Effects of rhythmic auditory stimulation on functionality in Parkinson's disease

Repercussões da estimulação auditiva rítmica sobre a funcionalidade na doença de Parkinson

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Abstract

Introduction: Functionality is affected by the clinical characteristics and progression of Parkinson's disease (PD). **Objective:** Assess the effects of a therapeutic exercise program associated with music-based rhythmic auditory stimulation (RAS) on the Activities and Participation Profile (APP) related to mobility of people with PD. **Methods:** Intervention study investigating people with moderate PD recruited from the Hospital das Clínicas of the Federal University of Pernambuco and the Parkinson's Disease Association of Pernambuco. The APP related to mobility of the participants was assessed based on the International Classification of Functioning Disability and Health (ICF). The APP contains 23 activity/participation items scored from 0 (no problem) to 4 (complete problem). The intervention consisted of 10 outpatient sessions of a therapeutic exercise program associated with music-based RAS, applied using a smartphone application (ParkinSONS®), performed twice a week, with an average duration of 50 minutes per session. Given the metric nature of the variable and its non-normal distribution, Wilcoxon's test was applied, considering $p < 0.05$. **Results:** In the sample of 8 patients, there was a significant decline in APP scores after intervention ($p = 0.018*$), indicating a positive change. Scores for all the APP activities decreased following the intervention, except for "transferring oneself to the left side while lying down". **Conclusion:** In this study, a therapeutic exercise program associated with music-based RAS had a positive effect on the APP related to mobility of people with moderate PD.

Keywords: Auditory stimulation. ICF. Music. Parkinson's disease. Physiotherapy.

Resumo

Introdução: *A funcionalidade é afetada pelas características clínicas e progressão da doença de Parkinson (DP).* ***Objetivo:*** *Avaliar as repercussões da aplicação de um protocolo de fisioterapia motora associado à estimulação auditiva rítmica (EAR) com música sobre o perfil de atividade e participação (PAP) relacionado à mobilidade de pessoas com DP.* ***Métodos:*** *Estudo de intervenção realizado com pessoas em estágio moderado de DP recrutadas no Hospital das Clínicas da Universidade Federal de Pernambuco e na Associação de Parkinson de Pernambuco. Estas foram avaliadas e reavaliadas mediante o PAP relacionado à mobilidade baseado na Classificação Internacional de Funcionalidade, Incapacidade e Saúde (CIF). O PAP apresenta 23 itens de atividades/ participação pontuados entre 0 (não há problema) e 4 (problema completo). A intervenção consistiu de 10 sessões ambulatoriais de fisioterapia motora associada à EAR com música fornecida por aplicativo instalado em smartphone (ParkinSONS®) duas vezes por semana, com duração média de 50 minutos por sessão. Devido à natureza métrica da variável e sua distribuição não normal, aplicou-se o teste de Wilcoxon, considerando p < 0.05.* ***Resultados:*** *Na amostra de oito pacientes, o PAP apresentou uma redução significativa dos escores após a intervenção (p = 0.018*), indicando mudança positiva no perfil. Todas as atividades do PAP apresentaram diminuição do escore após a intervenção, exceto "transferir-se para o lado esquerdo enquanto estiver deitado".* ***Conclusão:*** *Neste estudo, a aplicação de um protocolo de fisioterapia motora associada à EAR com música em pessoas no estágio moderado da DP apresentou repercussões positivas sobre o PAP relacionado à mobilidade baseado na CIF.*

Palavras-chave: *Estimulação acústica. CIF. Música. Doença de Parkinson. Fisioterapia.*

Introduction

The functionality of people with Parkinson's disease (PD) is affected by a number of impairments triggered by the disorder, such as bradykinesia, rigidity, resting tremor and postural instability. Additionally, discomfort such as aching, cramps and joint pain, and difficulties with motor coordination, transfers, mobility, postural control and the ability to perform activities of daily living can emerge over time as the disease worsens.[1, 2]

According to the International Classification of Functioning Disability and Health (ICF), functioning refers to all body functions, activities and participation, while disability is an umbrella term for impairments, activity limitations and participation restrictions. Environmental factors interact with these components and are key to determining the functioning/disability of the individual, since they represent barriers or facilitators.[3, 4]

People with PD who take part in exercise programs showed improved physical function and performance in activities related to functional mobility, muscle strength, endurance, coordination, flexibility, balance and walking, resulting in better perceived quality of life when compared to physically inactive patients.[5-7]

Physiotherapists use a series of techniques aimed at transfers, posture, upper limb function, balance and gait training and functional capacity, as well as activities that require cognitive and motor skills, in order to improve independence, safety and well-being.[6,8] In PD, the goal of physiotherapy is to maximize functional capacity through movement rehabilitation.[9]

Rhythmic auditory stimulation (RAS) with music is increasingly being used as a tool in functional rehabilitation, capable of promoting physiological changes, neuroplasticity and neural circuit reconstruction, thereby contributing to the recovery of motor skills in neurological patients. Research on the performance of the auditory system and rhythmic synchronization in motor control showed synchronization between the auditory and motor systems.[10-13]

Music has the ability to be engaging, emotional, personal, physical, social and persuasive, in addition to promoting movement synchronization, making it a relaxing and enjoyable therapeutic tool. It also provides motor, cognitive, psychosocial and behavioral benefits for people with neurological disorders such as PD, and should be included in multidisciplinary programs aimed at functionality.[14-16]

Individualized RAS approaches using mobile technology such as smartphone applications may be a safe and economical alternative for outpatient and home-based rehabilitation in patients with PD. However, the apps currently available are still lacking in terms of providing individualized stimulation suited to the task, with rhythm increases calculated to improve performance.[17,18]

No studies were found that assess the effects of physiotherapy protocols associated with music-based

RAS on the Activities and Participation Profile (APP) related to mobility in people with PD. As such, the aim of this study was to evaluate the effects of a therapeutic exercise program associated with music-based rhythmic auditory stimulation on the APP related to mobility of people with PD.

Methods

This is a preliminary before-and-after study. The non-probabilistic (convenience) sample consisted of people aged ≥ 50 years, of both sexes, with a clinical diagnosis of idiopathic PD. The diagnosis was in line with the Parkinson's UK Brain Bank Criteria stipulated in Ordinance 10/2017 of the Brazilian Ministry of Health,[19] and confirmed by the presence of clinically assessed bradykinesia (a necessary criterion), muscular rigidity and/or resting tremor (4-6 Hz), combined with at least three positive supporting criteria.[19] Included were people with moderate PD (stages HY2 and HY3), according to the original version of the Hoehn and Yahr (HY) scale.[20] The original version of the scale classifies patients into five stages: HY1 - unilateral involvement only, with little or no functional impairment; HY2 - bilateral or axial involvement, without balance impairment; HY3 – mild to moderate bilateral disease, with some postural instability and physically independent; HY4 – severe disability, but still able to walk or stand unassisted; HY 5 – wheelchair bound or bedridden unless aided.

All the patients were recruited from the Pro-Parkinson Program of the Hospital das Clínicas of the Universidade Federal de Pernambuco (HC/UFPE) and the Parkinson's Disease Association of Pernambuco, between May and October 2019. The study was conducted in accordance with National Health Council/Ministry of Health (CNS/MS) Resolution 466, of December 12, 2012,[21] and approved by the Research Ethics Committee of the Universidade Federal de Pernambuco's Health Sciences Center (CAAE n° 01548918.2.0000.5208). All the participants provided written informed consent.

Excluded were those with other neurological, orthopedic, rheumatological and/or vascular disorders that affected gait or made it impossible to walk for 10 meters unaided; amputees; lower limb prostheses and orthotics; self-reported hearing difficulties preventing them from hearing music or a conversation; uncontrolled high blood pressure; contraindication for physical exercises by the assistant physician; cognitive impairment identified by the Mini-Mental State Examination (MMSE) according to schooling level,[22,23] and severe depression based on the Beck Depression Inventory.[24]

The assessment was conducted in the so-called "on" phase (1h after taking medication) and involved recording personal and clinical information on a "sociodemographic/clinical data form", including the patient's full name, telephone number, address, schooling level, degree of dependence in activities of daily living, side of the body where initial symptoms emerged, medication used, with doses and times, and other information related to the eligibility criteria. Next, the APP was assessed based on a selection of 23 activity/participation items related to mobility from Chapter 4 of the ICF[25] that reflect the logic of neural development (Figure 1).

Each item is scored from 0 to 4, as follows: 0 - "no problem" (0-4%); 1 - "mild problem" (5-24%); 2 - "moderate problem" (25-49%); 3 - "severe problem" (50-95%); 4 - "complete problem" (96-100%); 8 - "not specified"; 9 - "not applicable". The sum of the scores for the items ranges from 0 to 100, and the final score is obtained by dividing by the number of items.[25]

The APP is related to functioning from both an individual and social perspective. The term activity refers to the execution of a task or action by an individual and participation is their involvement in a life situation.[3]

The participants underwent 10 outpatient sessions of therapeutic exercises associated with music-based RAS, applied using a smartphone application (ParkinSONS®), twice a week, with an average duration of 50 minutes per session.

The therapeutic exercise program was based on the Portuguese version of the European Physiotherapy Guideline for Parkinson's Disease, which aims to standardize evidence-based physiotherapy.[26] It was applied at two levels of difficulty, with complexity modified from the sixth session onwards. Of the nine therapeutic exercises, RAS was associated with the four that could be performed naturally to a beat (Figure 2).

The ParkinSONS® application provides a menu of gait training options and functional activities with RAS containing six Brazilian songs whose tempo varies from 70 to 120 bpm, which can be accompanied by a metronome. The app uses a smartphone touchscreen interface, facilitating clear and objective user interaction.

Activity and Participation Profile (APP) related to mobility based on ICF	
Name: _____	Date: ____/____/_____
1. Sitting	d4103 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
2. Lying down	d4100 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
3. Rolling over 3.1 To the right 3.2 To the left	d4107 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( ) d4107- xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( ) d4107 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
4. 4. Transferring oneself while lying down 4.1 To the right 4.2 To the left	d4201 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( ) d4201 – xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( ) d4201 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
5. Crawling	d4550 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
6. Kneeling	d4102 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
7. Bending	d4105 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
8. Transferring oneself while sitting	d4200 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
9. Standing	d4104 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
10. Squatting	d4101 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
11. Kicking	d4351 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
12. Pushing with lower extremities	d4350 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
13. Walking short distances	d4500 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
14. Walking long distances	d4501 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
15. Walking on different surfaces	d4502 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
16. Walking around obstacles	d4503 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
17. Climbing	d4551 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
18. Moving around within the home	d4600 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
19. Moving around within buildings other than home	d4601 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
20. Moving around outside the home and other buildings	d4602 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
21. Using private motorized transportation	d4701 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
22. Using public motorized transportation	d4701 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( )
23. Driving motorized vehicles	d4751 - xxx.0 ( ) xxx.1 ( ) xxx.2 ( ) xxx.3 ( ) xxx.4 ( ) xxx.8 ( ) xxx.9 ( )

Generic classification scale

xxx.0. No problem – none, absent, negligible (0 - 4%).
xxx.1. Mild problem – slight, low (5 - 24%) - uses strategies and/or compensates.
xxx.2. Moderate problem – medium, fair (25 - 49%) - needs some assistance.
xxx.3. Severe problem – high, extreme (50 - 95%) - capable, but needs significant assistance.
xxx.4. Complete problem (96 - 100%) - incapable, even with significant assistance.
xxx.8. Not specified - although the problem exists, it cannot be classified.
xxx.9. Not applicable.

Figure 1 - Evaluation of the Activity and Participation Profile (APP) of people with moderate stage of Parkinson's disease, based on chapter 4 of the International Classification of Functioning Disability and Health (ICF).

Therapeutic exercise program associated with music-based RAS from Pro-Parkinson Program
Transfer training 1. Rolling from side to side in bed – 5 times to the right and 5 to the left. Progression: combined with trunk and neck extensions. 2.Moving from lying to sitting on the easy side – 6 times. Progression: perform the same movement on the difficult side.
Strengthening the gluteus and abdominal muscles 3. Bridge – 6 times, holding the pelvis in a raised position for 5 seconds. Progression: combine with isometric thigh adduction exercises using an overball.
Reaching, grasping and upper trunk mobility 4. While sitting on a chair, reach forward and grasp the cones in front of you, pulling them towards you unilaterally – 2 sets of 5 repetitions on each side. Progression: perform the movement diagonally.
Upper trunk mobility 5. While sitting on an armless chair, shoulders flexed at 90°, elbows extended and holding a bar or overball, twist your trunk to the side for 30 seconds, alternating between sides. Progression: exercise 5 and side crunch to the left and right.
Strengthening exercise emphasizing the upper limbs, associated with RAS at 70 bpm 6. Sitting and standing from a chair – 10 times. Progression: combine with arm raise holding the overball.
Balance and proprioception associated with RAS at 70 bpm 7. Weight shift bounces on a trampoline in 5 stages – alternating between side-to-side and front-to-back shifts. Stage 1 – side to side Stage 2 – front to back shift with the right foot in front Stage 3 - side to side Stage 4 – front to back shift with the left foot in front Stage 5 - side to side Progression: add a 1 kg ankle weight to each leg.
Gait training associated with RAS, using songs accompanying training cadence, with an average increase of 10% of the comfortable walking speed 8. In parallel: walk forwards/ return walking backwards – 10 times; to the side and back – 10 times, and then walk along a 10-meter-long corridor, turn around and walk back again – 10 times. Progression: Walk along a 10-meter-long corridor, 2 sets of 10 laps with a 2-minute rest between sets.
Gait training associated with RAS, using songs accompanying training cadence, with an average increase of 10% of the comfortable walking speed 9. Performed after a draw to determine which leg to start with (right or left) and which direction to move in according to the stage of the protocol, which initially consisted of three steps in one direction (step forward-return; step sideways-return; step back-return) 30 seconds with each leg. Progression: six steps in two directions (step back-step forward-return; step back-step sideways-return; step forward-step sideways-return; step forward-step back-return; step back-step forward-return; step sideways-step back-return).
Note: Performed while standing, with the patient supported by a bar or the therapist to prevent possible accidents. The participants were given verbal instructions on correct posture during the exercises, gait and step training.

Figure 2 - "Pro-Parkinson" motor physical therapy protocol associated with rhythmic auditory stimulation (RAS) applied to patients with moderate stage of Parkinson's disease.

Songs with a tempo of 70 bpm were used for the strength and balance exercises, and songs with an average increase of 10% of the comfortable walking speed for gait and step training. In the case of gait, comfortable walking speed was determined based on cadence, represented by the number of steps taken in the time needed to walk a certain distance. To that end, the 10-meter walk test was used to determine the number of steps and time taken to walk comfortably along a 10-meter-long corridor, with markers placed at 2 and 8 m to signal the points for acceleration and deceleration, considering only the 6 central meters for calculation purposes. One evaluator was responsible for counting the number of steps taken over the 6 m considered and another for establishing the time needed to do so. The timer was activated and stopped when the patient's hallux touched the 2 and 8 m marks, respectively. Three tests were performed and the average was calculated. These data (steps and time) were used to calculate the speed and baseline cadence of the patients. The cadence measurements were converted by multiplying the time in seconds by 60 to obtain the steps/per minutes.[27]

Once the appropriate song had been chosen, the phone was connected to the headphones worn simultaneously by the patient and therapist, allowing the training session to be monitored at the selected tempo. All the participants were given verbal instructions to execute the movements in time with the music and,

when necessary, demonstrations were performed by the researchers. The volume of the music was approximately 75 dB, well above the threshold perceived by older adults with hearing loss, namely 25 to 40 dB.[28] The assessment and treatment were carried out by the same professionals.

The data were tabulated using descriptive statistics and expressed as mean, standard deviation and variation (minimum and maximum value). Given the metric nature of the variable and non-normal data distribution, paired comparison was performed using the Wilcoxon test at p < 0.05. The statistical package used was BioEstat5.0.

Results

Sixteen patients were recruited and eight excluded (seven for not meeting the eligibility criteria and one for withdrawing from the intervention in session 8 due to a domestic accident). The final sample consisted of eight

patients, most of whom were male and in stage HY2 of the disease. The symptoms of the majority of patients began on the right side of the body (Table 1).

In relation to the APP scores obtained at assessment, participants were classified as "mild problem" in 14 of the 23 items. At reassessment, only the item "transferring oneself to the left while lying down" maintained this classification. All the remaining APP items that obtained "problem" at assessment were categorized as "no problem" after the intervention (Table 2).

Scores varied from 0 to 2 ("no problem" to "moderate problem") for most of the items. Scores for "transferring oneself to the right and left while lying down", "transferring oneself while sitting" and "squatting" ranged from 0 to 3 ("no problem" to "severe problem"). Only the scores for "walking long distances" varied between 0 and 4 ("no problem" to "complete problem"). Six patients (75%) were attributed a score of 9 ("not applicable") for "driving motorized vehicles" and none of the APP items received a score of 8 ("not specified") (Table 2).

Table 1 - Personal and clinical characteristics of the sample (n = 8 patients)

Personal variables	n (%)
Age (years)	
≥ 60	6 (75)
51-59	2 (25)
Sex	
Male	5 (63)
Female	3 (37)
Clinical variables related to eligibility	**Mean (standard deviation)**
Mini-Mental State Examination	29 (02)
Beck Depression Inventory	11 (10)
Clinical variables related to Parkinson's disease	**n (%)**
Disease stage	
HY2	5 (63)
HY3	3 (37)
Disease duration (years)*	
1 a 5	2 (25)
6 a 10	5 (63)
>10	1 (12)
Side of symptom onset	
Right	6 (75)
Left	2 (25)

Note: *Time intervals according to supporting criteria positive for PD.[19] HY = stages of the original Hoehn and Yahr scale.

Tabela 2 - Activity and participation profile (APP) scores before and after the intervention (n = 8 patients)

APP item	Assessment (before intervention)			Reassessment (after intervention)		
	Score x (±)	Min-Max	Interpretation	Score x (±)	Min-Max	Interpretation
1. Sitting	0 (0)	0-1	No problem	0 (0)	0-1	No problema
2. Lying down	1 (1)	0-2	Mild problem	0 (0)	0-1	No problem
3. Roling over						
3.1 To the right	0 (1)	0-1	No problem	0 (0)	0-1	No problem
3.2 To the left	1 (1)	0-2	Mild problem	0 (0)	0-1	No problem
4. 2. Transferring oneself while lying down						
4.1 To the right	1 (1)	0-3	Mild problem	0 (1)	0-1	No problem
4.2 To the left	1 (1)	0-3	Mild problem	1 (1)	0-1	Mild problem
5. Crawling	1 (1)	0-2	Mild problem	0 (0)	0-1	No problem
6. Kneeling	0 (1)	0-1	No problem	0 (0)	0-0	No problem
7. Bending	1 (1)	0-2	Mild problem	0 (0)	0-1	No problem
8. Transferring oneself while sitting	1 (1)	0-3	Mild problem	0 (0)	0-1	No problem
9. Standing	1 (1)	0-2	Mild problem	0 (0)	0-0	No problem
10. Squatting	1 (1)	0-3	Mild problem	0 (0)	0-1	No problem
11. Kicking	0 (0)	0-1	No problem	0 (0)	0-0	No problem
12. Pushing with lower extremities	1 (1)	0-1	Mild problem	0 (0)	0-1	No problem
13. Walking short distances	0 (0)	0-1	No problem	0 (0)	0-0	No problem
14. Walking long distances	1 (1)	0-4	Mild problem	0 (0)	0-1	No problem
15. Walking on different surfaces	0 (1)	0-2	No problem	0 (0)	0-0	No problem
16. Walking around obstacles	0 (1)	0-1	No problem	0 (0)	0-1	No problem
17. Climbing	0 (1)	0-2	No problem	0 (0)	0-1	No problem
18. Moving around within the home	0 (0)	0-1	No problem	0 (0)	0-0	No problem
19. Moving around within buildings other than home	0 (1)	0-2	No problem	0 (0)	0-1	No problem
20. Moving around outside the home and other buildings	1 (1)	0-2	Mild problem	0 (0)	0-1	No problem
21. Using private motorized transportation	1 (1)	0-2	Mild problem	0 (0)	0-0	No problem
22. Using public motorized transportation	1 (1)	0-2	Mild problem	0 (0)	0-0	No problem
23. Driving motorized vehicles	n/a	0 ou 9	n/a	n/a	0 ou 9	-

Note: x (±) = mean (standard deviation); n/a: not applicable.

The percentage of patients classified as having some form of "problem" (score ≠ 0) in the APP declined significantly after the intervention. The item with the highest percentage of patients that exhibited some type of "problem" at assessment was "transferring oneself while lying down". The percentage of patients who experienced a "problem" for "transferring oneself to the left side while lying down" remained the same after intervention.

At reassessment, no patients experienced any difficulty for the items "kneeling", "standing", "walking short distances", "waking on different surfaces", "moving around within the home" or "using private motorized transportation" (Table 3).

The total score of the APP items declined significantly after the intervention ($p = 0.018$), with only one patient maintaining the same score. The decline in post-intervention score varied between 0 and 34 (Table 4).

Table 3 - Percentage of patients with some form of "problem" in APP items before and after the intervention (n = 8 patients)

APP item	Percentage (%) of patients with a "problem" per item	
	Assessment (before intervention)	Reassessment (after intervention)
1. Sitting	13	13
2. Lying down	50	13
3. Roling over		
3.1 To the right	38	13
3.2 To the left	38	25
4. 2. Transferring oneself while lying down		
4.1 To the right	63	38
4.2 To the left	50	50
5. Crawling	50	13
6. Kneeling	38	0
7. Bending	50	25
8. Transferring oneself while sitting	25	13
9. Standing	38	0
10. Squatting	50	25
11. Kicking	25	0
12. Pushing with lower extremities	50	13
13. Walking short distances	25	0
14. Walking long distances	38	13
15. Walking on different surfaces	25	0
16. Walking around obstacles	38	25
17. Climbing	25	25
18. Moving around within the home	25	0
19. Moving around within buildings other than home	25	25
20. Moving around outside the home and other buildings	50	25
21. Using private motorized transportation	38	0
22. Using public motorized transportation	38	0
23. Driving motorized vehicles	n/a	n/a
x (±)	36 (14)	14 (14)*

Note: APP = Activity and participation profile; x (±) = mean (standard deviation); *p < 0.0001 (Wilcoxon test); n/a: not applicable.

Table 4 - Total score for the 25 APP items per patient (n = 8 patients) before and after the intervention

Patient (No.)	Total score		Score reduction
	Assessment (before intervention)	Reassessment (after intervention)	
1	27	7	20
2	1	0	1
3	3	0	3
4	3	3	0
5	18	2	16
6	45	11	34
7	1	0	1
8	7	5	2
x (±)	13 (16)	4 (4)*	9

Note: APP = Activity and participation profile; x (±) = mean (standard deviation); *p < 0.018 (Wilcoxon test).

Discussion

In the present study, most of the APP items related to mobility based on ICF exhibited a "mild problem" at baseline assessment in a sample of people with PD. A positive effect was observed for these same items following therapeutic exercises associated with music-based RAS, suggesting that the intervention is a promising strategy for improving the functionality of people with PD and controlling the motor symptoms of the disease.

Exercise programs and training strategies play an important role in improving the functionality and participation of individuals with PD and must be chosen based on careful, comprehensive and individualized assessment of the difficulties they experience.[29] In the present study, we opted for a strategic assessment of the APP by selecting mobility-related activities/participation from the ICF.[25] We believe that this assessment contributed to a better understanding of the effects of our treatment strategy.

At assessment, three activities obtained scores between 0 and 3 ("no problem" to "severe problem"): "transferring oneself to the right and left while lying down", "transferring oneself while sitting" and "squatting". In a study that investigated women with PD, activities that required consecutive and alternating movements, such as transfers and squatting, were also the most negatively affected by the disease.[30]

In PD, changes in the modulation of basal ganglia caused by dopamine depletion result in less cortical activation, which explains the difficulty executing sequential movements and functional tasks. Additionally, axial rigidity is believed to limit trunk mobility and compromise co-contraction of the trunk and hip muscles, reducing selectivity and motor coordination and hampering functional activities.[2,31]

The only item with scores that varied between 0 and 4 ("no problem" to "complete problem") was "walking long distances". In a cross-sectional study on functionality, walking limitations were reported by 91% of the individuals with PD in an interview containing items from the ICF.[32] We believe that this finding may be related to compromised spatiotemporal gait parameters caused by the clinical picture of PD, such as shorter stride length, slower walking speed and increased cadence. Festinating gait and freezing may also be present, associated with postural instability.[31,33]

All the APP items improved to "no problem" after the intervention, except for "transferring oneself to the left while lying down", which remained the same ("mild problem"). The decision to apply the Pro-Parkinson therapeutic exercise program with music-based RAS using a smartphone application may have contributed to improving most of the APP items.

Neuroimaging studies suggest that rhythm perception activates motor structures that are often compromised in PD, such as the premotor cortex and supplementary motor area, basal ganglia and cerebellum.[34,35] Additionally, a continuous conditioned musical stimulus promotes an important increase in locomotor activity and extracellular dopamine levels in the basolateral amygdala and nucleus accumbens, contributing to the effectiveness of music as a motor stimulus.[36]

The fact that "transferring oneself to the left while lying down" continued to be a "mild problem" after intervention may be related to the protocol's not using RAS for the exercises "rolling over", "bridge" and "upper trunk mobility", which include the mobility needed to perform this activity. Reduced trunk mobility in PD due to axial rigidity is correlated with the difficulty in performing these tasks[2] and is present in the early stages of the disease.[37]

Another possibility is a relationship between difficulty with this item and the asymmetry of PD symptoms. The side of the body that patients report as being affected by initial symptoms is generally the most compromised, and in the present study, the right side was the most frequently cited. Patients need good motor control on the right side for "transferring oneself to the left side while lying down". Moreover, as a complex motor skill, this activity is considered difficult and requires the combined mobility of several subcomponents, such as the trunk and upper and lower limbs.[5,38]

The use of music-based RAS for transfer exercises in particular could contribute to future protocols, with a view to activating specific pathways in different brain motor areas and releasing biochemical mediators such as dopamine.[34]

The intervention had a positive effect on activities related to the exercises used in the therapeutic protocol. The item "walking long distances", whose scores varied between 0 and 4 ("no problem" to "complete problem") at assessment, improved to "no problem". It is believed that this was largely influenced by gait training associated with RAS, since this strategy seems to promote improvement in gait patterns, such as longer strides

and increased walking speed.[17,39] The positive effects of RAS on gait were also demonstrated in studies that use cadence training above the level of comfort in patients with PD,[12,40] adopting a beat rate of 10% for the music.[41]

At reassessment, no patients experienced any difficulty for the items "kneeling", "standing", "walking short distances", "waking on different surfaces", "moving around within the home" or "using private motorized transportation". The lower limb strengthening exercises associated with RAS, in addition to the balance and proprioception training performed in bed, may have favored this finding, since these tasks improve functionality.[42] Step training combined with RAS may also have influenced the postural stability and balance needed for these APP items, since these variables can be improved by including musical rhythm in PD treatment, enhancing the overall stability of postural coordination and optimizing motor function and rehabilitation.[43,44]

A study that used RAS only for step training demonstrated a significant improvement in trunk balance and oscillation, which was maintained for longer (8 weeks) when compared to a group not submitted to RAS, indicating this this stimulus prolonged the effects of step training.[45]

The percentage of patients with a "problem" in the "climbing" item remained unchanged post-intervention (25%), which may be because our protocol did not include an exercise compatible with this activity. Climbing stairs requires significant physical effort[46] and the skills and time needed to perform it have been linked to functional performance and quality of life in people with PD. Studies have found that interventions aimed at improving execution of this task enhance the functional performance of these patients.[46-48] Step or stair exercises (climbing up and down) combined with RAS are suggested for future studies.

There was a significant reduction in the total score for the APP items after intervention, with only one patient maintaining the same score. However, it is important to note that the patients studied are constantly monitored, which contributes to good performance. Further research is needed to clarify the effects of an exercise protocol associated with RAS on APP using the ICF, since none that addressed this topic were found. Furthermore, no studies were identified that use ICF items to assess the APP in PD, but rather other instruments commonly applied for functional assessment and included in ICF components.[49-51]

Global scientific production on the topic is still lacking in research that quantitatively applies the ICF in clinical practice.[52-54] A literature review found only four studies that associated the ICF with PD, in which the ICF domains chosen to classify these individuals were considered effective and suitable for describing functioning and disability in PD. No longitudinal studies were found that compared the ICF before and after intervention as done in this research.[55]

It is important to underscore that this is an original study because it describes the effects of therapeutic exercises associated with personalized music-based RAS, applied via a smartphone app, on the activity and participation profile of people with PD, using a selection of ICF items as an assessment instrument. In terms of limitations, it should be noted that preliminary intervention studies do not have the same rigor as randomized controlled trials, limiting extrapolation of the findings, which should be interpreted with caution.[56] An additional limitation was the inability to use RAS with all the exercises in the protocol.

We hope that this study will foster further in-depth research on the topic and technological development in health for PD, in addition to encouraging the use of the ICF as a tool in planning comprehensive care to improve the quality of life of this population.

Conclusion

In this study, therapeutic exercises associated with music-based rhythmic auditory stimulation had a positive effect on the Activities and Participation Profile related to mobility of people with Parkinson's disease.

Authors' contributions

IMA and ITGOG participated in its conceptualization, methodology, data analysis and interpretation, writing of the article, and approval of the final version to be published. KMCS and CAO participated in its conceptualization, methodology, data analysis and interpretation and approval of the final version to be published. CCSAL and MGWSC contributed to its conceptualization, methodology, data interpretation, critical review of the article, and approval of the final version based on their experience with Gerontology and Parkinson's disease.

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