CRITICALLY APPRAISED TOPIC

FOCUSED CLINICAL QUESTION

Is resistive gait training on a treadmill more effective than rhythmic auditory stimulation training in increasing step length in individuals with Parkinson's Disease?

AUTHOR

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CLINICAL SCENARIO

The patient was diagnosed with idiopathic Parkinson's Disease and demonstrated a gait pattern with decreased step length and decreased hip flexion. She was having difficulty with falling, and navigating obstacles in her everyday environment. During the treatment session, we did a lot of gait training using repetitive ambulation with external and verbal cues to increase step length/hip flexion. The patient was able to make isolated improvements, but with limited carry-over. I had learned about adaptive resistance training in the clinic and wondered if that would be a good intervention to combine with high repetition of gait training. I wondered if there would be more carry-over due to increased neural recruitment and the strengthening aspect of the resistance.

SUMMARY OF SEARCH

The evidence shows that there is a demonstrated step length change with both metronome and resisted gait training.[1,2,3,4,5,6,7,8] The literature for metronome training is more available and demonstrates a clear benefit.[5,8] However, for true resisted gait training the data is less prevalent, and much newer. Different studies indicate the kinematics for a potential benefit.[1,2,3,4] Reviewing the literature made it clear that there is no conclusion on the benefit of resisted gait training for individuals with Parkinson's Disease. There was additional information for individuals post-stroke, and there was a clear propulsive reserve.[2,3] There was a study that indicated this propulsive reserve may also be present in individuals with Parkinson's Disease.[1,4] Further research is needed to demonstrate the direct effects on a resisted gait training protocol, and at this time it would not be appropriate to perform in the clinic with an emphasis on neurological recruitment for changing step length. However, there is strong evidence for the use of rhythmic auditory stimulation as an effective intervention for improving the step length of individuals with Parkinson's disease.

CLINICAL BOTTOM LINE

Rhythmic auditory stimulation is an effective gait training intervention for increasing step length in individuals with Parkinson's Disease. For individuals with Parkinson's Disease, there is indirect evidence to support the use of resisted gait training to achieve a longer step length but not direct evidence supporting the use in the clinic.

This critically appraised topic has been individually prepared as part of a course requirement and has been peer-reviewed by one other independent course instructor

SEARCH STRATEGY

Terms used to guide the search strategy			
Patient/Client Group	**I**ntervention (or Assessment)	**C**omparison	**O**utcome(s)
Parkinson's Disease PD	Resistance Gait training Resistive Gait training	Rhythmic auditory training Metronome	Step Length Stride Length Gait kinematics

Final search strategy (history):

Search number	Query	Sort By	Filters	Search Details	Results
17	propulsion AND treadmill AND gait training AND step length NOT wheelchair NOT prosthesis			((("propulsion"[All Fields] OR "propulsions"[All Fields] OR "propulsive"[All Fields]) AND ("treadmill"[All Fields] OR "treadmill s"[All Fields] OR "treadmills"[All Fields]) AND (("gait"[MeSH Terms] OR "gait"[All Fields]) AND ("educati	7
16	propulsion AND treadmill AND gait training NOT wheelchair NOT prosthesis			((("propulsion"[All Fields] OR "propulsions"[All Fields] OR "propulsive"[All Fields]) AND ("treadmill"[All Fields] OR "treadmill s"[All Fields] OR "treadmills"[All Fields]) AND (("gait"[MeSH Terms] OR "gait"[All Fields]) AND ("educati	58
15	propulsion AND treadmill NOT wheelchair AND gait training			((("propulsion"[All Fields] OR "propulsions"[All Fields] OR "propulsive"[All Fields]) AND ("treadmill"[All Fields] OR "treadmill s"[All Fields] OR "treadmills"[All Fields])) NOT ("wheelchair s"[All Fields] OR "wheelchairs"[MeSH Term	61
14	propulsion AND treadmill NOT wheelchair			(("propulsion"[All Fields] OR "propulsions"[All Fields] OR "propulsive"[All Fields]) AND ("treadmill"[All Fields] OR "treadmill s"[All Fields] OR "treadmills"[All Fields])) NOT ("wheelchair s"[All Fields] OR "wheelchairs"[MeSH Terms	252
13	propulsion AND treadmill			("propulsion"[All Fields] OR "propulsions"[All Fields] OR "propulsive"[All Fields]) AND ("treadmill"[All Fields] OR "treadmill s"[All Fields] OR "treadmills"[All Fields])	361
12	gait propulsion AND treadmill				0
11	propulsive reserve AND gait training			("propulsion"[All Fields] OR "propulsions"[All Fields] OR "propulsive"[All Fields]) AND ("reserve"[All Fields] OR "reserve s"[All Fields] OR "reserves"[All Fields]) AND (("gait"[MeSH Terms] OR "gait"[All Fields]) AND ("education"[M	1
10	propulsive reserve AND physical thearpy - Spellcheck off			("propulsion"[All Fields] OR "propulsions"[All Fields] OR "propulsive"[All Fields]) AND ("reserve"[All Fields] OR "reserve s"[All Fields] OR "reserves"[All Fields]) AND (("physical examination"[MeSH Terms] OR ("physical"[All Fielc	0
9	propulsive reserve AND physical therapy			("propulsion"[All Fields] OR "propulsions"[All Fields] OR "propulsive"[All Fields]) AND ("reserve"[All Fields] OR "reserve s"[All Fields] OR "reserves"[All Fields]) AND ("physical therapy modalities"[MeSH Terms] OR ("physical"[A	6
8	propulsive reserve			("propulsion"[All Fields] OR "propulsions"[All Fields] OR "propulsive"[All Fields]) AND ("reserve"[All Fields] OR "reserve s"[All Fields] OR "reserves"[All Fields])	48
7	lewek md OR lewek m			lewek md[Author] OR lewek m[Author]	75
6	resisted walking			("resist"[All Fields] OR "resistance"[All Fields] OR "resistances"[All Fields] OR "resistant"[All Fields] OR "resistants"[All Fields] OR "resisted"[All Fields] OR "resistence"[All Fields] OR "resistences"[All Fields] OR "resistent"[All F	3,747
5	resistance to ambulation			("resist"[All Fields] OR "resistance"[All Fields] OR "resistances"[All Fields] OR "resistant"[All Fields] OR "resistants"[All Fields] OR "resisted"[All Fields] OR "resistence"[All Fields] OR "resistences"[All Fields] OR "resistent"[All F	4,020
4	gait adapted resistance			("gait"[MeSH Terms] OR "gait"[All Fields]) AND ("acclimatization"[MeSH Terms] OR "acclimatization"[All Fields] OR "adaptation"[All Fields] OR "adaptations"[All Fields] OR "adapt"[All Fields] OR "adaptabilities"[All Fields] OR "	155
3	(Parkinson's Disease OR PD) AND resistance gait training AND step length			("parkinson disease"[MeSH Terms] OR ("parkinson"[All Fields] AND "disease"[All Fields]) OR "parkinson disease"[All Fields] OR "parkinson s disease"[All Fields] OR ("pharmacology"[MeSH Subheading] OR "pharmacology"[A	3
1	Parkinson's Disease AND resistance gait training AND (external cues OR gait training OR amb*)			("parkinson disease"[MeSH Terms] OR ("parkinson"[All Fields] AND "disease"[All Fields]) OR "parkinson disease"[All Fields] OR "parkinson s disease"[All Fields]) AND (("resist"[All Fields] OR "resistance"[All Fields] OR "resista	51
2	(Resistance gait training) AND (step length OR stride length)			("resist"[All Fields] OR "resistance"[All Fields] OR "resistances"[All Fields] OR "resistant"[All Fields] OR "resistants"[All Fields] OR "resisted"[All Fields] OR "resistence"[All Fields] OR "resistences"[All Fields] OR "resistent"[All F	87

Parkinson's Disease AND resistance gait training AND (external cues OR gait training OR amb*)

- (51 results) Many comparing resistance training versus actual resistive gait training

(Resistance gait training) AND (step length OR stride length)

- (87 results) Many of them were comparing resistance training, versus resistive gait training

(Parkinson's Disease OR PD) AND resistance gait training AND step length

- Only three results
- One study looking at patients with PD, repetitive step training with preparatory visual cues
- There others were using a different type of resistance training

parkinson's disease AND step length AND physical therapy NOT virtual reality NOT balance

- (68 results)
- Updated to : parkinson's disease AND step length AND physical therapy NOT virtual reality NOT balance NOT exercise
    - 27 results, a variety of which are relevant to the question, wanted to find more about the effect on gait/propulsion

Parkinson's disease AND propulsive reserve

- No Results

Propulsive Reserve

    - 48 results → too broad

Propulsive Reserve AND Physical Therapy

- Many results were based on wheelchair propulsion
    - 6 results

Propulsion AND Treadmill NOT Wheelchair

- Many were looking at healthy individuals so added gait training to specify

Propulsion AND treadmill NOT wheelchair AND gait training

- Included many individuals with prosthetics, and had a large variety of outcome measures

Propulsion AND treadmill AND gait training AND step length NOT wheelchair NOT prosthesis

- Some of the
- There were some relevant studies

        - Large Propulsion Demands Increase Locomotor Adaptation at the Expense of Step Length Symmetry
            - DOI: 10.3389/fphys.2019.00060
        - Effects of real-time gait biofeedback on paretic propulsion and gait biomechanics in individuals post-stroke
            - DOI: 10.1080/10749357.2018.1436384

Propulsive Reserve AND gait

- 9 results
    - Relevant articles
        - The Presence of a Paretic Propulsion Reserve During Gait in Individuals Following Stroke
            - DOI: 10.1177/1545968318809920

propulsion AND inclined treadmill AND (gait OR walk* OR Amb*)

- Included incline treadmill, because it is a similar concept to adding resistance to forward movement (aka gravity is resisting)
- This was the last search result I used, and found two related articles to effects on propulsion with resistance to gait (aka incline) but not in the population I wanted to initially focus
- 11 Results
    - Relevant articles
        - Augmenting propulsion demands during split-belt walking increases locomotor adaptation of asymmetric step lengths
            - DOI: 10.1186/s12984-020-00698-y
        - Immediate effects of a single inclined treadmill walking session on level ground walking in individuals after stroke
            - DOI: 10.1097/PHM.0b013e31823cabe3

Databases and Sites Searched	Number of results	Limits applied, revised number of results (if applicable)
Pubmed → results and rationale for revision listed above		
(PEDro) "Propulsive Reserve AND gait" (PEDro) "propulsive reserve" (PEDro) "incline treadmill AND gait"	0 0 2	
(EMBASE) "Propulsive Reserve AND gait" (EMBASE) propulsion AND inclined treadmill AND (gait OR walk* OR Amb*) (EMBASE) Propulsion AND treadmill AND gait training AND step length NOT wheelchair NOT prosthesis	2 4 5	
(CINAHL) "Propulsive Reserve AND gait" (CINAHL) "propulsion AND inclined treadmill AND (gait OR walk* OR Amb*)" (CINAHL) "Propulsion AND treadmill AND gait training AND step length	2 0 2	

INCLUSION and EXCLUSION CRITERIA

Inclusion Criteria
Idiopathic Parkinson's Disease Parkinson's Disease Adults and older adults (over the age of 18) Patients ambulatory w/ no assistive device
Exclusion Criteria
Additional comorbidities that may affect gait (i.e. TBI) Case studies

RESULTS OF SEARCH

Summary of articles retrieved that met inclusion and exclusion criteria

Author (Year)	Risk of bias (quality score)*	Level of Evidence**	Relevance	Study design
Title: Plantarflexor strength, gait speed, and step length change in individuals with Parkinson's disease[1] **Author:** Staci M Shearin, Ann Medley, Elaine Trudelle-Jackson, Chad Sqank and Ross Querry **Year:** 2020	20/27 (was affected a lot by inability to blind) Downs and Black Checklist	Level 3 – Strong study design but lacking a control group	Moderate: This study demonstrates the effect of step length for individuals with Parkinson's disease. They found that individuals with mild PD had significant step lengths and moderate PD. The same was true for health controls and both groups of participants with PD. There was also a significant difference in number of heel raises. The data supported that individuals with PD would have decreased step length and planter flexor strength. This is relevant to the propulsive effects individuals have when ambulating.	Cross-sectional design with convenience sample, non-experimental design Participants performed: 10MWT, comfortable gait speed, MDS-UPDRS Part III then CRS N=96 (71 w/ PD, 25 healthy peers) Independent variable: Level of PD, healthier peers, and two different levels of PD (mild and moderate) Dependent Variables: Gait speed, step length, and plantar flexor strength
Title: The Presence of a Paretic Propulsion Reserve during Gait in Individuals Following Stroke[2] **Authors:** Michael D. Lewek, PT, PhD, Cristina Raiti, PT, DPT, and Amanda Doty, PT, DPT **Year:** 2018	21/27 (some points like randomization of intervention were not possible) Downs and Black Checklist	Level 3 – Strong study design but lacking control group	High: This study analyzed the effects of resistance training, but on with participants who had undergone stroke and not Parkinson's disease. However, they found that there was a large propulsive	Quasi-experimental design (no ability to randomize), cross-sectional, repeated measures Individuals with chronic hemiparesis walked with an anterior → posterior force applied at the center of mass (pelvis) on the treadmill with ascending percentage of BW force. Propulsive forces and other body kinematics were measured via treadmill

			reserve that post-stroke participants were able to use and laid the foundation for potential future interventions.	force plates and 3-d capture.
Title: Effects of treadmill inclination on hemiparetic gait: Controlled and Randomized Clinical Trial[3] **Authors:** Gama, Gabriela Lopes MDde Lucena Trigueiro, Larissa Coutinho MDSimão, Camila Rocha MDde Sousa, Angélica Vieira Cavalcanti MDde Souza e Silva, Emília Marcia Gomes PTGalvão, Élida Rayanne Viana Pinheiro PTLindquist, Ana Raquel Rodrigues PhD **Year:** 2015	Pedro Scale 9/11	Level 2 – Strong design	Moderate The study used inclination training to impact gait parameters. This concept is similar to resistance training because gravity is acting as the resistance force. In the study, the experimental group showed differences in paretic step length and velocity.	RCT, with blinding N=16 Subjects were randomized into two training groups, the control group, and the experimental group. Both groups received partial body weight treadmill training, but the experimental group was at a 10% inclination.
Title: The Effect of One Session Split-Belt Treadmill Training on Gait Adaptation in People with Parkinson's Disease and Freezing of Gait[4] **Authors:** Jana Seuthe, MA, Nicholas D'Cruz, MSc, Pieter Ginis, PhD, Jos Steffen Becktepe, MD Burkhard Weisser, PhD, Alice Nieuwboer, PhD, and Christian Schlenstedt, PhD **Year:** 2020	Pedro Scale 4/11 (Limitations inability to blind, and designed to be a one-day treatment)	Level 2 – The lower score Pedro scale had a lot to do with limitations in blinding, for what the researchers were measuring the study was well designed	High This study analyzed the effects of split-belt treadmill training for gait adaption in individuals with PD. They found that participants with PD were able to alter their step length and freezing of gait. The effects were retained 24 hours later to a certain extent. This relates to the PICO because it demonstrates individuals with PD can alter propulsive forces and indicates some propulsive reserve.	Experimental Design, RCT, cross-sectional design Individuals with PD and healthy controls were randomly assigned to 3 split-belt treadmill trainings or tied-belt treadmill training. Then participants completed a standardized adaption test on a split belt treadmill.

Title: Kinematic variables of gait and quality of line in Parkinsonians after different treadmill trainings a randomized control trial[5] **Author:** Maira Peloggia Cursino, Doralice Fernanda Raquel2 Camilla Zamfolini Hallal, Flávia Roberta Faganello **Year:** 2018	Pedro Scale 5/11 (unable to blind)	Level 2	Moderate This study includes a rhythmic auditory stimulus (metronome) that was set to induce an increased step length.	RCT, N=21 Participants were partial body weight support, auditory stimulus, and control treadmill gait training, groups Trainings were completed for six weeks (3x week for 30 minutes) Kinematic data were collected from the participants including soil step length, step length variability, step width, step width variability, and gait speed.
Title: Targeted Pelvic Constraint force induces enhanced use of the paretic leg during walking in person's post stroke[6] **Authors**: Seoung Hoon Park, Jui-Te Lin, Weena Dee, Chao-Jung Hsu, Elliot J. Roth, William Z. Rymer **Year:** 2020	Downs and Black Checklist 19/27 (many points lost for inability to blind)	Level 3 – No control group, patients establishing their own baseline	Moderate The study is using resisted gait training, but using variable techniques and focused on individual's post-stroke. The targeted resistance during stance phase resulted in enhance medial hamstring activity on the paretic leg, which was retained after force was removed. They also found an improvement in step length with application of target resistance. They also analyzed constant force application.	Quasi-experiment design (no randomization), cross-sectional, repeated measures N=13 individuals post stroke hemiparesis Participants underwent a controlled backward resistance, with a targeted resistance force and continuous while walking on the treadmill. They collected data on muscle activity of tibialis anterior, medial gastrocnemius, rectus femoris, and medial hamstrings from both legs using EMG.
Title: Large Propulsion Demands Increase Locomotor Adaptation at the Expense of Step Length Symmetry[7] **Authors:** Carly J. Sombric, Jonathan S.	Downs and Black Checklist 20/27 Missing information for participant recruitment, and unable to blind	Level 2 – They had individuals walking flat, but there was a small N in each group, no discussion of power and they did not gather baseline data from the incline	Moderate This article presents good information about how individuals adapt gait under different conditions. One of those	Experiment design cross-sectional, RCT N=24 in three groups (incline, control, and decline)

Calvert and Gelsy Torres-Oviedo **Year:** 2019		data on a flat surface	conditions includes included an incline which will be a similar adaption to resistance. They also looked at decline and flat. Additionally they incorporated an adaption on the split belt so that one extremity was moving faster than the other, which differs from my PICO.	
Title: Rhythmic auditory stimulation for reduction of falls in Parkinson's disease: a randomized controlled study[8] **Authors:** Michael H Thaut, Ruth Rice, Thenille Braun Janzen, Corene P Hurt-Thaut and Gerald McIntosh **Year:** 2019	Pedro Scale 10/11	Level 2	High This study was focused on fall risk, which is an important factor. However, for relevance to the PICO question they also included gait kinematics and found that rhythmic auditory stimulation (music with calculated tempo, with metronome beats) significantly increased stride length and velocity.	Randomized withdrawal study design, intent-to-treat experimental design N=60 Inclusion: Idiopathic PD (Hoehn and Yahr Stages III or IV) with at least two falls in the past 12 months Participants randomly allocated to two groups and completed 30 minutes of daily home-based gait training with metronome click embedded music. Experimental group completed 24 weeks of RAS training, control group discontinued RAS training between weeks 8 and 16 Outcomes: Clinical and kinematic parameters assess at baseline, 8 weeks, 16 weeks, and 24 weeks

BEST EVIDENCE

The following 2 studies were identified as the 'best' evidence and selected for critical appraisal. Rationale for selecting these studies were:

- **1. The Effect of One Session Split-Belt Treadmill Training on Gait Adaptation in People with Parkinson's Disease and Freezing of Gait**[4]
  - To be honest this isn't the article with the highest level of evidence. However, there is not a lot of literature for resisted gait training. However, it is highly relevant to my PICO because it applies directly to the population and includes an intervention that is somewhat similar to my PICO question. The underlying assumption for resisted gait training is an individual with PD's ability to adapt their propulsion and while this was not the focus of the study for step length, that is a variable they included. The other potential studies that support resisted gait training were done with participants who were post-stroke.
- **Rhythmic auditory stimulation for reduction of falls in Parkinson's disease: a randomized controlled study**[8]
  - This is a high quality study, that analyses the effects of rhythmic auditory stimulation. Similar to the above article, their main focus is the reduction in falls, but their outcome measures included kinematic data that will demonstrate changes in step length.

SUMMARY OF BEST EVIDENCE

(1) Description and appraisal of The Effect of One Session Split-Belt Treadmill Training on Gait Adaptation in People with Parkinson's Disease and Freezing of Gait[4] **by** Jana Seuthe, MA, Nicholas D'Cruz, MSc, Pieter Ginis, PhD, Jos Steffen Becktepe, MD Burkhard Weisser, PhD,
Alice Nieuwboer, PhD, and Christian Schlenstedt, PhD, 2020[4]

Aim/Objective of the Study/Systematic Review:
The objective of the study was three-fold to compare immediate effects of split-belt treadmill training in individuals with Parkinson's Disease and freezing of gait to healthy control, find the most effective split-belt training protocol, and compare different outcome measures that measure gait adaptability.
Study Design
This study is an experimental non-blinded randomized control trial with a cross-sectional design. There were two groups an experimental group (PD+FOG) and healthy control (HC). The subjects were randomized into four different trainings using a stratified process that took into consideration Hoehn and Yahr (H&Y) stage and age. The randomization was done by an additional person who did not directly participate in the study. The trainings include a tied belt training (TBT), a split-belt control (SBTCR), a split-belt at fifty percent (SBT50), a split-belt at seventy-five percent (SBT75). Only a single belt was adapted in split belts trainings, which was chosen based on the lower extremity with the longest step length. Some baseline outcome measures were completed at the pre-test (UPDRS Part III, MoCA, and Mini-BEstest test). During the Pre-, Post- and retention test gait kinematics were analyzed during a standardized adaption test. All the subjects underwent a Pre-, Post-, and retention standardized gait adaptation test. This test included walking on the split-belt treadmill for 90 seconds. The initial 30 seconds were at a comfortable baseline speed, then 30 seconds at 50% of their comfortable speed on one side, and finally the last 30 seconds participants were returned to their initial speed. During the standardized adaption test, both legs underwent the adjusted speed by completing the test twice, and the initial limb was kept the same each trial for a participant. However, there was a counterbalancing for the tested limb between participants, in an alternating fashion.
Setting
This study was administrated in a laboratory setting at Christian-Albrechts-University (CAU) in Kiel, Germany as well as Katholieke Universiteit (KU) in Leuven, Belgium.
Participants
There were 81 included participants in the study, all of which completed the protocol. Participants were recruited through a variety of sources including outpatient clinics, support groups, community groups, flyers, and databases. Two individuals were lost during a training session due to fatigue, and an additional third participant was lost before retention testing due to fatigue. Individuals were included in the experimental group of the study if they were diagnosed with idiopathic Parkinson's Disease and experienced freezing of gait. They

were excluded if they used an assistive device for walking times (minimum 5 minutes), had any other neurological conditions, scored less than or equal to a 24 on the Mini-Mental State Examination (MMSE) indicating cognitive impairment, or have any other medical conditions that could impair walking. There was also a group of age-matched health control participants, who would be excluded with any history of neurological disease. The experimental group (n=45) and healthy control groups (n=36) demographics were compared. The average age of the PD+FOG was 71 years (60-77 years) compared to HC of 69.5 years (66-74years). The majority of the PD+FOG cohort was male (n=33) compared to female (n=12), with the HC having more males (n=20) than females (n=16. Notably, between HC and PD + FOG at baseline, there was a statistical difference in Mini-BESTest and MoCA scores. For the PD+FOG group, the average age disease length of 13 years (7-15), with the majority of participants being H&Y scores of II (n=18) and III (n=20).

The participants were stratified by a blinded individual into the different trainings including SBT50 (n=11), SBT75 (n=12), SBTCR (n=12), and TBT (n=10). The study compared their age, outcome measures, and levodopa equivalent daily dosage of medication. They did not find any statical difference among the trainings.

Intervention Investigated

Control

There was a healthy control group that was randomly assigned to all four groups of training. These participants were age-matched to PD+FOG participants by a blinded individual to their different trainings. They all underwent the MoCA and Mini-BESTest before training, and a standardized gait adaptability test. The training consisted of 30 minutes of trainings in 5-minute blocks with 1 minute of rest. After the training, they underwent a post-test and repeated the standardized gait adaptability test. Then, 24 hours later they performed a retention test that included the same standardized gait adaptability test. When comfortable gait speed was calculated, it was done through an over-ground test using a 3-D gait analysis that assessed initial and terminal contact.

Their training sessions were individualized based on their assigned condition. If subjects were in a split-belt percentage group there was a reduction in speed for one belt based on their assignment, with the other continuing at a comfortable speed. The SB75 group had a reduction of 25% of comfortable speed on one belt, the SB50 group had a reduction of 50%, and the SBTCR groups speed alternating during the session from 25-50% reduction. The belt selected to be reduced was the extremity that demonstrated a longer step length in the overground testing. The TBT group trained with the belts at the same speed, matching their baseline overground velocity.

Experimental

The PD+FOG individuals all underwent the NFOG-Q Item 1, and MMSE to qualify for the study. In regards to medication, the PD+FOG participants were tested during medication "on" times, when their medication was at the greatest effect. During the pre-assessment participants completed the MDS-UPDRS-III, MoCA, and Mini-BESTest before training, and a standardized gait adaptability test. The training consisted of 30 minutes of trainings in 5-minute blocks with 1 minute of rest. After the training, they underwent a post-test and repeated the standardized gait adaptability test. Then, 24 hours later they performed a retention test that included the same standardized gait adaptability test. When comfortable gait speed was calculated, it was done through an over-ground test using a 3-D gait analysis that assessed initial and terminal contact.

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Outcome Measures

The study was not clear of the credentials of individuals performing the outcome measures, but all measures were administered in the laboratory setting. The New Freezing of Gait Questionnaire (NFOG-Q Item 1) is a single question that asks "Did you experience freezing in the last month" with a yes or no response. This was used as a qualifying tool for PD+FOG participants. If participants qualified, they completed the full questionnaire which consists of 28 points (with a higher number relating to more difficulty with freezing of gait). The Mini-Mental State Examination (MMSE) was used for qualifying PD+FOG participants for the study as well, and it was a requirement to score greater than or equal to a 24. The MMSE contains 11 questions, with a total possible score of 30, and is intended to assess cognitive impairment. The Movement Disorder Society Unified Parkinson's Disease Rating Scale III (MDS-UPDRS III) was administered to the experimental group and is the specific motor examination component of the test. The MDS-UPDRS III is scored out of 132 points with a higher score indicating more involvement of the disease. All the participants completed the Montreal Cognitive Assessment (MoCA) during the pre-test, which is a 16-question test with a total possible score of 30 which assesses different cognitive domains. Additionally, everyone completed the Mini-Balance Evaluation System

Test (Mini-BESTest) to evaluate components of balance and gait. The Mini-BESTest includes 14 items and researchers score out of 24 with a higher number indicating less impairment in balance and gait.

During the Pre-, post-, and retention testing individuals underwent a standardized adaption testing protocol, and gait kinematics were assessed. This was done using a 3D-motion capture system, with reflective markers located on the individual's lateral malleoli, heel, and the tip of both shoes. Step length symmetry and limb excursion asymmetry were calculated using the equation: (fast leg parameter – slow leg parameter)/(fast leg parameter + slow leg parameter). These kinematics were evaluated at specific time points (baseline, early split, late split, early tied, and late tied) for a standardized measure. Additionally, a visual analog scale to evaluate fatigue (VAS-F) was administered immediately before and post-training. This scale includes 16 questions with a scale from 0-10 for individuals to quantify fatigue levels.

Main Findings

The findings in this study were separated into their initial aims and analyzed based on specific goals. The first aim was to compare the spit belt training effect between HC and PD+FOG groups. The study found a HCs had a significantly greater improvement in mean step length asymmetry in all training protocols, but that PD+FOG still had a significant reduction in gait asymmetry when comparing pre-test to retention. They also found that the SBT had a significantly greater improvement than the TBT for both HC and PD+FOG participants. This significant change for SBT versus TBT was also seen in Pre-test to Post-test comparisons for all participants. Additionally, PD+FOG participants indicated a significantly higher level of fatigue but this was not correlated with step length asymmetry. The was a significant correlation between MDS-UPDRS III and VAS-F scores.

The next objective of the study was to compare the different split-belt training protocols in the experimental group. A significant finding occurred for training group x time interaction x mean step length asymmetry. The SBTCR which trained with variable ratios was the only condition to significantly reduce their mean step length asymmetry during gait adaption from Pre to Post-test. "The effect sizes of the changes from pre to post for the SBT groups versus the TBT groups were as follows: SBT 75% versus TBT: d=0.81; SBT50 versus TBT: d=0.63; and SBTCR versus TBT: d=1.14."[4]

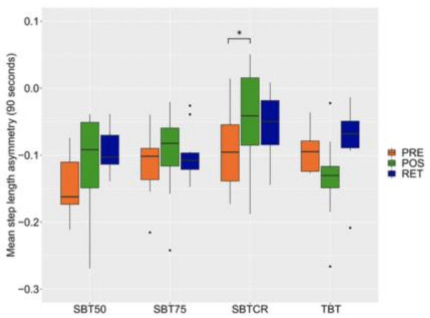

Figure 3. Mean step length asymmetry in people with Parkinson's disease and freezing of gait (PD + FOG) before, after, and 24 hours after an split-belt treadmill (SBT) training session. A value of zero indicates a perfect gait adaptation. Displayed is the median with the lower and upper hinges representing the first and third quartile. Data points outside the mentioned quartiles are displayed as outliers. *Significance level of $P < .05$.

The last aim of the study was to understand which outcomes were best at identifying gait adaptions. The study found that different parts of the adaption test found different significant results for mean step length asymmetry, and mean limb excursion asymmetry. For mean step length asymmetry, at the late split and early-tied, there was a significant difference (lower in HC) between the groups. During early split and late split, there was a significant difference between groups (lower in HC) for mean excursion asymmetry. Individuals in the PD+FOG group. They also compared mean step length to other outcome measures, and found a negative correlation at pre-test with MDS-UPDRS-III, but not with NFOG-Q or age.

Original Authors' Conclusions

Single belt treadmill training is more effective at reducing mean asymmetrical gait in individuals with PD than tied-belt treadmill training for short retention (24 hour time period). The effects of SBT are significantly beneficial in both HC and PD+FOG groups. The retention findings in individuals with PD+FOG support the use of clinical interventions using SBT. This training will allow for implicit training versus using the use of external commands to adapt gait for individuals with PD. Notably, the HC had a larger improvement in step length asymmetry immediately post-training, however, PD+FOG individuals had the best improvement from pre-testing to retention. The authors surmise this may be due to the effects of fatigue. For the specific protocol for SBT, the SBTCR was the training that had significant improvements for gait adaptation in the PD+FOG group. This training included variability versus the block training occurring in other trainings which can lead to better retention. To measure gait adaptability, "measuring gait asymmetry during gait adaption test could be used to quantify adaptation ability in PD"[4] (Page 961).

Critical Appraisal
Validity
This study is a Level 2 randomized control study but has low quality based on the PEDro scale (4/11). This reduction in points is due to lack of explanation for eligibility criteria, lack of concealed allocation, lack of blinding n subjects, therapists, and accessors, no intention to treat analysis, and no between-groups comparisons. A large strength of this study is that they have a healthy control comparison to assess the ability of individuals with Parkinson's Disease to adapt their gait. They also have a retention component to analyze the benefit of the intervention to get more information than the immediate follow-up. The study's population applies to the clinical scenario and includes older adults. With neurological involvement. The split-belt training is not comparable to resistive gait training, but due to the lack of evidence on resistance gait training, it is an important component to note that individuals with Parkinson's Disease can adapt their gait, especially average step length. To answer the clinical question, much more specific research will have to be completed. This study does have some weaknesses including their lack of detailed data presented in the results. They do discuss important results but don't provide additional data sets to analyze independently of their discussion. The authors also disclose that some individuals needed the use of handrails that could skew their results. The authors also discuss limitations around blinding, lack of controlling medication effects and the smaller sample sizes of each training. A weakness of the study is the missing credentials of the individuals performing the trainings and analysis. Additionally, the study also lacked transparency with the specific computer system alternating the SBT velocity ratios in the SBTCR training group. There was also some lack of clarity about when exactly some outcome measures were performed. It would have been beneficial to include the rationale behind them, and more detail behind how the overground comfortable walking speed test was administered when it was administered, and how often.
Interpretation of Results
The study provides strong evidence of the benefit of SBT training at variable ratios for creating beneficial gait adaptions for individuals with Parkinson's Disease. The lack of transparency with some data points and a table of collected statistical analysis would have provided a more substantial argument. The results are also hard to support when the information for who administered the outcome measures is not provided in the study. Due to the significant results, this study supports the ability for individuals with PD to alter their gait mechanics, which provides underlying support for interventions targeting this area. The results ultimately show that gait variability and step length can be altered, and those adaptions can be retained for at least twenty-four hours.
Applicability of Study Results
The overarching theme of the study results (the ability of individuals with PD to alter gait) is widely applicable in the clinic. However, specifically split-belt treadmills are not common equipment found in physical therapy clinics and the practice would be difficult to replicate with other equipment. The knowledge of the ability to adapt gait and the benefit of variability in training can be used to apply to a resistance gait intervention that applies to the clinical scenario and is feasible to perform in the clinic. However, these findings alone only support the ability for gait adaption, and more research will have to be performed to support resistive gait training for individuals with neurological conditions.

(2) Description and appraisal of Rhythmic auditory stimulation for reduction of falls in Parkinson's disease: a randomized controlled study **by** Michael H Thaut, Ruth Rice, Thenille Braun Janzen, Corene P Hurt-Thaut and Gerald McIntosh, 2019[8]

Aim/Objective of the Study/Systematic Review:
The objective of this study was to assess if by undergoing a home-based RAS training, individuals with Parkinson's Disease and a history of falls could reduce their number of falls.
Study Design
This was a randomized control study, with an intent-to-treat experimental design and a withdrawal control group. There was random allocation, allocation concealment, and blinding to the therapist training participants on their home RAS program. There were several outcome measures assessed in this study and they were measured at baseline, 8 weeks, 16 weeks, and 24 weeks of completing the RAS.
Setting
This study was performed in a university laboratory setting at Colorado State University and Poudre Valley Health System, Fort Collins, Colorado. Some components of the research were completed at the laboratory, and some at participants' homes.
Participants
The participants were recruited through a variety of methods including PD support groups, and neurological practices. All participants were diagnosed with idiopathic Parkinson's disease and the inclusion criteria included a H&Y stage of III or IV, two falls in the past year, stable medication, and ability to ambulate 50m. If individuals had an additional neurological or orthopedic condition, hearing loss, or dementia (defined by MMSE of less than 24) they were excluded from the study. During recruitment, a total of eighty-five people were screened, and sixty were enrolled in the study. The participants were randomized into a control (con) group (n=30) and experimental (exp) group (n=30) via a randomized computer program, with an external provider which ensured concealed allocation. Ultimately, the experimental group had twenty-five participants and the control group had 22 participants, none of the dropouts were related to adverse events from the study. The participants that completed the study (n=47) had no significant differences in baseline characteristics (age, sex, H&Y, number of falls, or disease duration). The average age in the experimental group was 71 years, and the control group was 73 years. The experimental group had more males (n=17), than females (13), which was slightly different than the control group having more females(n=16) compared to males (n=15). Both groups are comparable with H&Y Stage (Experimental=3.6, control= 3.4), number of falls in the past year (experimental=4.5, control = 4.2) and disease duration (experimental= 10.9, control= 11.2).
Intervention Investigated
Control
The control group underwent testing that included a 3-D motion system to capture gait kinematics and dorsiflexion range of motion, the TUG, and BBS by an experienced physical therapist. Additionally, they filled out subjective measures including the FES and subjective Falls Index from reports from participants and families. These measures were administered at baseline, week 8, week 16, and week 24 always two hours after medication intake. Subjects in the control group were received the experimental treatment for the first 8 weeks, were withdrawn for the second 8-weeks, and then continued treatment for the last 8 weeks. The control group was instructed by a therapist (who were blinded to allocation) on a home training program for RAS. They underwent self-driven daily training by walking for 30 minutes listening to music with metronome clicking embedded. The first 8-weeks subjects choose between 100%, 105%, and 110% of baseline cadence; second 8-weeks they were withdrawn from treatment and did not complete the RAS training program; and third 8-weeks subjects choose between 105%, 110%, and 115% with an option to request faster rates.
Experimental
The experimental group underwent testing that included a 3-D motion system to capture gait kinematics and dorsiflexion range of motion, the TUG, and BBS by an experienced physical therapist. Additionally, they filled out subjective measures including the FES and subjective Falls Index from reports from participants and families. These measures were administered at baseline, week 8, week 16, and week 24 always two hours after medication intake. Subjects underwent a twenty-four-week RAS 6-step training protocol The experimental group was instructed by a therapist (who were blinded to allocation) on a home training program for RAS. They underwent self-driven daily training by walking for 30 minutes listening to music with

metronome clicking embedded. The first 8-weeks subjects choose between 100%, 105%, and 110% of baseline cadence; the second 8-weeks subjects choose between 105%, 110%, and 115%; and the last 8-weeks subjects choose between 110%, 115%, and 120% of their baseline cadence.

Outcome Measures

The Mini-Mental State Exam (MMSE) was used to meet qualifying criteria, is a measure that quantifies cognitive impairment with a score out of 30. For individuals to qualify they have to receive a score of 24 or greater. Two other outcome measures were administered by experienced physical therapists including the Berg Balance Scale (BBS) and the Timed Up and Go (TUG). The BBS is measured looking at balance and includes items with a maximum score of 56. A higher score on the BBS indicates a higher level of function. The TUG is a measure that assesses functional mobility and gait, it is performed by timing the number of seconds it takes for a participant to stand up from a chair, walk 10 feet, turn around, and sit back down. A faster time on the TUG is associated with better functional mobility. Additionally, subjective measures were collected including the Falls Efficacy Scale (FES) and a Fall Index. The FES is a 14-item questionnaire that assesses an individual's fear of falling. There is a maximum score of 100, with a higher score indicating less fear of falling. The Fall Index was a self-reported measure that qualitatively described the severity of a fall, and quantified it on the scale. The article is unclear about the range due to providing an explanation up to 3 but presenting data much higher than that. Overall, the higher a Fall Index score, the higher incidence of falls.

The assessment sessions also included using 3-D motion capture to obtain different kinematic and gait variables. Sensors in the participant's shoes and markers were placed on the ankle, heel, and toe were all used to capture the outcomes. Velocity, stride length, cadence, and ankle dorsiflexion angles were assessed.

Main Findings

The total participants that completed the study (n=47) were divided into an exp group (n=25) and con group (n=22). There were no significant differences between groups at baseline or at week 8 (when both have been undergoing the RAS protocol).

Table 2. Group scores across all tested time periods.

		Cadence (steps/min)	Velocity (m/min)	Stride length (m)	Dorsiflexion left ankle (angle)	Dorsiflexion right ankle (angle)	Fear of Falling	Fall Index	TUG (s)	BBS
Week 16	Exp Group	113 (5.4)	**62 (15.4)****	**6.3 (2.2)***	**6.9 (2.4)***	**68.7 (7.7)****	**4.0 (4.6)****	11.6 (3.6)	50.5 (2.4)	
	Con Group	107 (9.0)	55 (9.8)	4.7 (2.8)	4.6 (2.7)	54 (6.8)	10.3 (5.9)	10.9 (2.7)	49.9 (4.3)	
Week 24	Exp Group	**113 (4.2)***	**65 (13.2)****	**7.4 (2.0)***	**7.3 (2.3)***	**79.3 (7.4)***	3.1 (2.6)	12.1 (5.5)	51.8 (2.3)	
	Con Group	111 (8.8)	60 (9.5)	5.3 (3.1)	5.8 (3.2)	69.8 (11.9)	5.1 (4.4)	12 (5.8)	51.7 (3.8)	

Note: *P<0.05, **P<0.005

The main results occur in the week 16 and week 24 analysis, due to both groups completing the intervention during the first eight weeks. During week 16 there are significant differences between groups with stride length, dorsiflexion angle, fear of falling, and fall index. After the control group continues the intervention for the last three weeks there was the same significant difference between groups, in addition to a difference in velocity. The study analyzed the progress over time and found the first eight weeks is when the most significant improvements happened during the first eight weeks of training

Table 3. Pearson's Correlation coefficient values between all outcome measures at week 16

	Fall Index	Cadence	Velocity	Stride Length	Fear of Falling	Dorsiflexion	TUG	BBS
Fall Index								
Cadence	0.28							
Velocity	0.39	0.29						

Stride Length	0.32	0.35	0.71**					
Fear of Falling	0.30	0.26	0.78**	0.58**				
Dorsiflexion	0.64** (P=0.01)	0.25	0.50* (P=0.02)	0.51* (P=0.02)	0.55* (P=0.0358)			
TUG	0.15	0.19	0.49*	0.62**	0.40	0.52* (P=0.019)		
BBS	0.55*	0.27	0.68**	0.75**	0.62**	0.55* (P=0.012)	0.86**	

Note: *P<0.05, **P<0.005

These comparisons were made at week 16, so their associations can be contributed to the controls group's withdrawal of treatment. Reduction in dorsiflexion was correlated strongly withal the other variables, except cadence. Additionally, the BBS was highly correlated with all other measures except cadence.

Original Authors' Conclusions

The author concluded that a home-based RAS training protocol can "significantly reduce the number of fall incidents, reduce fear of falling, and modified key kinematics in gait control in Parkinson's disease patients with a history of frequent falls."[8](Page 33) The significant changes between groups after the withdrawal of RAS protocol at home, highlighted the effects the program had on the outcomes. There was also a significant relationship between velocity and stride length. For falls incidence, the Fall Index score increased during the withdrawal for the control and then decreased again once the intervention was reimplemented. The authors provide a potential explanation of the improved dorsiflexion and decreased fall risk as an attribution of neural anticipatory control that is improved with rhythmic cueing.

Critical Appraisal

Validity

This study is a level 2 study and is highly valid receiving a 10/11 on the PEDro scale. The study included random allocation, concealed allocation, baseline comparability, blinded therapist, blinded assessors, follow-up, intention-to-treat analysis, between-group comparisons, and point estimates of variability. The study did not include blinded subjects due to the nature of the intervention. The study has a very strong design with many strengths including the withdrawal control structure that allowed for a very direct comparison of the RAS intervention. They had a large sample size, with a long time for interventional training. The authors highlighted some weaknesses in the study including lack of long-term effect analysis, and the incorporation of subjective measures that could be biased. To be stronger, this study would improve by describing the instructions given to the control group during their withdrawal period. The study did not mention if the subjects were asked not to ambulate or how their activity was modified. Additionally, to reduce the influence on the change in habits, the researchers could have instructed control participants to continue ambulating 30 minutes a day, but without any auditory stimulation. This would have helped control for the effects change in activity may have had on the results. Additionally, in their results, it would have been beneficial to include effect size and their specific statistical results (i.e. P-values) in the chart. Some were given in the text of the article, but it was difficult to compare not in the table. The study would have also benefited from a retention assessment, that would have been performed after both groups stopped the home-based RAS training to see how the effects lasted.

Interpretation of Results

The author's main conclusion from the results of the study is the risk of falls, but due to my clinical scenario, the change in stride length was an important component. At week 16 and week 24 there was a significant difference (P<0.005) between the experimental and control groups for individuals stride length. The experimental group's stride length steadily increased throughout the 24-week intervention, while the control groups dropped during the withdrawal period. After the first 8 weeks, the increase in stride length (in the experimental group) was not significant, but it was still progressively increasing. The change insignificance is most likely due to a slight ceiling effect or a result of blocked practice each week. This is important because it shows that RAS interventions can have a strong impact on improving step length and other gait kinematics with individuals who have Parkinson's Disease. The continued improvement over a long period also provides evidence for intervention during a rehabilitation course of treatment. The results also show that individuals with Parkinson's Disease are capable of adapting their gait kinematics to a stimulus.

Applicability of Study Results
The results are very applicable to the clinical scenario and question. The study's protocol is relatively feasible to perform in the clinic, but there may be issues with access to resources for a home-based prescription. Additionally, the frequency of the study is too high to be performed in the clinic alone for outpatient settings. However, the quality of the evidence is very strong and demonstrates the significant impact a high-frequency RAS intervention can have on an individual with Parkinson's disease's step length.

SYNTHESIS AND CLINICAL IMPLICATIONS

Overall, both studies provide foundational evidence for the ability of individuals with Parkinson's Disease to increase their step length. There is strong evidence for the use of RAS, but the evidence for resistance gait training is lacking, but no contraindications were found in the literature.

There was very limited evidence available on resisted gait training in the population that related to the clinical scenario. The first study, Seuthe et al. supported that implicit cueing can improve an individual's step length, and retain that improvement for twenty-four hours. The study has a weaker validity and is lacking in some transparency for protocol. However, from their data important components of a future study can be extrapolated. The variable training was significantly better than the other split belt sessions. This can be incorporated into a future study on resistance gait training to compare the effects of constant resistance to a variable resistance.

In the second article, Thaut et al. provided significant evidence for the use of a RAS home-based protocol to improve gait kinematics and reduce the risk of falls for individuals with Parkinson's Disease. The study's design was high quality with a PEDro score of 10/11. The main weakness was in the lack of retention analysis once the intervention was removed. The course of the intervention (24 weeks) and the withdrawal control group demonstrated a direct significant effect on multiple outcomes, including step length. Their protocol frequency is not as feasible for an outpatient setting and requires the technical skills or purchase of music with an incorporated metronome. Overall, the study provides strong support for the use of a RAS protocol for individuals with Parkinson's Disease with a history of falls.

Based on the two studies, I am not able to conclude the benefit of resistance gait training compared to a rhythmic auditory stimulation protocol. There are no contraindications for a resistive gait protocol, and the potential mechanics and indirect support are present. However, the current literature is not present to find any direct conclusions on the benefit or lack thereof to resistance gait training for increasing step length. The evidence still strongly supports the use of RAS interventions for individuals with Parkinson's disease, and future research should be completed to analyze the potential benefits of resistance gait training for individuals with Parkinson's Disease.

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