weight/height^2 (kg/m^2). A Tanita TBF300 scale with a precision of 0.1 kg and a Handac stadiometer with a precision of 1.0 mm were employed in this process (Arisrizábal, et al., 2007).
- Motor symptomatology. The Unified Parkinson's Disease Rating Scale III (UPDRS III -Motor) was used to evaluate bradykinesia, tremor, and rigidity. It consists of 18 items, which are rated from 0 to 4, with 4 being the most severe (Martinez-Martin, et al., 2013).
- Lower limb strength. The 30 Second Chair Stand test (30SCS) was used. This test is part of the Senior Fitness Test battery designed to evaluate the physical condition of the subjects (Rikli & Jones, 2013). This test assesses the strength and resilience of the subjects' lower limbs by registering the number of times they can sit down and stand up from a chair in 30 seconds.
- Gait Speed. This variable was assessed using the Timed Up and Go test (TUG) of 3 meters with gait high speed. It was donewith Wiva® sensors (Kleiner et al., 2018) a set of wireless inertial detection devices placed in the L4-L5 spinal segment. Wiva® sensors include an accelerometer, a magnetometer and a gyroscope that allow professionals and practitioners to gather information about gait speed. All this information was saved and sent to a PC via Bluetooth, using Biomech Study 2011 v.1.1.
- Feasibility. The following data was gathered to evaluate feasibility in both groups: recruitment rate (number of participants recruited vs. number of participants who met the inclusion criteria), participation rate (total completed hours of exercise vs. total possible hours of exercise), adherence (rate of patients with 80% participation or higher), dropout (number of participants who could not complete the program) and safety and tolerability (number of patients who suffered adverse effects due to the intervention, such as pain, dizziness, vertigo, falls, etc.).

All participants were assessed during their "activation" phase (1 to 1.5 hours after taking their PD medication). All pharmacological treatments and dosage were kept stable for the duration of the study. The assessments were carried out by physiotherapist expert in PD.

Intervention

A 12-week programme was carried out (two sessions per week) with a total of 24 non-consecutive 60-minute sessions. The interventions took place in a 20x20 meters multi-purpose room and were carried out by a physiotherapist certified in the Pilates Method.

The LMPG participants followed a mat Pilates-based programme, consisting of two sessions per week. One session was performed while standing and seated, and the other session was performed on the floor. In the standing and seated session, the standing warm-up (10 minutes) focused on costo-lateral breathing, mobilisation, and body awareness exercises. The central part (45 minutes) consisted of one set of 18 MP exercises (arm arcs, femur arcs, leg cycles…) adapted to the seated position, focusing on strength, stabilisation, and mobility. All these exercises had easy and difficult variations. The return to calm (five minutes) focused on breathing and stretching different muscle groups. The floor session was carried out in the same way as the standing and seated session, with the same objectives and duration (one set of 13 MP exercise in central part). Variants of all the exercises were also designed, both easy and difficult, to adapt to the needs of the PD patients (Cancela, et al., 2018). It should be noted that for each exercise, whether standing, seated or on the floor, one set of five repetitions was performed. Low training intensity was measured using the modified Borg Perceived Exertion Scale (Penko, et al., 2017), which was to be kept constant with a rating of three throughout the programme.

The HMPG participants followed a Mat Pilates-based exercise programme adapted to PD populations using a medium resistance TheraBand® (1,8kg at 100% de elongation) as well as 0.5kg weighted ankle and/or wrist straps. The session, as in the LMPG, was divided into three parts, with the same warm-up (10 minutes) and cool-down (five minutes), but with the central part (45 minutes) varying. The central part consisted of three sets seven exercises (arm arcs, bridge, curls, leg circles, side leg, superman, and squats), eight repetitions on average for each exercise. Training intensity was measured using the modified Borg Perceived Exertion Scale (Penko, et al., 2017), which was to be kept constant with a score of seven-eight throughout the programme, adapting the tasks specifically to each participant, adding additional resistance with the TheraBand® and/or weighted ankle/wrist straps. After completing each exercise sets, participants rated their effort on the Modified Borg scale so that the physiotherapist could adjust the load accordingly (Mollinedo- Cardalda, et al., 2018). It is important to highlight that the PM sessions, in both groups, were carried out in groups of 5 people. The description of the exercises carried out in the session are colleted in the "El manual de aplicación del método Pilates en Enfermedad de Parkinson" (Mollinedo-Cardalda & Cancela-Carral, 2018).

Procedure

The first step was to contact the Parkinson's Association of the province of Pontevedra, with which the University of Vigo has a collaboration agreement, to verify if they were interested in the intervention proposal. A report into the members of the Association was drawn up to exclude all those who did not meet the selection criteria. Members who chose to participate were randomised into two intervention groups (LMPG and HMPG) and initially assessed using the BMI, MDS-UPDRS III (motor), 30 Second Chair Stand and Timed up Go. After the initial assessment, the two 12-week intervention programmes were started, with a weekly frequency of two 60-minute sessions. At the end of the intervention programmes, final assessments were carried out. A follow-up assessment was carried out four weeks after the end of the programmes. Once data collection was completed, the results were entered into the IBM SPSS Statistics Software v21, where they were subsequently analysed.

Statistical analysis

The sample was randomly divided into two groups (LMPG and HMPG) and the characteristics of each group were described by means of mean, standard deviation, and percentage. An intra-group analysis was carried out using one-factor Anova to observe the effect of each of the programmes on the variables BMI, MDS-UPDRS III (motor), 30 Second Chair Stand and Timed up Go (gait speed), over each of the three moments of evaluation (table 2).

The study of the differential effect of the programmes carried out (Low Mat Pilates and High Mat Pilates) was carried out using analysis of variance for repeated measures (2x2). One of the factors was the time of data collection (Baseline- post intervention and Post-intervention-follow up) with the other factor being the intensity of the exercise programmes undertaken (Low and High intensity). Post-hoc analysis was conducted using a Bonferroni adjustment (Table 3).

A linear regression analysis was carried out to identify the degree of relationship between the variables: gait speed (m/s) and lower body strength measured with the 30 Second Chair Stand, as a function of the intervention group (week #12).

Results

The recruitment rate for the intervention was 64.00%. 18 patients out of the total number pre-selected did not meet the study selection criteria; ten declined to participate in the study, before its start, due to characteristics related to the intervention and timing, and 8 decided not to participate in the study for other unstated reasons. Therefore, the initial sample consisted of a total of 32 participants who were randomly assigned to the LMPG (n=16) and the HMPG (n=16).

Of the total number of participants who voluntarily started the study, 90.62% completed the programme. The participation rate for the LMPG was 91.14%, completing a total of 350 hours of physical therapy out of a possible 384 hours, while the participation rate for the HMPG was 70.05%, completing a total of 269 hours out of a possible 384 hours. All LMPG participants completed 80% of the sessions, while in the HMPG, 3 people did not complete 80% of the sessions, indicating a programme adherence rate of 100% for the LMPG (0% dropout rate) and 81.25% for the HMPG (18.75% dropout rate), due to the problems of displacement of the patients to attend the PM session. The safety and tolerability rate of both programmes was 100%, as no adverse effects due to the programmes were reported.

A total of 29 participants attended 80% of the intervention sessions (LMPG, n=16; HMPG, n=13). Table 1 shows the characteristics of the sample by intervention group. It should be noted that the groups were homogeneous in baseline in the variables of Hoehn & Yahr scale and BMI.

Table 1.
Characteristics of the sample

	LMPG (n=16)		HMPG (n=13)	
	Mean	SD	Mean	SD
Age (years)	69.13	8.23	62.85	9.75
Gender (Female, %)	37.5%		61.53%	
Hoehn & Yahr Score	2.19	0.66	2.08	0.49
Height (cm)	160.13	6.79	162.18	6.43
Weight (Kg)	69.68	9.27	71.27	10.13
BMI (Kg/m2)	27.22	3.64	27.05	3.30

Note. LMPG: Low-intensity Mat Pilates group; HMPG: High-intensity Mat Pilates group.

In Table 2, the intra-group inferential analysis is presented. The LMPG showed no statistical difference for BMI in pre-post assessment, and a statistical worsening in the follow-up stage, while motor symptomatology shows a tendency to improve between baseline and post-intervention, but there a significant worsening in follow-up when compared to post-intervention. Both gait speed and lower limb strength significantly improved at post-intervention. Additionally, the HMPG showed no significant differences in the MDS-UPDRS III (motor). The BMI, gait speed and lower limb strength showed significant improvements in the post-intervention (27.61±3.36 *vs* 27.27±3.36, $p<0.05$, 0.31±0.11 *vs* 0.37±0.14, $p<0.05$, 17.75±6.36 *vs* 23.83±6.42, $p<0.001$, respectively), and lower limb strength showed a significant worsening in follow-up. Table 3 presents the intergroup inferential analysis which shows significant differences in favour of the HMPG for the gait speed and lower limb strength in the post-intervention period ($p<0.05$). In the follow-up period, there was a significant difference for lower limb strength, with a worsening in HMPG ($p<0.05$). Finally, Figure 2 shows the relationship between lower limb strength and gait speed in each group. Both charts show a proportional relationship between lower limb strength and gait speed (LMPG $p<0.05$, Pearson correlation 0.418 vs HMPG $p<0.05$, Pearson correlation 0.477), with the HMPG showing a greater relationship.

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Table 2.
Intragroup analysis of the variables

	LMPG (n=16)						
	Baseline		Post-Intervention		Follow up		Anova
	Mean	SD	Mean	SD	Mean	SD	
BMI (Kg/m^2)	27.22	3.64	27.46	3.89	28.05	4.21$^{\#}$	F=3.657 p=0.040
MDS-UPDRS III (Motor)	29.97	13.12	27.25	9.03	32.47	12.55$^{\#}$	F=4.234 p=0.010
Gait Speed (m/s)	0.33	0.12	0.37	0.11*	0.36	0.11	F=2.123 p=0.032
30s chair stand (n)	10.83	4.84	11.73	5.42*	11.25	5.55	F=7.836 p=0.001
	HMPG (n=13)						
	Baseline		Post-Intervention		Follow up		Anova
	Mean	SD	Mean	SD	Mean	SD	
BMI (Kg/m^2)	27.61	3.36	27.27	3.36*	27.42	3.49	F=2.001 p=0.045
MDS-UPDRS III (Motor)	28.33	12.09	27.92	12.46	27.82	15.87	F=3.876 p=0.017
Gait Speed (m/s)	0.31	0.11	0.37	0.14*	0.36	0.14	F=2.345 p=0.023
30s chair stand (n)	17.75	6.36	23.83	6.42**	23.00	6.91$^{\#}$	F=6.678 p=0.002

Note. LMPG: Low-intensity Mat Pilates group; HMPG: High-intensity Mat Pilates group; n: repetitions. Obs. Baseline-Post-intervention difference (*p<0.05; **p<0.001); Post-intervention-Follow up difference ($^{\#}$p<0.05).

Table 3.
Intergroup analysis of the variables

	LMPG (n=16)			HMPG (n=13)			Moment (2x2)
	Dif post-pre		% Change	Dif post-pre		% Change	F; P; Eta
	Mean	SD		Mean	SD		
BMI (Kg/m2)	0.24	0.25	0.88	-0.34	0.001	-1.23	F1.50=0.101; p=0.983; Eta=0.002
MDS-UPDRS III (Motor)	-2.72	-4.09	-9.07	-0.41	0.37	-1.44	F1.50=1.056; p=0.200 Eta=0.002
Gait Speed (m/s)	0.04	-0.01	12.12	0.06	0.03	19.35	F1.50=4.278; p=0.013; Eta=0.211
30s chair stand (n)	0.90	0.58	8.31	6.08	0.06	34.25	F1.50=6.195; p=0.020 Eta=0.205
	LMPG (n=16)			HMPG (n=13)			Moment (2x2)
	Dif follow up-post		% Change	Dif follow up-post		% Change	F; P; Eta
	Mean	SD		Mean	SD		
BMI (Kg/m2)	0.59	0.32	2.15	0.15	0.13	0.55	F1.50=0.111; p=0.923; Eta=0.010
MDS-UPDRS III (Motor)	5.22	3.52	19.15	-0.10	3.41	-0.36	F1.50=1.126; p=0.287 Eta=0.026
Gait Speed (m/s)	0.01	0.01	-3.60	0.01	0.01	-3.60	F1.50=1.043; p=0.863; Eta=0.001
30s chair stand (n)	-0.48	0.13	-4.10	-0.83	0.49	-3.49	F1.50=11.410; p=0.002 Eta=0.210

Note. LMPG: Low-intensity Mat Pilates group; HMPG: High-intensity Mat Pilates group;Dif, difference.

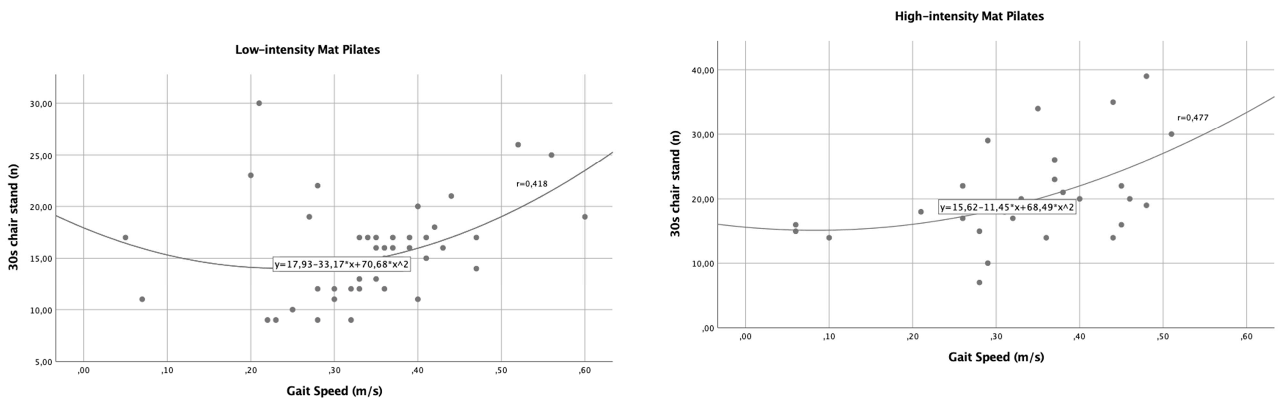

Figure 2. Relationship between gait speed and lower limb strength according to the intensity of the intervention program.

Discussion

The purpose of this study was to compare the effects of a Mat Pilates programme performed at two intensities (Low vs High) in a population diagnosed with PD. The results show that the HMPG obtained greater benefits in gait speed and lower limb strength than the LMPG, these results being in line with other studies in which high intensity work showed benefits for a population diagnosed with PD (Ebersbach, et al., 2015; Schenkman, et al., 2018).

MP is usually applied following Joseph Pilates' guidelines, which are: between three-six repetitions. No further repetitions are performed because muscle fatigue can be generated, leading to an incorrect pattern of movement and the recruitment of accessory muscles (McNeil & Blandford, 2013) or because the movement can become automatic. This study aimed to explore a new approach by combining higher loads during different Pilates exercises included in the section but maintaining the general characteristics of a Pilates session suitable for these patients.

This research demonstrates a significant increase in both lower limb strength and gait speed, after the application of MP for 12 weeks, regardless of the load. Bakhshayesh et al. (2017) showed that after an eight-week physical exercise programme of three sessions per week, based on conventional MP (standing, sitting, supine and prone), improvements in lower limb strength were obtained in people with PD. Such improvements can also be found in the studies by Cancela et al., (2018b) and Mollinedo-Cardalda et al. (2018) after a 12-week programme of two sessions per week. Therefore, MP is a valid tool for increasing lower limb strength, which is related to improved patient autonomy (Carral, et al., 2019). In terms of walking speed, several studies have also shown an improvement in this area after the application of PM for eight-12 weeks, both in the 8-foot up and go test (Bakhsyayesh, et al., 2017) and the Timed up and go test (Mollinedo-Cardalda, et al., 2018).

If we analyse the data obtained by intensity levels, the results are similar with respect to walking speed and lower body strength, but the gains are slightly greater in the HMPG intervention with respect to strength. This results are in line with those presented in figure 2, where there is a moderate positive correlation (Akoglu, 2018) between the lower body strength test and the speed of gait. There is even an improvement in BMI. Strength gains were also expected to have an impact on the gait speed in follow-up, however this was not observed in this study. Perhaps one of the possible explanations for this result is related to the test used for its assessment, in which the PD patients had to perform turns and decision-making, which may have been a limiting factor in maintaining the improvement achieved with the PD intervention (Bouça, et al., 2018).

Another aspect to highlight is the loss in the levels of strength that occurs in the high intensity group during the month of follow-up. A possible explanation could be that the training methodology applied in the HMPG reached the limit of power training and before reaching the possible endurance training. This fact may mean that, especially in the follow-up, the loss of strength/power may be more accentuated than the likely loss observed in resistance would be, although this variable was not measured (Carballo et al., 2015; Kelly et al., 2014). In addition, according to the principle of reversibility of training, strength usually presents a more pronounced drop than resistance (Redín, 2008).

It might be expected that the gains in lower body strength and gait speed would have a positive effect on the MDS-UPDRS III (motor) scale, but this does not occur; deterioration takes place after the LMPG intervention. However, a tendency to maintain the values of the MDS-UPDRS III scale is identified in the high intensity group (HMPG). The latter can be considered a positive aspect (no worsening after a period), due to the presence of a neurodegenerative disease, and may be in line with the benefits described with high intensity work in PD (Saltychev, et al., 2016).

The strength of this research lies in the load (volume and intensity) at which MP is performed. In this study, those who performed the MP programme at high intensity showed higher levels of strength and gait speed than those who performed conventional MP. This highlights the importance of the loads when patients with neurodegenerative pathologies carry out therapeutic exercise, observing that more intense loads produce better results on their physical condition, in addition to not presenting adverse effects (moderate fatigue, muscular pain, or dizziness). There is little literature on the ideal loads (intensity, volume, frequency, rest) for physical therapy in people with PD. Therefore, more studies focusing on therapeutic exercise loads are needed to be able to achieve the greatest possible benefits for this population.

Regarding the viability of the programme, the participation rate is higher in LMPG (91.14%) than in HMPG (70.05%). This may be because belonging to the HMPG would require the participants to make a greater effort, and as the study by Torriani-Pasin et al. (2021) shows, not presenting a correct physical aptitude for the exercise decreases adherence to physical exercise programmes.

Finally, a series of limitations must be considered, such as the sample size, the duration of the intervention, and the effect of these interventions on other variables not analysed in this study. Future research should carry out interventions of a longer duration, with the analysis of more variables (especially functional ones) and ones which also establish higher loads.

Conclusions

Therefore, we can suggest MP as a comprehensive rehabilitation strategy in PD patients, as it increases lower limb strength levels and gait speed. Also, we can suggest that high intensity MP work in PD results in improvements which are related to this high intensity strength work.

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References

Akoglu, H. (2018). User's guide to correlation coefficients. Turkish journal of emergency medicine, 18(3), 91-93. https://doi.org/10.1016/j.tjem.2018.08.001

Aristizábal, J. C., Restrepo, M. T., & Estrada, A. (2007). Evaluación de la composición corporal de adultos sanos por antropometría e impedancia bioeléctrica. *Biomédica, 27*(2), 216. https://doi.org/10.7705/biomedica.v27i2.217

Bakhshayesh, B., Sayyar, S., & Daneshmandi, H. (2017). Pilates Exercise and Functional Balance in Parkinson's Disease. *Caspian Journal of Neurological Sciences, 3*(8), 25-38. doi:10.18869/acadpub.cjns.3.8.25

Bouça-Machado, R., Maetzler, W., 6 Ferreira, J. J. (2018). What is functional mobility applied to Parkinson's disease? *Journal of Parkinson's Disease, 8*(1), 121-130. doi:10.3233/JPD-171233

Bulguroglu, I., Guclu-Gunduz, A., Yazici, G., Ozkul, O., Irkec, C., Naztiel, B., & Batur-Caglayan, H. Z. B. (2017). The effects of Mat Pilates and Reformer Pilates in patients with Multiple Sclerosis: A randomized controlled study. *NeuroRehabilitation, 41*(2), 413-422. https://doi.org/10.3233/NRE-162121.

Bullo, V., Bergamin, M., Gobbo S., Sieverdes, J. C., Zaccaria, M., Neunhaeuserer, D., & Ermolao, A. (2015). The effects of Pilates exercise training on physical fitness and wellbeing in the elderly: A systematic review for future exercise prescription. *Preventive Medicine,* 75, 1-11. https://doi.org/10.1016/j.ypmed.2015.03.002

Cancela, J. M., Mollinedo-Cardalda, I., Ayán, C., & de Oliveira, I. M. (2018). Feasibility and Efficacy of Mat Pilates on People with Mild-to-Moderate Parkinson's Disease: A Preliminary Study. *Rejuvenation Research, 21*(2). https://doi.org/10.1089/rej.2017.1969

Carral, J. M. C., Rodríguez, A. L., Cardalda, I. M., & Bezerra, J. P. A. G. (2019). Muscle strength training program in nonagenarians – a randomized controlled trial. *Revista da Associação Médica Brasileira, 65(*6), 851-856. https://doi.org/10.1590/1806-9282.65.6.851

Chou, H. H., Lai, T. J., Yen, C. H., Chang, P. S., Pan, J. C., & Lin, P. T. (2022). Sarcopenic Obesity Tendency and Nutritional Status Is Related to the Risk of Sarcopenia, Frailty, Depression and Quality of Life in Patients with Dementia. International journal of environmental research and public health, 19(5), 2492. https://doi.org/10.3390/ijerph19052492

Carvalho, A., Barbirato, D., Araujo, N., Martins, J. V., Cavalcanti, J. L. S., Santos, T. M., ... & Deslandes, A. C. (2015). Comparison of strength training, aerobic training, and additional physical therapy as supplementary treatments for Parkinson's disease: pilot study. *Clinical Interventions in Aging,* 10, 183. doi: 10.2147/CIA.S68779.

Ebersbach, G., Grust, U., Ebersbach, A., Wegner, B., Gandor, F., & Kühn, A. A. (2015). Amplitude-oriented exercise in Parkinson's disease: a randomized study comparing LSVT-BIG and a short training protocol. *Journal of Neural Transmission, 122*(2), 253-256. https://doi.org/10.1007/s00702-014-1245-8

Fritz, N. B., Bernucci, P. A., Flores, C. A., & Cárdenas, K. C. (2019). Efectos del entrenamiento sensoriomotor en balance, deambulación y calidad de vida en personas con enfermedad de Parkinson. *Salud de los Trabajadores, 27*(1), 65-75.

Jellinger, K. A. (2015). How close are we to revealing the etiology of Parkinson's disease? Expert *Review of Neurotherapeutics, 15*(10), 1105-1107. https://doi.org/10.1586/14737175.2015.1079486

Johnson, L., Putrino, D., James, I., Rodrigues, J., Stell, R., Thickbroom, G., & Mastaglia, F. L. (2013). The effects of a supervised Pilates training program on balance in Parkinson's disease. *Advances in Parkinson's Disease, 2*(02), 58-61.

Kelly, N. A., Ford, M. P., Standaert, D. G., Watts, R. L., Bickel, C. S., Moellering, D. R., ... & Bamman, M. M. (2014). Novel, high-intensity exercise prescription improves muscle mass, mitochondrial function, and physical capacity in individuals with Parkinson's disease. *Journal of applied physiology. 116:5, 582-592. https://doi.org/10.1152/japplphysiol.01277.2013*

Kleiner, A. F. R., Pacifici, I., Vagnini, A., Camerota, F., Celletti, C., Stocchi, F., ... & Galli, M. (2018). Timed Up and Go evaluation with wearable devices: validation in Parkinson's disease. *Journal of bodywork and movement therapies*, 22(2), 390-395. doi: 10.1016/j.jbmt.2017.07.006.

Machado, S., Teixeira, D., Monteiro, D., Imperatori, C., Murillo-Rodriguez, E., da Silva Rocha, F. P., ... & de Sá Filho, A. S. (2022). Clinical applications of exercise in Parkinson's disease: what we need to know?. *Expert Review of Neurotherapeutics,* 22(9), 771-780. doi: 10.1080/14737175.2022.2128768.

Martínez-Martin P, Rodríguez-Blazquez C, Alvarez-Sanchez M, Araki, T., Bergareche-Yarza, A., Chade, A., & Goetz, C. G. (2013). Expanded and independent validation of the Movement Disorder Society–Unified Parkinson's Disease Rating Scale (MDS-UPDRS). *Journal of Neurology, 260*(1), 228-236. https://doi.org/10.1007/s00415-012-6624-1

McNeill, W., & Blandford, L. (2013). Pilates: Applying progression and goal achievement. *Journal of Bodywork and Movement Therapies, 17*(3), 371-375. https://doi.org/10.1016/j.jbmt.2013.05.004

Menéndez-González, M., Castro-Santos, P., Suazo-Galdames, I. C., & Díaz-Peña, R. (2016). Farmacogenética en la Enfermedad de Parkinson: Influencia de Polimorfismos Genéticos Sobre los Efectos de la Terapia Dopaminérgica. *Archivos de Medicina, 12*(3), 9. https://doi.org/10.3823/1308

Mollinedo-Cardalda, I., & Cancela-Carral, J. M. (2018). *Manual de aplicación del metodo pilates en enfer-*

medad de parkinson. Wanceulen Editorial.**Sevilla:España.**

Mollinedo-Cardalda, I., Cancela-Carral, J. M., & Vila-Suárez, M. H. (2018). Effect of a Mat Pilates Program with TheraBand on Dynamic Balance in Patients with Parkinson's Disease: Feasibility Study and Randomized Controlled Trial. *Rejuvenation Research, 21*(5), 423-430. doi: 10.1089/rej.2017.2007.

Panhan, A. C., Gonçalves, M., Eltz, G. D., Villalba, M. M., Cardozo, A. C., & Bérzin, F. (2019). Electromyographic evaluation of trunk core muscles during Pilates exercise on different supporting bases. *Journal of Bodywork and Movement Therapies, 23*(4), 855-859. https://doi.org/10.1016/j.jbmt.2019.03.014

Pata, R. W., Lord, K., & Lamb, J. (2014). The effect of Pilates based exercise on mobility, postural stability, and balance in order to decrease fall risk in older adults. *Journal of Bodywork and Movement Therapies, 18*(3), 361-367. https://doi.org/10.1016/j.jbmt.2013.11.002

Penko, A. L., Barkley, J. E., Koop, M. M., & Alberts, J. L. (2017). Borg scale is valid for ratings of perceived exertion for individuals with Parkinson's disease. *International Journal of Exercise Science, 10*(1), 76-86.

Pérez-de la Cruz, S., García-Luengo, A. V., & Lambeck, J. (2016). Efectos de un programa de prevención de caídas con Ai Chi acuático en pacientes diagnosticados de parkinson. *Neurologia, 31*(3), 176-182. https://doi.org/10.1016/j.nrl.2015.05.009

Queiroz, B. C., Cagliari, M. F., Amorim, C. F., & Sacco, I. C. (2010). Muscle Activation During Four Pilates Core Stability Exercises in Quadruped Position. *Archives of Physical Medicine and Rehabilitation, 91*(1), 86-92. https://doi.org/10.1016/j.apmr.2009.09.016

Redín, M. I. (2008). *Biomecnica y Bases Neuromusculares de la Actividad Fsica y el Deporte/Biomechanics and Neuromuscular Bases of Physical Activity and Sport.* Ed. Médica Panamericana. Madrid: Spain.

Rikli, R. E., & Jones, C. J. (2013). *Senior fitness test manual*. Human kinetics. United Kingdom.

Rodríguez-Fuentes, G., de Oliveira, I. M., Ogando-Berea, H., & Otero-Gargamala, M. D. (2014). An observational study on the effects of Pilates on quality of life in women during menopause. *European Journal of Integrative Medicine,* 6(6). https://doi.org/10.1016/j.eujim.2014.08.003

Saltychev, M., Bärlund, E., Paltamaa, J., Katajapuu, N., & Laimi, K. (2016). Progressive resistance training in Parkinson's disease: A systematic review and meta-analysis. *BMJ Open,* 6(1). https://doi.org/10.1136/bmjopen-2015-008756

Schenkman, M., Moore, C. G., Kohrt, W. M., Hall, D. A., Delitto, A., Comella, C. L., & Corcos, D. M. (2018). Effect of High-Intensity Treadmill Exercise on Motor Symptoms in Patients With De Novo Parkinson Disease. *JAMA Neurology,* 75(2), 219-226. https://doi.org/10.1001/jamaneurol.2017.3517

Suarez-González, I. V., & González –Ortiz, F. (2019). Efectos de un programa de ejercicio basado en boxeo sobre el balance en un sujeto con Enfermedad de Parkinson: estudio de caso. *Revista Científica Estudios e Investigaciones, 8*, 227-228. https://doi.org/10.26885/rcei.foro.2019.227

Suárez-Iglesias, D., Miller, K. J, Seijo-Martínez, M., & Ayán, C. (2019). Benefits of pilates in Parkinson's disease: A systematic review and meta-analysis. *Medicina (Lithuania),* 55(8), 1-14. https://doi.org/10.3390/medicina55080476

Suchowersky, O., Gronseth, G., Perlmutter, J., Reich, S., Zesiewicz, T., & Weiner, W. J. (2006). Practice Parameter: neuroprotective strategies and alternative therapies for Parkinson disease (an evidence-based review): report of the Quality Standards Subcommittee of the American Academy of Neurology. *Neurology,* 66(7), 976-982.

Torriani-Pasin, C., Domingues, V. L., de Freitas, T. B., Silva, T. A. D., Caldeira, M. F., Júnior, R. P. A., ... & Mochizuki, L. (2022). Adherence rate, barriers to attend, safety and overall experience of a physical exercise program via telemonitoring during COVID-19 pandemic for individuals with Parkinson's disease: A feasibility study. *Physiotherapy Research International*, 27(4), e1959. doi: 10.1002/pri.1959. Epub 2022 May 28.

Xu, X., Fu, Z., & Le, W. (2019). Exercise and Parkinson's disease. *International Review of Neurobiology, 1*47(1), 45-74. https://doi.org/10.1016/bs.irn.2019.06.003

Yang, Y., Wang, G., Zhang, S., Wang, H., Zhou, W., Ren, F., ... & Wei, J. (2022). Efficacy and evaluation of therapeutic exercises on adults with Parkinson's disease: a systematic review and network meta-analysis. *BMC geriatrics,* 22(1), 813. doi: 10.1186/s12877-022-03510-9.

Yoshitaka, T., Shimaoka, Y., Yamanaka, I., Tanida, A., Tanimoto, J., Toda, N., ... & Hamawaki, J. (2022). Cognitive impairment as the principal factor correlated with the activities of daily living following hip fracture in elderly people. Progress in rehabilitation medicine, 7, 20220026. https://doi.org/10.2490/prm.20220026