The use of rhythmic auditory stimulation on gait parameters in Parkinson's disease: A systematic review

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Abstract

Introduction: Parkinson's disease (PD) is a neurodegenerative disorder that commonly affects the basal ganglia dopaminergic signaling system, which can contribute to moderate-severe gait impairments in individuals. Many therapies have been proposed to mitigate this effect, however, there are often issues to consider such as the relative invasiveness of the procedure and other side effects. Rhythmic auditory stimulation (RAS) is a non-invasive therapeutic avenue with the potential to mitigate associated impairments in gait parameters. This review aims to evaluate the recent literature regarding the efficacy of this intervention in improving gait parameters in individuals with Parkinson's disease.

Methods: PubMed and OVID Medline databases were consulted to find nine randomized controlled trials (RCTs) written in the English language, published between 2012 and 2022 and subject to a strict inclusion criterion. Keywords included, but were not limited to, "Parkinson's disease", "rhythmic auditory stimulation", and "gait". Outcomes were critically analyzed, and their implications were evaluated in the context of existing research within this field.

Results: Many of the studies showed a strong immediate improvement in several of the gait parameters, such as speed, stride length, cadence, balance, and falls, identified across a variety of RCT designs. However, many reviewed studies included a small sample size (n ≤ 30) and showed no significant outcomes in specific parameters, and several lacked an adequate follow-up period, limiting assessment of long-term efficacy.

Discussion: The findings showed strong implications surrounding the use of rhythmic cues to prime the motor system to facilitate gait relearning and motor rehabilitation, at least in the short term. This method can be applied in future therapeutic avenues to address gait rehabilitation in a non-invasive manner.

Conclusion: Existing literature demonstrates that RAS therapy is a promising method to incorporate into such therapeutic avenues; however, further research for the long-term efficacy of this approach is required.

Background[1-13]

Parkinson's Disease (PD):

- PD is a common neurodegenerative disorder resulting from damage to dopaminergic signalling systems at the substantia nigra
- It is commonly associated with a "classical triad" of symptoms ranging from bradykinesia, cogwheel rigidity and resting tremors
- While no cure currently exists, numerous therapeutic options have been proposed to address the issue (i.e. pharmaceuticals, physiotherapy)
- Researchers are continuing to look for less invasive therapeutic options

Rhythmic Auditory Stimulation (RAS):

- RAS is a neurological music therapy technique aimed at applying the use of rhythmic cueing to improve gait parameters
- While minimal research is available regarding its application in PD specifically, it has shown promise in stroke rehabilitation as an intervention
- It has been thought to contribute to rehabilitation by acting as an "internalized timekeeper for rhythmic patterned movements."

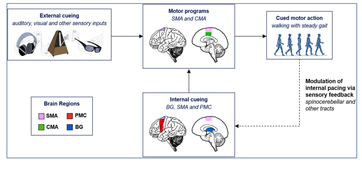

Figure 1: Retrieved from Ashoori et al., 2015. Without external cueing, the basal ganglia (BG), supplementary motor area (SMA) and premotor cortex (PMC) receive sensory inputs to help create rhythms to modulate gait parameters in the body. When these internal cues are impaired, external cues can supplement them, particularly bypassing the basal ganglia.

Objectives

This systematic review aims to investigate the effectiveness of RAS in improving movement parameters most affected in individuals with PD, such as:

- Speed
- Number of falls
- Balance
- Cadence
- Stride length
- Gait

Methods

- Database searches were conducted in PubMed and OVID MedLine over a ten-year period between 2012 and 2022
- Searches were conducted (all: filtered with RCT): "(Rhythmic Auditory Stimulation OR RAS) AND (Parkinson's disease OR PD)".
- Searches were restricted to papers written in English and were selected according to the following inclusion criteria:
  1. *Title and abstract must be relevant to the research question*
  2. *Main body text must be relevant to the scope of the review*
  3. *Methods must include a specific intervention relevant to research outcome*
  4. *Methods must include intervention targeted to specific outcomes relevant to the research question*
  5. *Recruited participants must meet the inclusion criteria*

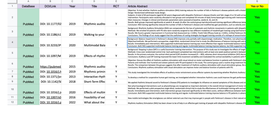

Figure 2: Screening and extraction from all approved studies (n=9). 25 initial studies were identified from OVID Medline and PubMed databases. Eight studies were removed as duplicates (n = 17), and 6 further studies were removed during abstract screening against eligibility criteria (n = 11). Two further studies were removed for lack of relevant outcome measures and issues related to research question scope uring full text review (n = 9). The scientific rigor of the associated eligibility criteria and of diagnosis of PD was assessed by all authors.

Results[14-22]

Table 1: Summary of intervention groups and outcomes identified from the nine included RCTs.

Included RCTs	Intervention Groups	Main Outcomes
Thaut et al., 2019	Experimental: 30 min/day of home-based gait training via metronome click-embedded music for 24 weeks Control: 30 min/day of home-based gait training via metronome click-embedded music for 24 weeks except for Week 8-16	• Speed, cadence, stride length, gait parameters improved, falls reduced in RAS/experimental group, maintained across full 24-week timeframe.
Calabro et al., 2019	Experimental: Treadmill gait training with RAS at various frequencies Control: Treadmill gait training without RAS.	• Gait, stride length, cadence and UPDRS improved in RAS/experimental group, reduced falls • Nonsignificant changes in speed between RAS and control conditions.
Capato et al., 2020	Experimental: Group 1: Multimodal balance training supported by RAS. Group 2: Regular multimodal balance training without RAS. Control: General education program	• Balance, falls, gait, UPDRS improved in RAS-supported group, maintained to 6 month follow up. • Both multimodal training groups showed improved balance, gait from control, maintained to 6-month follow-up.
Chang et al., 2019	Experimental: AC: SIP training, metronome-applied auditory cueing Control: NC: SIP training, at participant speed	• Nonsignificant changes in speed and stride length between AC and NC conditions. • Cadence improved in AC and NC, not maintained to follow-up.
Song et al., 2015	Experimental: Conventional drugs alongside RVS + RAS training Control: Conventional drug treatment	• Significant improvements in BBS scores, increase in stride length, reduced UPDRS score, and an improvement in cadence in the experimental group.
Braun Janzen et al., 2019	Experimental: 1 - Finger Tapping: Tap with index finger of the least affected hand in synchrony with a metronome. 2 - Arm Swing: Swinging both arms in an alternating motion in synchrony with a metronome set 20% faster than pre-training walking cadence. Control: No training; rested for 4 mins.	• Finger tapping group: significant improvement within gait velocity and gait cadence post-training. • No changes to gait cadence pre- and post-swing training for the arm swing group and in the control group.
Uchitomi et al., 2013	Experimental: 1) interactive WalkMate, 2) fixed tempo, or 3) *1/f* fluctuating tempos Control: No cue provided.	• Gait fluctuation in the WalkMate group gradually increased to a healthy *1/f* level.
Capato et al., 2020	Experimental: Multimodal balance training with RAS cues provided by metronome Control: Multimodal balance training without RAS cues	• Sustained improvements in balance in those with advanced staged PD.
Zhao et al., 2016	All participants underwent 4 walking courses (i) wide turn (ii) narrow turn (iii) full turn (iv) doorway. Experimental: 3 audiovisual cues using Google Glass (i) metronome (ii) LED flashing light (iii) optic flow. Control: No cues from Google Glass.	• Increased stride length using metronome. • Fewer FOG episodes per trial with metronome. • More stable gait pattern with cues for complicated walking courses.

Discussion

- The aging population and growing prevalence of PD makes the need for effective non-invasive therapies even greater to address this disease
- The results overall show a strong improvement in gait related outcomes in experimental/RAS groups in comparison with control groups
- Some of the main limitations associated with analysis of the recorded data includes small sample sizes, variations in methodological design and a lack of follow-up in some studies
- Further research could also clarify the ideal frequency for RAS intervention implementation to optimize efficacy

Conclusions

- Existing literature shows RAS to be a promising therapeutic intervention in the treatment of PD and should be further investigated to determine how it can be implemented in this setting.
- Many studies given lack conclusive evidence in support of RAS, and so further research is necessary to confirm the findings seen across these RCTs.

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References