**Supplementary Material**

**Multimodal Balance Training Supported by Rhythmical Auditory Stimuli in Parkinson’s Disease: A Randomized Clinical Trial**

**Overview of the RAS-supported multimodal balance training (supported by rhythmical auditory) stimuli and Regular multimodal training (without rhythmical auditory stimuli) (exercises program) and control intervention (educational program)**

1. **Participants:** patients with mild to moderate PD and without cognitive impairments (Hoehn and Yahr (H&Y) stage 1-3; Mini-Mental Status Examination (MMSE) ≥24).

* Number of participants per group:10
* Number of supervising physiotherapists per group:2

1. **Prescription: Intensity, Frequency and Dose administration**

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| **Intensity** | **Frequency** | **Duration/ Dose** | **Progression / Dose** |
| **5 weeks** | **2x/week** | **45 minutes**  **Warm-up: 5 minutes; Main Part: 30 minutes; Cool down: 10 minutes** | **Personalized** |

1. **Cues management:** The auditory rhythmical cues were delivered in an open-loop fashion (throughout the whole duration of the exercises) by a metronome at 50, 80, 100, 120, or 140 bpm beats per minute (bpm), according the exercises. When the patient was unable to perform the movement safely or with sufficient quality, the rhythm was personalized and the patient was instructed to use double the time to execute the movements (e.g., 100 bpm instead of 50 bpm).
2. **Materials:** Chairs, Ball (65 cm, 55 cm, 30 cm); Rubbers band (120 cm - medium density); Sticks (100 cm), Foams: 160 x 23 x 6 cm; 50 x 41 x 6 cm; 100 x 41 x 6 cm; 185 x 100 x 1.5 cm); Bar, Colored adhesive tapes; MA-1 KORG Metronome.

**Supplementary Table 1. Training program contents**

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| **Intensity** | **Frequency** | **Duration/ Dose** | **Progression / Dose** |
| **5 weeks** | **2x/week** | **45 minutes** | **Personalized** |
| **General content** | Both interventions (RAS-supported multimodal balance trainingand regular multimodal training) consisted of 3 parts: balance, gait and functional movements) | **Week 1** - each exercise was explained and demonstrated by the physiotherapist; patients were encouraged to pay attention on the most difficult aspects of movement execution. They performed five repetitions of each movement/ exercise (5 RM).  **Warm-up: 5 minutes**  **Main Part: 30 minutes**  **Cool down: 10 minutes** | **Week 2 and 3,** the subjects performed a series up to 10 repetitions per movement/exercise (RM) and in the third week, two series up to 10 RM (20 RM in total).  **Week 4 and Week 5, if** the subjects were able to execute 20 RM, they were instructed to progressively increase or decrease the movement speed depending on the exercise (and thereby making the exercise more difficult). |
| **Balance** | Anticipatory postural adjustments (postural transitions, and multidirectional stepping, emphasizing movement velocity and amplitude);  Compensatory postural adjustments (high challenges conditions and quick shifts of movement characteristic during predictable and unpredictable conditions);  Performance at stability limits (controlled leaning tasks performed while standing with varying bases of support, stimulating weight shifts in multiple directions and turning);  Attentional strategies (maintenance of attention during all exercises). | All patients who did not show t a good performance in Week 1, received additional instructions from a physiotherapist in terms of how to perform the exercises correctly.  In the RAS-supported group, patients were instructed to perform the movements slowly (twice the beat of the metronome) (see example in supplementary video) | Decreasing and increasing of the base of support.  Increasing and decreasing movement velocity and amplitude.  Progress - not holding on wall, bar or chair |
| **Gait** | Motor agility (e.g. interlimb coordination under varying gait conditions and quick shifts of movement characteristic during predictable and  unpredictable conditions);  Performance at stability limits (controlled leaning tasks performed while walking with varying bases of support, in multiple directions and turning);  Attentional strategies (maintenance of attention during all exercises). | Focusing on big steps, and visual cues  In the RAS-supported group, patients were instructed to perform the movements on the beat of the metronome (see example in supplementary video) | Increase environmental demands: surfaces, narrow  spaces, doorways, varying bases of support, in multiple directions and turning |
| **Functional movements** | Performance at stability limits (controlled leaning tasks performed while standing with varying bases of support, stimulating weight shifts in multiple directions and turning);  Posture core stabilization;  Attentional strategies (maintenance of attention during all exercises). | Focusing attention on the most difficult part of the movement  In the RAS-supported group, patients were instructed to perform the movements slowly (twice the beat of the metronome) | Increase coordination demands  sit-to-stand, start-stop  increase or decrease the speed |
|  |  |  |  |
| **Educational Program** | Contents of components were distributed in lectures, video sessions, general orientations about Parkinson’s Disease and Discussions | (5 minutes – Welcome; 30 minutes – Lecture, Video, Orientations; 10 minutes- Discussion) | The educational program was delivered in Portuguese (as the study was conducted in Brazil and all participants spoke Portuguese) |
|  | **Lectures** | 1.Parkisnon’s Disease – Epidemiology, Path physiology and diagnosis  2. Treatment Pharmacological, Neurosurgery and Rehabilitation (general information)  3. Quality of life and self-management  4. Patient centered care. How to be involved?  5.Falls prevention |  |
|  | **Video session** | 6. Advocating for Parkinson’s disease. Videos of famous people with Parkinson’s Disease  7. Discussion about lectures and videos sessions (hot topics chosen by the group) |  |
|  | **Orientations and Discussions** | 8. Make a list of your PD problems and try guiding us to help you.  9. What people with Parkinson’s disease should do and are able to do? Making your plans to the future.  10. Doubts (question and answers about all educational program topics and coffee) |  |

**Supplementary Table 2. List of exercises delivered on RAS-supported multimodal balance training and regular multimodal training (1 to 40)**

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|  | **Exercises** | **Mode of Execution** | **Aim** | **Progression (personalized)** | **\*BPM -Metronome \*\* (personalized)** |
| **1** | Diagonal Reach in sitting position and head movement |  | Improve trunk mobility + train voluntary arms and head movements | Increase and decrease movement amplitude | 50 bpm  or  100 bpm |
| **2** | Stability Ball Seated with trunk twist |  | Improve postural adjustments + Core Stabilization + trunk mobility + train voluntary arms movements | Increase and decrease movement velocity and amplitude | 50 bpm  or  100 bpm |
| **3** | Ball lifted over head in sitting position | C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\81OMCUUE\IMG_1139.JPG C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\81OMCUUE\IMG_1138.JPG | Improve postural adjustments + trunk mobility + train voluntary arms movements | Increase and decrease movement amplitude | 50 bpm  or  100 bpm |
| **4** | Ball lifted over head in up right posture | Uma imagem contendo parede, interior, pessoa, chão  Descrição gerada automaticamente | Improve balance + postural transitions and adjustments + trunk mobility + train voluntary arms movements | Decreasing and increasing of the base of support.  Increase and decrease movement velocity and amplitude | 50 bpm  or  100 bpm |
| **5** | Seated Balance on Swiss Exercise Ball |  | Improve postural stability + Core Stabilization + postural transitions and anticipatory adjustments | Decreasing and increasing of the base of support | 50 bpm  or  100 bpm |
| **6** | Stability Chair Seated with |  | Improve postural stability + + Core Stabilization + postural transitions and anticipatory adjustments + train amplitude of voluntary arms movements | Decreasing and increasing of the base of support.  Increase and decrease movement velocity and amplitude | 50 bpm  or  100 bpm |
| **7** | Shift weight with Stand holding a stick |  | Improve performance at stability + postural anticipatory adjustments + train voluntary arms movements + interlimb coordination under varying during predictable  conditions | Decreasing and increasing of the base of support.  Increase and decrease movement velocity and amplitude | 50 bpm  or  100 bpm |
| **8** | Trunk rotation holding a rubber | C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\81OMCUUE\IMG_9142.jpg | Improve postural stability + Core Stabilization + postural transitions and anticipatory adjustments + train amplitude of voluntary arms movements | Decreasing and increasing of the base of support.  Increase and decrease movement velocity and amplitude | 50 bpm  or  100 bpm |
|  |  | **Balance** | maintenance of attention during all exercises |  |  |
| **9** | Shift weight | C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\81OMCUUE\IMG_8557.JPG | Improve Motor agility (Step forward + shift weight postural); Performance at stability limits | cid:F0339B8E-78F6-4C58-8901-2BBCDCA3A9C5  Decreasing and increasing of the base of support.  Increase and decrease movement velocity and amplitude | 50 bpm  or  100 bpm |
| **10** | Heel Raises | cid:90EF5597-CBD5-4672-AFD0-BBB1A09EF1B2 cid:2F7FDBEF-D658-4259-96D9-972E8940C956 | Improving balance and Motor agility + Dorsiflexion and plantar and flexion of the foot + shift weight anterior and posterior direction, | Not holding on wall, bar or chair).  Increase and decrease movement velocity and amplitude | 80 bpm,  or  120 bpm  or  140 bpm |
| **11** | One-leg stand |  | Improve performance at stability + postural anticipatory adjustments + train voluntary arms movements + interlimb coordination under varying during predictable  conditions | Decreasing and increasing of the base of support. (not holding on wall, bar or chair).  Increase and decrease movement velocity and amplitude | 80 bpm,  or  120 bpm  or  140 bpm |
| **12** | Balance on both foot with visual cues |  | Improve balance + hip and lower limbs control control + coordination | Decreasing and increasing of the base of support. (not holding on walll bar or chair)  Increase and decrease movement velocity and amplitude | 50 bpm  or  100 bpm |
| **13** | On leg instance touching the ball with foot |  | Improve balance + hip and lower limbs control control + coordination and agility | Decreasing and increasing of the base of support. (not holding on wallall, bar or chair)  Increase and decrease movement velocity and amplitude | 80 bpm,  or  120  or  140 bpm |
| **14** | Balance on both foot with visual cues | C:\Users\z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\U9RUBOTN\IMG_6996 (2).JPG C:\Users\z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\U9RUBOTN\IMG_7028 (2).JPG | Improve performance at stability + postural anticipatory adjustments + shift weight under varying during predictable  conditions | Decreasing and increasing of the base of support. (not holding on wallwall, bar or chair)  Increase and decrease movement velocity and amplitude | 50 bpm  or  100 bpm |
| **15** | Balance on one foot | C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\H9QCCUNK\IMG_7358.PNG C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\H9QCCUNK\IMG_7359.PNG | Improve performance at stability + postural anticipatory adjustments + core stabilization + shift weight under varying during predictable  conditions | Not holding on wall, bar or chair Increase and decrease movement velocity and amplitude | 50 bpm  or  100 bpm |
| **16** | Rock around the clock | C:\Users\z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\U9RUBOTN\IMG_6993 (2).JPG C:\Users\z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\U9RUBOTN\IMG_7016 (2).JPG  C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\H9QCCUNK\IMG_7361.PNG C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\H9QCCUNK\IMG_7362.PNG | Improve Compensatory and Anticipatory postural adjustments (postural transitions, shift weight and unidirectional stepping, emphasizing movement velocity and amplitude);  Improving turning. | Decreasing and increasing of the base of support.  not holding to the wall, bar or chair  Increase and decrease movement velocity and amplitude | 80 bpm,  or  120  or  140 bpm |
| **17** | Unipedal stance with step | C:\Users\z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\U9RUBOTN\IMG_6982 (2).JPG | Improve anticipatory postural adjustments (postural transitions, shift weight and unidirectional stepping, emphasizing movement velocity and amplitude); + Core Stabilization | Decreasing and increasing of the base of support. (not holding on wallall, bar or chair**)**  Increase and decrease movement velocity and amplitude | 80 bpm,  or  120 bpm  or  140 bpm |
| **18** | Knee bent |  | Improve anticipatory postural adjustments (postural transitions, shift weight and unidirectional stepping, emphasizing movement velocity and amplitude); + Core Stabilization | Decreasing and increasing of the base of support. (support wall, bar or chair)  Increase and decrease movement velocity and amplitude | 80 bpm,  or  120 bpm  or  140 bpm |
| **19** | Unipedal stance with rubber band | cid:5B667E7C-0AF2-417F-A944-BFD8F153859D | Improve anticipatory postural adjustments (postural transitions, shift weight and unidirectional stepping, emphasizing movement velocity and amplitude); | Decreasing and increasing of the base of support. (Increase and decrease movement velocity and amplitude | 80 bpm,  or  100 bpm |
| **20** | Unipedal stance with rubber band | C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\81OMCUUE\IMG_6767.jpg | Improve anticipatory postural adjustments (postural transitions, shift weight and unidirectional stepping, emphasizing movement velocity and amplitude); | Decreasing and increasing of the base of support. Increase and decrease movement velocity and amplitude | 80 bpm,  or  100 bpm |
| **21** | Unipedal stance with weight balls from | C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\H9QCCUNK\IMG_6782.jpg | Improve Anticipatory postural adjustments (postural transitions, shift weight and unidirectional stepping, emphasizing movement velocity and amplitude); | Decreasing and increasing of the base of support,not holding on wall, bar or chair**.**  Increase and decrease movement velocity and amplitude | 80 bpm,  or  100 |
|  |  | **Gait** | maintenance of attention during all exercises |  |  |
| **22** | Heel-to-Toe Walking |  | Improve walking with varying bases of support + Cadence, stride length and turning | Increase environmental demands: surfaces, narrow  spaces, doorways, varying bases of support, in multiple directions and turning | 50 bpm,  or  100 bpm  or  150 bpm |
| **23** | Sideways walking with visual cues and foam |  | Improve compensatory and anticipatory adjustments (high challenges conditions and quick shifts of movement characteristic during predictable and unpredictable conditions)  -maintenance of attention during all exercises). | Increase environmental demands: surfaces, narrow  Spaces.  Increase or decrease movement velocity and amplitude | 80 bpm,  or  100 bpm |
| **24** | Walking with visual cues in high challenges conditions and upper limbs and dual task |  | Improve compensatory and anticipatory adjustments (high challenges conditions and quick shifts of movement characteristic during predictable and unpredictable conditions) + interlimb coordination (dual task) | Increase environmental demands: surfaces, narrow  Spaces.  Increase or decrease movement velocity and amplitude | 80 bpm,  or  100 |
| **25** | Walking with visual cues in high challenges conditions |  | Improve compensatory and anticipatory adjustments (high challenges conditions and quick shifts of movement characteristic during predictable and unpredictable conditions) | Increase environmental demands: surfaces, narrow  Spaces.  Increase or decrease movement velocity and amplitude | 80 bpm,  or  100 bpm |
| **26** | Walking with visual cues |  | Improve walking and step  Cadence, stride length and turning | Increase or decrease movement velocity and amplitude | 80 bpm,  or  120 bpm  or  140 bpm |
| **27** | Sideways walking with visual cues |  | Improve walking and step  Cadence, stride length and turning | Increase or decrease movement velocity and amplitude | 80 bpm,  or  120 bpm  or  140 bpm |
| **28** | Walking with visual cues using obstacles |  | Improve walking and step  Cadence, stride length and turning | Increase or decrease movement velocity and amplitude | 80 bpm,  or  100 bpm |
| **29** | Backwards Walkingwith visual cues |  | Improve walking and step  Cadence, stride length and turning | Increase or decrease movement velocity and amplitude | 80 bpm,  or  100 bpm |
| **30** | Walking with visual cues using roll foam | C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\81OMCUUE\IMG_6759.jpg | Improve compensatory postural adjustments (high challenges conditions and quick shifts of movement characteristic during predictable and unpredictable conditions); | Increase or decrease movement velocity and amplitude | 50 bpm,  or  100 bpm |
| **31** | Walking with visual cues + cones | C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\81OMCUUE\IMG_6778 (2).PNG | Improve walking with visual cues; multidirectional stepping, emphasizing movement velocity and amplitude  Improve walking and step  Cadence, stride length and turning | Increase or decrease movement velocity and amplitude | 50 bpm,  or  100  or  150 bpm |
|  |  | Functional Exercises | maintenance of attention during all exercises |  |  |
| **32** | Diagonal Reach with ball |  | Improve postural stability + trunk mobility + Core Stabilization + postural transitions and anticipatory adjustments + train amplitude of voluntary arms movements | Increase and decrease movement velocity and amplitude | 50 bpm,  or  100 bpm |
| **34** | Hip extension with reverse fly |  | Improve postural stability + Core Stabilization + postural transitions and anticipatory adjustments + train e of voluntary arms movements | Increase and decrease movement velocity and amplitude | 50 bpm,  or  100 bpm |
| **35** | Diagonal reach  Single-leg balance |  | Improve postural stability + Core Stabilization + postural transitions and anticipatory adjustments | Decreasing and increasing of the base of support. (support wall, bar or chair)  Increase and decrease movement velocity and amplitude | 80 bpm,  or  100 bpm |
| **36** | Hell touch | [therapeutic exercise software](https://www.exerciseprolive.com/wp-content/uploads/2017/10/heel-touch-step-down.jpg) | Improve postural stability + Core Stabilization + postural transitions and anticipatory adjustments | Decreasing and increasing of the base of support (progress - not holding on wall, bar or chair) Increase and decrease movement velocity and amplitude | 50 bpm,  or  100 bpm |
| **37** | Knee lift  Lunge with back row | C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\H9QCCUNK\IMG_7044.JPG C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\H9QCCUNK\IMG_7041.JPG | Improve postural stability + trunk mobility + Core Stabilization + postural transitions and anticipatory adjustments + train amplitude of voluntary arms movements | Decreasing and increasing of the base of support. Increase and decrease movement velocity and amplitude | 80 bpm,  or  100 bpm |
| **38** | Sit to Stand | C:\Users\z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\U9RUBOTN\IMG_7124 (2).JPG C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\H9QCCUNK\IMG_7366.PNG C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\H9QCCUNK\IMG_7364.PNG | Improve postural stability + Core Stabilization + postural transitions and anticipatory adjustments + train e of voluntary arms movements | Decreasing and increasing of the base of support. Increase and decrease movement velocity and amplitude  holding a ball | 80 bpm,  or  100 bpm |
| **39** | Kneeling Deadlift | C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\81OMCUUE\IMG_6771.PNG C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\81OMCUUE\IMG_6772.PNG | Improve postural stability + Core Stabilization + Trunk mobility + postural transitions and anticipatory adjustments + train e of voluntary arms movements | Decreasing and increasing of the base of support. Increase and decrease movement velocity and amplitude | 80 bpm,  or  100 bpm |
| **40** | Kneeling Twisting | C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\81OMCUUE\IMG_6774.PNG C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\81OMCUUE\IMG_6775 (2).PNG | Improve postural stability + Core Stabilization + Trunk mobility + postural transitions and anticipatory adjustments + train e of voluntary arms movements | Decreasing and increasing of the base of support.  Increase and decrease movement velocity and amplitude | 80 bpm,  or  100 bpm |
| Legend: \* Beats per minute (BPM); Metronome \*\* - Patients was oriented to using the cues according their capacity to follow the cues deliveries by Metronome | | | | | |

**Overall impression of the intervention’s programs**

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| 1. **Overview of the RAS-supported and regular exercises program positions** | | |
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| C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\H9QCCUNK\IMG_7057.JPG | C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\H9QCCUNK\IMG_7352.PNG | cid:B8178889-38E9-4A72-BEE8-7EB9BB06D00E |

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| **b) Overview of the control intervention placement** | | |
| **Lectures** | **Video session** | **Orientations and Discussions** |
| cid:81DF4410-DD4F-4D5E-BE68-3FCD4AFF9B5D | C:\Users\Z824189\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.Outlook\81OMCUUE\IMG_9067.JPG | cid:5E1F4220-8550-46CF-95FE-E09E6F8DAEEF |
| Patients from control intervention group, received educational program educational program in sitting position. The chairs were organized according the content (lecture, video session, orientations and discussions). | | |