WHITE**PAPER**

Rehabilitation of Neurologically Affected Gait with Music Enhanced Treadmill

BIODEX

Rehabilitation of Neurologically Affected Gait with Music Enhanced Treadmill

A research summary by Hope Young, MT-BC | The Center for Music Therapy, Inc.

Gait disorders, particularly freezing of gait, are among the most disabling features of Parkinson's disease.[1] Freezing of gait (FOG) tends to correlate with bradykinesia, rigidity, and cognitive impairment, symptoms attributed to formation of cortical Lewy bodies – proteins that form in dopamine-producing regions that control voluntary movement – e.g., basal ganglia. Those tissues begin to die shortly after Lewy bodies appear, explaining the movement-related symptoms of Parkinson's disease.

Exogenous provision of dopamine can be beneficial in improving the speed and degree of muscle response. However, after years of receiving dopamine treatments, its efficacy may decline. Dosage may need to be increased or new medicines introduced. A study comparing the reaction time of people with Parkinson's disease showed patients were unaffected whether they were on or off prescribed dopamine therapy, suggesting that the integrity of the basal ganglia is necessary for response.[2]

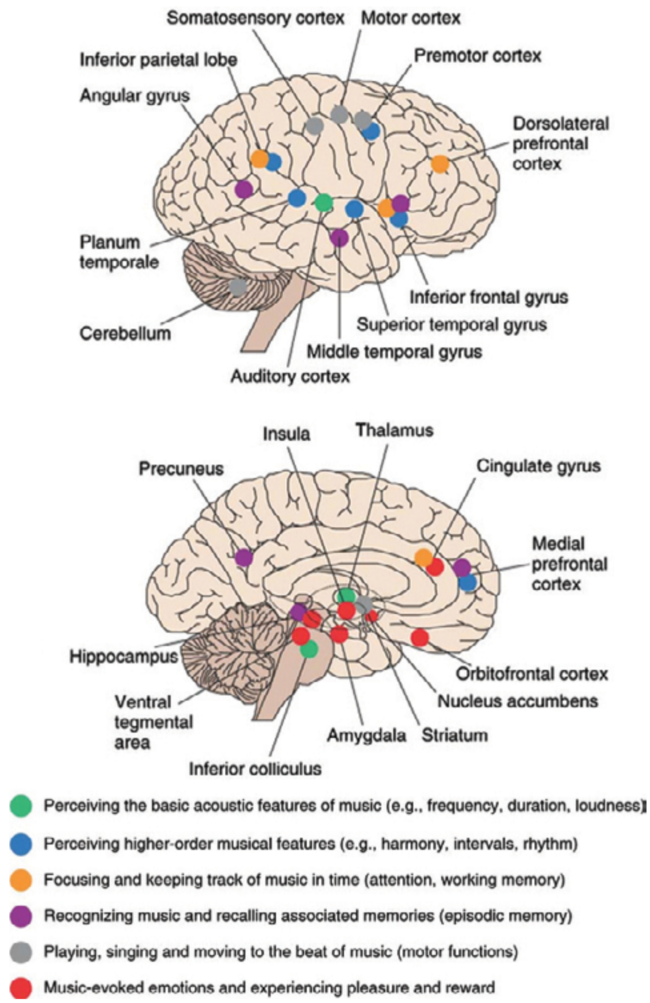
Collectively, movement-related Parkinson's disease symptoms lead to more frequent falls, a major cause of death among patients with this disorder. Conventional therapeutic interventions for Parkinson's disease, such as pharmacotherapy and deep-brain stimulation can be effective in managing gait abnormalities. However, neurological music therapy interventions such as rhythmic auditory cueing (RAC) and music enhanced motor augmentation techniques have shown effectiveness as adjuncts to pharmacological and surgical treatments.

Beyond Parkinson's disease

Parkinson's disease is only one of several neurological conditions that impair patient gait. Stroke, traumatic brain injury, multiple sclerosis, and cerebral palsy can present as similar gait-rehab challenges.

Rhythmic auditory cueing

For many years, investigators and clinicians worldwide have observed that individuals with Parkinson's disease display improved gait when provided audio pacing with a metronome. A subset of studies by specialists trained in music therapy has demonstrated that introducing rhythmic auditory cueing (RAC) with music that has a strong rhythmic beat may even be more effective than a metronome in enhancing gait in patients with Parkinson's disease.



Schematic illustration of key brain areas associated with music processing, based on neuroimaging studies of healthy subjects. Note: Although the image displays parts of the right hemisphere of the brain, many musical subfunctions are actually largely bilateral (with the exception of pitch and melody processing, which is more lateralized to the right hemisphere). Ref: O'Kelly, Julian Winn. Music Therapy and Neuroscience: Opportunities and Challenges. Voices: A World Forum for Music Therapy, [S.l.], v. 16, n. 2, Apr. 2016. ISSN 1504-1611

However, Dalla Bella and associates,[3] Ashoori and colleagues,[4] and others have demonstrated that RAC that adapts to patients' movements may be more effective than the rigid, fixed-tempo RAC used in most studies. Improved gait results not from direct therapy on dopamine-deficient brain regions, but instead from brain neuroplasticity – repurposing of tissue not ordinarily responsible for movement, but conditioned to act as such via music-enhanced therapy.

Music enhanced motor augmentation

While RAC is the most widely researched neurological music therapy application, new studies are emerging that show non-rhythmic elements in music can be applied to improve not only temporal gait measures such as stride length and gait velocity, but functional movements such as arm swing, hip flexion, and postural alignment.

With this technique, the therapist structures the music with consideration to duration, pitch, dynamics, and harmony to elicit specific movements that improve the overall quality of a patient's gait. Because music therapists using this type of treatment require the ability to incorporate and adjust the music to each patient, they will often play an instrument themselves, which can limit their ability to incorporate all the necessary musical patterns that would facilitate desired movement.

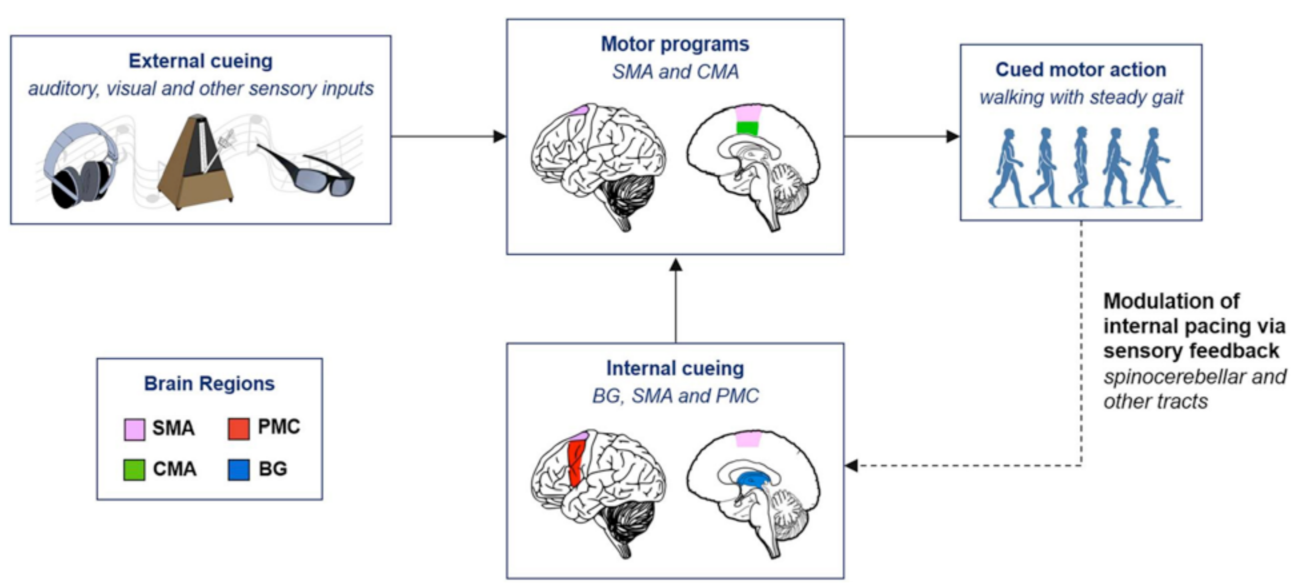
Music-enhanced Gait Trainer

For more than a decade, clinicians worldwide have used the Biodex Gait Trainer, with its instrumented treadmill track, to help patients with a range of neurologic, orthopedic, and cardiologic conditions to recover disease- and disorder-compromised gait.

Recently, in collaboration with experienced physical and music therapists, Biodex developed and added sensorimotor music enhancements to its instrumented-track Gait Trainer treadmill. Consistent with the finding of Dalla Bella and others, the Biodex Gait Trainer incorporates melodies written and scored by music therapists who are experts in a range of neurologic disorders. These music therapy-informed compositions not only incorporate the adaptable rhythmic timing necessary for RAC therapy, they are structured with specific musical patterns that help augment functional gait movements. The instrumented track of the Gait Trainer records and analyzes step length, step speed, and step symmetry. Pretest data, compared to normative data and posttest results, document the efficacy of Biodex gait therapy essential for proving therapeutic benefit to referring physicians, payers, patients, and peer reviewers of research studies.

Humans display a natural rhythm range

The strong connections between gait, innate internal timing, and rhythmic perception are demonstrated



Neurological schema of cued gait training. BG, basal ganglia; CMA, cingulate motor area; PMC, premotor cortex; SMA, supplementary motor area. Front Neurol. 2015; 6: 234.

by humans' rhythmic preference in music. Although humans' perceptible temporal range is 40-300 bpm, the preferred musical tempo is at 120-130 bpm. This preferred tempo is at the middle of the range of the average gait cadence of males (103-150 strides per minute) and females (100-149 strides per minute) across different age groups.[5]

The temporal sensitivity of the auditory system, in combination with the strong temporal characteristics of music (rhythm), can potentially provide a normalizing temporal input to the body's motor system. Most music therapists treating neurologic conditions attempt to encourage patient movement with music offering a strong beat.[i] The theory is, although initially an auditory stimulus, the beat can also induce an internally generated sense of rhythm – and once the pattern has been established, that beat can continue in the mind of the listener even when the rhythm pauses.[6] The process of synchronizing endogenous sensations of beat with an external rhythm of movement is termed *entrainment*.

Accordingly, humans' natural musical rhythmic preferences may be influenced by their natural spontaneous gait rhythm. This powerful connection between rhythm and locomotion has led rhythmic entrainment to be clinically employed for gait rehabilitation in patients with neurological disorders including stroke, traumatic brain injury, cerebral palsy, and Parkinson's disease.

Music enhances gait of patients with Parkinson's disease

Cerebello-thalamo-cortical (CTC) dysfunction explains many of the symptoms of Parkinson's disease, from tremors to disturbed gait.

For more than 40 years, researchers have shown how rhythmic auditory cue-based training can produce a compensation of the CTC network, leading to development of muscle synchrony with auditory stimuli – and thus, improved gait speed, step length, and perceptual and motor timing abilities.[7] Those beneficial effects persist even after training ends[8] – even for such challenges as having to turn while walking.[9]

This persistence suggests that regular rhythmic pulse stimulates putamen activity, facilitating movement, providing input for sequential movements and entrainment processes impaired by lack of dopaminergic stimulation. Through synchronization and adjustment of muscles to auditory stimuli, regular rhythmic pulse facilitates movement synchronization, coordination and regularization, and may even produce an internal rhythm that persists in the absence of stimuli.

"The process of synchronizing endogenous sensations of beat with an external rhythm of movement is termed *entrainment*."

Neuroimaging studies show that rhythm perception activates structures within key motor networks, such as premotor and supplementary motor areas, basal ganglia and the cerebellum – many of which are compromised to varying degrees in Parkinson's. Thus, it seems likely that automatic engagement of motor areas during rhythm perception may be the connecting link between music and motor improvements in Parkinson's.[10]

It is important to stress that the music used in Parkinson's rehabilitation must be specifically selected or composed for this function. Failure to do so can actually retard, rather than enhance, gait performance.

Early studies in Parkinson's disease[ii]

One of the pioneering groups illustrating the potential of music-augmented gait therapy was the Center for Research in Neurorehabilitation at Colorado State University and Poudre Valley Hospital, Fort Collins, Colorado. In their landmark study,[15] participants were volunteers randomly selected from local Parkinson's support groups and primary care physicians. All subjects had a primary diagnosis of idiopathic Parkinson's disease. All had significant gait deficits regarding velocity, stride length, and cadence but were able to walk without physical assistance. The subject pool was randomly divided into three groups:

1. An experimental group (EX), ten men and five women
2. A control self (internally)-paced group (SPT), eight men and three women
3. A control no-training group (NT), eight men and three women

i. A series of regular, recurring acoustical events that encourage in the patient a strong temporal expectation of subsequent beats.

ii. This paper selects early studies on Parkinson's disease to illustrate the extensive history of research supporting the effects of RAC therapy. More recent studies explore forced exercise as a potential non-pharmacological alternative to increasing plasticity and improving motor function in patients with Parkinson's.[11,12,13,14]

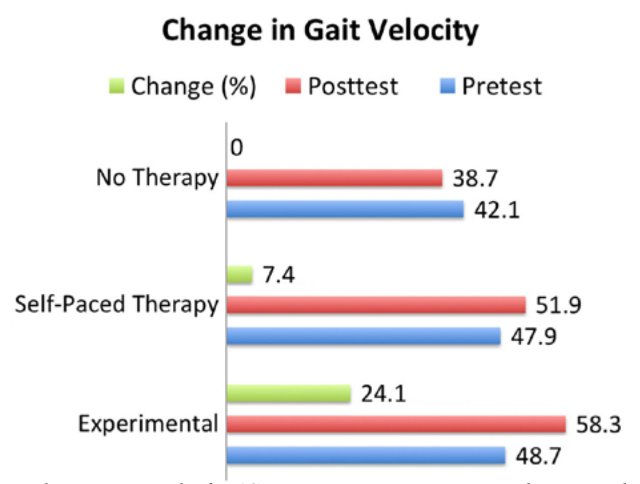
All patients were on a stable medication regimen (carbidopa/levodopa or selegiline/carbidopa and levodopa) during the study.

RAC/RAS program[iii]**:** The RAS program consisted of walking on a flat surface, stair stepping, and stop-and-go exercises to rhythmically accentuated music at three different tempos. Subjects walked at each tempo for one-third of the exercise time. Subjects could select from four short instrumental music pieces in four different styles familiar to the elderly age group in this study (folk, classical, jazz, country). Each selection was composed in 2/4 or 4/4 meter, and 32 measures in length. Rhythmic on-beats were enhanced by overlaying the click-function of the sequencer over the musical beat structure.

The investigators chose rhythmic stimuli embedded in a musical structure based on findings that rhythmic patterns within a musical context reduced response variability and synchronization offset more effectively than did single-pulse pattern in the frequency range of 1 to 2 Hz (60 to 120 steps/min).[16] Each selection was programmed on an eight-channel sequencer/synthesizer module in digital audio signal form. Digital audio recording allowed use of the sequencer to change the tempo of the music without losing pitch control. The tempos were labeled "normal," "quick," and "fast."

"The investigators chose rhythmic stimuli embedded in a musical structure based on findings that rhythmic patterns within a musical context reduced response variability and synchronization offset more effectively than did single-pulse pattern…"

- For the first week of EX group training, the normal tempo was the pretest cadence; the quick tempo was 5 to 10% faster, and the fast tempo an additional 5 to 10% faster. After each week, each tempo increased by 5 to l0%, so the quick tempo became normal, etc. The rate of increase was based on the subject's ability to match the tempos and the requirement to keep the fastest tempo from exceeding 130 steps/min. The subjects used portable tape players with lightweight headsets. Each musical selection was recorded for 30 minutes on tapes in the laboratory. The subjects exercised on their own, or with spousal assistance at home or in the community.

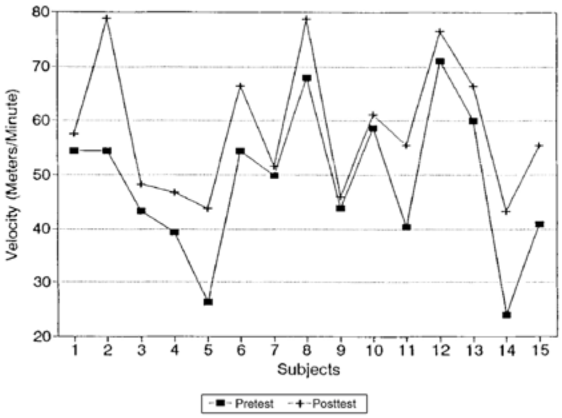


The major goal of RAS training was to increase the normal gait velocity of patients with Parkinson's disease for flat surface and incline walking. Subjects who participated in the RAS training improved on average 25% in both of these tasks. The improvement was facilitated by nearly equal percentage increases in cadence and stride length.

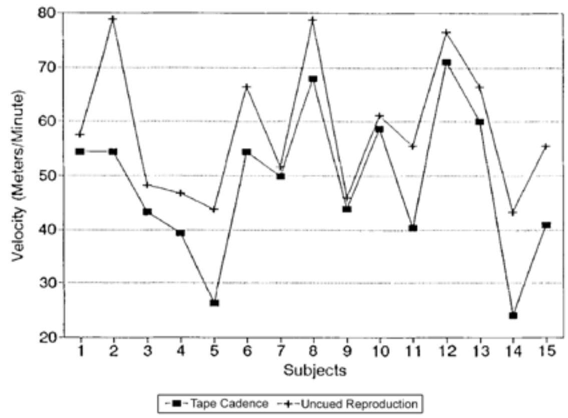
- The SPT group performed their walking sessions without RAS, following the same training protocol and training exercises for the same length of time. They were instructed to divide their exercise time into three equal periods, during which they would walk first at normal speed, then increase their speed for the next period, and increase it again for the last period. Compliance was 100% for both groups.

Gait was studied through measurement of footfall patterns and EMG recordings of the medial gastrocnemius (GA), tibialis anterior (TA), and vastus lateralis (VL) muscles on both sides, averaged across five strides. Data were recorded from subjects walking at their normal speed along a 6-m walkway with 2 m on each side for acceleration and deceleration. Two trials were run; the first was a flat surface walk followed by a walk over an incline-step obstacle. The incline-step obstacle was 3 m long with a 1-m incline rising 20 cm, a 1-m platform, and a 10-cm step down; another 1-m platform, and a final 10-cm step down.

iii. Rhythmic auditory stimulation (RAS) is the term coined by Michael H. Thaut and colleagues in their development of the rhythmic cueing technique used in neurological music therapy. For our purposes and in research, it is used interchangably with RAC.



Graph of gait velocity pretest (squares) and posttest (plus signs) for the 15 experimental subjects.



Graph of maximal training tape cadence (squares) and uncued cadence reproduction (plus signs) for the 15 experimental subjects.

Results: All experimental subjects increased their individual gait velocity during posttest. The mean increase for the EX group was 24.1% ($t = 3.84$; $p = 0.007$) in the flat walk (48.7 m/min to 58.3 m/min) and 26.1% ($t = 3.27$; $p = 0.009$) over the incline-step obstacle (40.8 to 49.4 m/min).

- The velocity of the NT group actually decreased slightly from pretest to posttest (42.1 to 38.7 m/min), which suggests that familiarity with the laboratory environment was not a factor in the experimental group's improvement.
- The SPT group did show an improvement in velocity of 7.4% (47.9 to 51.9 m/min), which is less than one-third that of the experimental group gain.
- The EX group's increase in velocity was nearly equally achieved through an increase in cadence and stride length, 10.4% ($t = 2.9$; $p = 0.01$) and 12.0% ($t = 3.63$; $p = 0.009$) respectively, whereas the SPT group's increase was achieved solely through increases in stride length of 7.9%.

To test for possible entrainment mechanisms between RAS-beat frequency and step frequency, subjects in the EX group were asked – after completion of the posttest – to reproduce the cadence of their fastest training tape from memory without RAS present. On average, the fastest training cadence was 18.2% faster than their normal training cadence of 5.0% (22.9%), with the group average cadence only 1.8% (+-5.6%) slower than the training tempo.

The objective gains in gait performance were quite noticeable to the study subjects, who reported a 100% strong agreement on an exit questionnaire that RAS training had made their walking patterns more stable, had improved their speed, and had helped their walking in activities of daily life.

Conclusion: Subjects who participated in the music-enhanced RAS training improved on average 25% in both of these tasks. The improvement was facilitated by nearly equal percentage increases in cadence and stride length. The control group that participated in self-paced training also improved their gait velocity, but by less than one-third of the improvement seen in the RAS group.

Part of the mechanism involved with this tempo shift may have been a rhythmic entrainment effect, evidenced by the subject's ability to reproduce the tempo of the musical rhythm without cueing. Although motivational factors through the music cannot be excluded as a reason for enhanced gait performance, their effects were minimized by the fact that each subject had to train with the same musical selection for three weeks.

The subjects' ability to reproduce the fastest training cadence without cueing 24 hours after the last training session indicates the possible effect of rhythmic entrainment mechanisms. Auditory rhythm may have acted as an external timekeeper to which the step cadence became synchronized during the training phase, thus helping to stabilize internal time keeping and rhythm formation processes in the patients.[10,11]

Several patients reported pacing themselves by singing the music silently.

In summary, RAS training improved gait velocity, cadence, and stride length significantly after only three weeks. In addition, some features of EMG gait-cycle profiles changed toward more normal muscle-activation patterns. The data suggest a viable role for RAS music therapy as a sensorimotor-based technique for gait facilitation in patients with Parkinson's disease.

A 2014 study by clinicians in Poland, Germany, and France confirmed the Colorado findings that musically cued gait training significantly improves gait, motor timing, and perceptual timing in patients with Parkinson's disease.

In this study, therapy consisted of three 30-min training sessions per week for one month. During each session, the participants walked to the salient beats of German folk music without explicit instructions to synchronize their footsteps to the beat. All maintained their dopamine therapy regimen during the trials.

- Prior to training, 73% of the patients displayed timing deficit that decreased to 67% immediately post-training.
- But one month later, only 40% displayed deficits in motor and perceptual timing tests.

Thus, in addition to gait enhancement, this study demonstrates RAS can improve perceptual timing with continued therapeutic effect, even in the absence of auditory cueing.

Rhythmic auditory cueing in stroke rehab

Arguably, Yoo and Kim published the most current and exhaustive analysis of the use of rhythmic auditory cueing in the motor rehabilitation of stroke patients in a 2016 issue of the Journal of Music Therapy.[17]

Between October and December 2014, the authors searched electronic databases for all relevant English-written articles on RAC and stroke patients published between 1990 and 2014. Databases searched include CINAHL, Cochrane Central Register of Controlled Trials, EMBASE, MEDLINE, and PubMed. That search yielded 1,535 articles, from which 27 were identified for study after initial database and hand searches. After duplicates and irrelevant studies were excluded, 11 studies with a total of 356 participants were selected as meeting the inclusion criteria. Eight studies examined the effects of rhythmic auditory cueing for gait training, and three studies investigated the upper-extremity functions of stroke patients after intervention using rhythmic auditory cueing.[iv]

CT Scan of Acute Subdural Hematoma. Photo courtesy of #FOAMed Medical Education Resources by LITFL. https://lifeinthefastlane.com.

This study aimed to systematically review the literature to identify the effects of rhythmic auditory cueing on motor rehabilitation of stroke patients in terms of motor outcomes (gait and upper-extremity function), type of cueing, and stage of stroke answering the following research questions:

- Does rhythmic auditory cueing improve gait following stroke?
- Does the outcome of intervention differ depending on the provided type of rhythmic auditory cueing?
- Does the outcome of intervention differ depending on the stage of stroke?

Type of participants: Criteria for participants included a clinical diagnosis of stroke, with no limitation with

iv. This white paper references only RAC gait therapy. Review the complete Yoo and Kim article for upper-extremity studies analyzed.

regard to site of lesion. Individuals with comorbidity, such as other neurological or degenerative disorders, were excluded. No demographic characteristics, including age, sex, or ethnicity, were limited.

Type of intervention: Articles were included if the intervention utilized intentional synchronization of target movement to externally generated rhythmic auditory cueing as the primary intervening stimulus. Studies using traditional treatment, combined with rhythmic auditory cueing, were also included if the process of synchronization was reported. Studies using the rhythmic aspects of music but not implementing the entrainment were excluded. Trials using a one-group pretest-posttest design without a control group were also excluded from the analysis.

Type of comparison: Studies on the use of rhythmic auditory cueing compared to traditional rehabilitative interventions or compared to other controlled interventions using different cueing (e.g., visual cueing) or using different rehabilitative strategies (e.g., neurodevelopmental therapy) were included in the synthesis.

Type of outcome measures: To analyze the effects of rhythmic auditory cueing across studies, common outcome measures reported in the literature with regard to gait function were selected, including spatiotemporal parameters (e.g., cadence, velocity, and stride length during gait), kinematic parameters (e.g., range of motion in relevant joints), and functional ability test scores (e.g., Timed Up and Go, Fugl-Meyer Assessment, and Wolf Motor Function Test). These outcome measures had to be statistically analyzed in the original research.

Type of studies: Research that included systematic methods for comparing the RAC group with a no-intervention group, a conventional-care group, or an alternate-intervention group was eligible for this review. Randomized controlled trials and controlled clinical trials were considered for possible inclusion.

As a result, a total of eight studies with 242 participants were included for analyses to determine the effects of rhythmic auditory cueing on gait training.[18,19,20,21,22,23,24,25,26]

Overall effect of rhythmic auditory cueing on spatiotemporal gait parameters: The weighted mean effect size for studies of gait training was calculated in terms of three gait spatiotemporal parameters with sufficient studies for meta-analysis: walking velocity, cadence, and stride length.

- For walking velocity, the mean difference in the posttest data between groups was 15.3 cm/s (95% CI = 11.5 to 19.1), and the weighted mean effect size for included studies reached a large size (Hedges's g = 0.984, 95% CI = 0.689 to 1.278, $p < .001$), indicating that stroke patients showed significantly greater walking velocity after intervention with rhythmic auditory cueing, compared to a control group who received only traditional rehabilitative interventions or other types of intervention.
- For cadence, the mean difference in the posttest data between groups was 16.1 steps/min (95% CI = 12.0 to 20.2), and for stride length, the mean group difference was 16.9 cm (95% CI = 12.7 to 19.4). The weighted mean effect size of rhythmic auditory cueing was also large in both parameters (Hedges's g = 0.840, 95% CI = 0.532 to 1.148, $p < .001$ for cadence and Hedges's g = 0.760, 95% CI = 0.470 to 1.051, $p < .001$ for stride length), indicating statistical improvement after intervention.

Conclusion: This rigorous analysis of carefully selected peer-reviewed studies supports the role of rhythm as a primary therapeutic agent capable of meaningfully improving gait therapy in a wide range of stroke patients.

Most important for clinicians seeking to implement RAC with their patients, analysis of the included studies concludes that the use of musically adapted rhythmic cueing (i.e., the combined use of prerecorded music and metronome) contributed to improvement in terms of walking speed more than the single use of a metronome, indicating that musical aspects may enhance rehabilitative outcomes.

Gait Training for patients with traumatic brain injury

Of the 1.7 million Americans who sustain a TBI each year, 52,000 die, 275,000 are hospitalized, and 1.365 million are treated and released from an emergency department. The Centers for Disease Control and Prevention estimates that at least 5.3 million Americans currently have a long-term or lifelong need for help to perform activities of daily living as a result of a TBI. TBI patients can present a wide range of disabilities, from physical to emotional and executive processing. Many suffer gait dysfunctions – the subject of this discussion.

While current gait training has shown successes in meeting the needs of patients with TBI, research investigating and supporting gait rehabilitation techniques that incorporate RAC has enhanced our understanding of how to improve gait deficits in TBI patients through the most effective and understood methods.

Success with stroke suggests potential in TBI: Several studies have clinically investigated whether auditory rhythm can facilitate gait performance in patients with neurological disorders.

Of special interest for this study were results of RAC music therapy with stroke patients, due to similarities to TBI gait hemiparesis. Gait of stroke patients, similar to gait in TBI patients, is frequently characterized by asymmetric stride periods of both lower limbs, and high variability in gait-related lower-limb muscle activation patterns, indicating deficient motor unit recruitment patterns.[27]

Application of RAC to TBI: As a result of the limitations of traditional gait therapy for TBI patients, the team of the Center for Biomedical Research in Music at Colorado State University applied rhythmic auditory cueing (RAC) as a therapeutic stimulus to facilitate gait patterns in eight traumatically brain-injured individuals (5 male/3 female; mean age 30 ± 5 years) with persisting gait disorder, 4-24 months post-injury.[28] The purpose of this study was to examine the use of RAC to cue gait patterns of patients with traumatic brain injury who were no longer making progress toward conventional physical therapy goals.

- All subjects were 4 to 24 months post-injury, had participated in conventional physical therapy for the duration of their illness, and were no longer showing observable improvement in gait performance.
- Participation in the study was based on physician referral, and all subjects had a significant gait deficit regarding velocity, cadence, stride length, and symmetry, compared to normal, age-matched data.
- All subjects were able to walk independently or with an assistive device (cane, walker) without physical assistance from the therapist.

All subjects in the study exhibited significant deficits in all gait parameters during the uncued trials, including decreased velocity (normal mean, 41.78 m/min; fast mean, 64.90 m/min) and cadence (normal mean, 86.69 steps/min; fast mean, 105.86 steps/min), shortened stride length (normal mean, 0.9421 m; fast mean, 1.1836 m), and decreased symmetry (normal mean ratio, 0.7906; fast mean ratio, 0.7888). According to Oberg, Karsznia and Oberg,[29] age-matched reference data for normal gait patterns for the subjects in this study would be approximately 76 m/min for normal velocity, and 102 m/min for fast velocity; 123 steps/min for normal cadence, and 148 steps/min for fast cadence; 1.2265 m for normal stride length, and 1.4125 m for fast stride length.

The two experiments pursued the following research questions:

- Are there immediate effects of RAC on gait patterns in normal and fast walks of subjects with a traumatic brain injury?
- Will RAC improve gait patterns over a five-week training period in subjects with traumatic brain injury?

Steps in presenting RAC gait therapy program to TBI patients

- The music therapist assessed the gait parameters of velocity, cadence, and stride length. Cadence was computed by counting heel strikes for 60 seconds. Velocity was calculated as the number of meters walked in 60 seconds, and stride length was solved by velocity/cadence x 2. This information also was available from the computerized foot switch recording of normal walk.
- Next, the therapist walked with the patient with RAC for 3 minutes at the patient's normal walk. Pulse and blood pressure were then taken as a precaution.
- The therapist then walked with the patient with RAC for 3 minutes at the patient's fast walk. Pulse and blood pressure were taken again.

- When the patient was able to endure 3 minutes of training at their normal walk, and 3 minutes at their fast walk, the therapist started their home program at 6 minutes of gait training.
- After each week of training, the patient's endurance was reassessed, increasing the initial training period for the normal and fast walks by 1 minute each.

> **"[R]esearch investigating and supporting gait rehabilitation techniques that incorporate RAC has enhanced our understanding of how to improve gait deficits in TBI patients..."**

All experiments took place in the gait laboratory of the Center for Biomedical Research in Music at Colorado State University. During the experimental session subjects walked four times along a 10-meter walkway. Data was recorded along the middle 6 meters which allowed 2 meters on each end of the walkway for the subjects to accelerate and decelerate their walking tempo. Stride timing was recorded using a commercially available stride analysis system.

- For the first walk, subjects were instructed to walk at their normal pace in order to compute an accurate calculation of their internal baseline stride pattern.
- During the second walk, the subjects were instructed to walk on the beat to rhythmic stimuli presented by a metronome pulse sequence imbedded into rhythmically accented music. The metronome marking of the music was set at the cadence (step frequency) of the first walk. When necessary, the therapist provided additional verbal (counting "1, 2" or "left foot, right foot") or tactile cueing (light hand touches on the patient's shoulder or forearm) to assist the subject in rhythmic entrainment. RAC was presented by the click metronome function of a sequencer/synthesizer module. The music, an original instrumental blues in 2/4 meter composed for this study, was programmed in the same module. The metronome was set to coincide with each on-beat (in quarter notes) of the music.
- For the third walk, the subject was instructed to walk as fast as they safely could, without RAC. Once again, the foot switches recorded velocity, cadence, stride length, and symmetry. In the fourth walk, RAC was added, using the metronome pulse sequence and the rhythmically accented music set at a tempo 5% faster than the fast walk without music.

Experiment 1: The analysis of variance was used to determine if there were significant differences between the normal and fast walk gait trials, cued and uncued trials, and if there was any significant interaction between the two conditions of walking tempo and cueing. Velocity, cadence, stride length, and symmetry data were computed for normal and fast, cued and uncued walks.

Although the RAC frequency was set to match the baseline step frequency of each subject, all parameters increased when RAC was present during the normal walking condition. Average velocity increased by 18% (41.78 to 45.66 m/min), due to an 8% increase for cadence (86.69 to 91.35 steps/min) and a 7% increase for stride length (0.9421 to 0.9760 m). A strong sign of responding to the temporal symmetry embedded in the metronome rhythm was evidenced by an 18% increase for swing symmetry (ratio of 0.7906 to 0.8744). Exact synchronization measures, that is, a complete match between step and RAC frequency, showed an average frequency deviation of 5.09 ± 2.05%, with seven subjects stepping ahead of the beat rhythm and one subject falling slightly behind.

During the fast walking condition, velocity decreased 6% (64.90 to 63.88 m/min) due to a slight decrease in stride length by 2% (1.1836 to 1.1561 m). Step cadence increased by 2.13 ± 1.74 steps/min over the non-cued fast walk. However, since the RAC frequency had been set at 5% over baseline, subjects actually walked about 3% slower than cued by RAC. Swing symmetry ratio increased 28% (0.7888 to 0.8373).

- Although the immediate changes from uncued to cued normal and fast walking were all statistically nonsignificant, 7 out of 8 subjects increased their velocity during the normal walk, and 6 out of 8 subjects increased their velocity during the fast walk.
- Seven out of 8 subjects increased their cadence in the normal walking condition, and 5 improved during the fast walk when RAC was present.

- Six out of 8 subjects increased their stride length during normal and fast walking when RAC was present. Five out of 8 subjects increased their symmetry during the normal and fast-cued walk.

Experiment 2: The purpose of the second experiment was to identify whether training with RAC for a five-week period would significantly improve gait performance. Results showed overall increases in all parameters during both the normal and fast walks, with statistically significant increases in velocity, cadence, and stride length ($p < 0.05$) during normal walking. Thus, isolated unilateral eccentric training in a controlled manner is needed in rehabilitation of hamstring strains – and so, lengthened-state eccentric training is performed at NISMAT using the Biodex System 4 Dynamometer with the use of accessories that simplify placing the patient into hip flexion.

- Velocity increased from 65.20 m/min to 82.24 m/min with an average increase across subjects of 33%.
- Cadence increased from 108.54 steps/min to 112.12 steps/min, with an average percentage increase of 2%. Stride length increased from 1.1546 m to 1.2845 m with a mean percentage increase of 18%.
- Symmetry increased from 0.7606 to 0.8602, with an average percentage increase of 13%.

Results of this experiment showed that RAC can strongly modify gait parameters of traumatically brain-injured patients in a long-term training application. The changes that were achieved through rhythmic pacing addressed important areas in gait training with traumatically brain-injured patients.

It is important to note that increases in stride length were seen in both immediate application and training with RAC. Since stride length is an important factor in increasing velocity, rhythmic pacing could be an important tool for clinicians working with TBI patients who need to increase their stride length and velocity to a more normal level. Stride length is a spatial parameter and is not directly cued by auditory temporal stimulus. It is, therefore, important to recognize that RAC addresses the total pattern of gait and not just selected temporal parameters. Enhanced timing through rhythmic synchronization may thus mediate motor performance on a more central control level.

Conclusion: RAC appears useful in TBI during entrainment, with RAC frequency matched to baseline cadence.

- Velocity and stride symmetry both increased by an average of 18%. Increases contributing to the velocity improvement were seen in both stride length (7%) and cadence (8%).
- With RAC accelerated 5% over the fast walking step rate of the patients, 5 patients could entrain to a higher step frequency. The 2 patients with the slowest baseline gait velocity could not entrain to faster RAC frequencies.
- After 5 weeks of daily RAC training, 5 patients significantly increased their mean velocity (p </=.05) by 51% (38.8 m/min to 57.6 m/min. Cadence (+16%) and stride length (+29%) also showed statistically significant improvement. Stride symmetry improved nonsignificantly by 12%.

"It is, therefore, important to recognize that RAC addresses the total pattern of gait and not just selected temporal parameters."

This study offers evidence of the benefit of RAC in the treatment of patients with traumatic brain injuries.

- The results of the first experiment provided evidence that TBI patients can synchronize their walking patterns to RAC, although exact entrainment ability seems somewhat deficient and highly variable across different patients – probably due to the diffuse and widespread focus of brain injuries that TBI patients experience.
- The second experiment offered evidence that over time, training with RAC can result in statistically significant increases in velocity, cadence, and stride length, even when the subject is no longer making progress in conventional physical therapy. The results are specifically interesting because these training effects were achieved with patients who were all past the initial phase of three months for spontaneous neurological recovery where most significant therapy benefits tend to occur.

The experimental design of this study compared patients with themselves, using the pretest as a stable indicator of the effects of previous therapy, rather than using control samples that are extremely difficult to match in a very heterogeneous TBI population. Thus, these results provide encouraging preliminary evidence for the music therapist that RAC can facilitate long-term gait training in TBI patients.

RAC gait therapy in children with spastic cerebral palsy[30]

Cerebral palsy is a collection of motor disorders resulting from brain damage before the age of two. According to the United Cerebral Palsy Association, 764,000 children and adults in the U.S. manifest one or more of the symptoms of cerebral palsy. According to the Centers for Disease Control and Prevention (CDC), about 10,000 babies born in the United States each year will develop cerebral palsy.

Those with cerebral palsy display impaired ambulation that involves gait and upper body coordination, as well as problems with balance. A normal gait requires at least 30 major muscles working at exactly the right times and with exactly the right force to take two steps. Common problems in gait for those with spastic cerebral palsy include ineffective gait patterns, such as short stride length, asymmetrical gait, slowness, impairment in coordination, and unnecessary body movement. Because of lack of muscle use, the degree of muscle atrophy progresses throughout a child's development. Physical therapy is often recommended for children with cerebral palsy to maintain and improve their physical functions.

Damage to the motor cortex in a person with cerebral palsy disturbs the normal process for the motor control system; in addition, the lower function motor control system could also be affected by brain damage. When the gait pattern of a person with cerebral palsy is not rhythmic, it is likely that the internal timekeeper is not working.

Treatments such as drug therapy, nerve injections, and orthopedic surgery are commonly used to treat spasticity to improve gait performance; yet, to date, there is no singular treatment that is most promising in reducing movement problems. Unpredictability of results plagues those who attempt to treat individuals with spastic cerebral palsy. The nature of cerebral palsy and the complexity of brain function disturbance make treatment outcomes difficult to predict. Drug therapy side effects and injections of botulinum toxin are effective only for six months or less. Sometimes, corrective surgery results in deformity of the antagonistic muscles.

Study purpose: Use rhythmic auditory cueing (RAC) for children with spastic cerebral palsy in a clinical setting in order to determine its efficacy in gait training for ambulation.

The research questions were:

- Does RAC enhance physical therapy for children with spastic cerebral palsy? Specifically, does it influence cadence, increase stride length, increase velocity, and improve gait symmetry?
- Is there a difference between the control, therapist-guided training group (TGT), and self-guided training group (SGT)?

Participants: Thirty participants aged 6-20 years with spastic cerebral palsy were enrolled from a South Korean school for children with physical disabilities. All had participated in physical therapy for gait training at school. All were ambulatory but needed to stabilize gait and gain more coordinated movement.

- A 10-subject control group received conventional gait training from a physical therapist while a music therapist observed.
- A 10-subject therapist-guided training group received conventional gait training, enhanced by RAC from both a physical therapist and a music therapist.

- A 10-subject self-guided training group received conventional gait training from a physical therapist, and RAC self-guided training observed by a music therapist.

Due to illnesses, inconsistent school attendance, and lack of a posttest, five participants did not complete the experiment. Therefore, results were studied based on nine participants, each in the control group and the therapist-guided group, and seven participants in the self-guided group.

> **"The nature of cerebral palsy and the complexity of brain function disturbance make treatment outcomes difficult to predict."**

Study details: The course for the pretest and posttest was a 14-meter walkway, with a 10-meter section marked for test measurement, with a 2-meter section allowance for acceleration and 2-meter section allowance for deceleration. Subjects used unrestricted school space – a playground, hallway, and a slope – for gait training.

- Source of the music for the test was a computer with a music software program capable of providing variable tempo changes of recorded music to accommodate the various cadences of each participant's gait. The music used was "Dixie Land," "When the Saints Go Marching In," and a blues-style selection – all with a steady 4/4-meter beat pattern, recorded using quarter notes equal to 100 bpm.
- Since a majority of children with cerebral palsy walk slower than typically developed children, the music was recorded slower than normal walking tempo (105 to 120 steps per minute). This slower tempo allowed for a possible variation of tempo range from 80 bpm to 120 bpm. A metronome was used to confirm the accuracy of the tempo and assist in synchronizing participants during the warm-up activity in therapist-guided and self-guided groups.
- Therapists used a djembe[v] drum to emphasize the fundamental beat in the prescribed music. When a participant's cadence fell below 65 steps per minute, to avoid excessively slow music, the cadence was multiplied by two as a tempo for the RAC music, and then the actual cadence was emphasized by drumming or clapping (e.g., a participant who walked 45 steps per minute had a music tempo of 90 beats per minute, and the drumming or clapping was maintained at 45 beats per minute).
- A stride analyzer recorded foot-floor contact data by means of four pressure-sensitive switches placed under the heel, at the heads of the first and fifth metatarsals, and at the big toe. The analyzer calculates and compares gait parameters: cadence, stride length, velocity, gait cycle, gait symmetry, and foot contact pattern.

Procedure: Participants were asked to walk at their most comfortable tempo. Based on the pretest, observation, and conference with the physical therapist, the tempo of the music was increased 5% above each participant's current walking tempo for the first week of training. The tempo was increased if a subject's balance and gait pattern tended to be better when taking faster steps, just as riding a bicycle is usually easier at a faster speed. The tempo of the music was increased by 10% from the baseline for the second week, and 15% for the third week.

For the therapist-guided group, music was played through the computer's sound system. For the self-guided group, music was recorded on three cassette tapes distributed to the participants. When a participant had a problem with gait posture such as toe walking due to muscle contracture, and/or spinal deformities, the tempo of the music was either decreased or maintained for the first week. Depending on their progress, tempo changes of the prescribed music were made every week.

Difference between the therapist-guided training group (TGT) and the self-guided training (SGT) group**:** Both experimental groups used RAC technique for gait training, but the delivery of RAC technique was different; while the music therapist is actively involved with participants with verbal instructions and reinforcement, the music therapist was presented to SGT as an observer.

Therapist-guided sessions for each participant lasted for 30 minutes, five days a week for three weeks. During the entire session, prescribed music for the participant was played to increase the effect of entrainment.

v. A djembe is a rope-tuned, skin-covered goblet drum played with bare hands.

At the first session of the self-guided training group, participants were given a tape and instructions, and encouraged to use them for three weeks of training. For the control group, therapists administered a pretest and a posttest. During the three-week experiment, participants in the control group had conventional physical therapy with a researcher present as an observer.

Results: Cadence was the element that the researchers used to adjust RAC training based on each participant's ability. Depending on the participants' gait performance, the treatment goals were to increase cadence in nine cases, to decrease cadence in four cases and to maintain cadence in three cases. Physical therapist at the school noted that some participants did not need to increase their cadence and some participants' cadence were faster than normal gait parameter due to their insecurity in balance. Therefore, unlike planned procedure, cadence needed to be adjusted depending on the participants.

Cadence increased approximately 5% in the therapist-guided and self-guided groups, and decreased by 1.2% in the control group. A paired-sample t-test indicates that there was no statistical difference between pretest and posttest in the cadence within the groups.

- **RAC training increases stride length:** Stride length of a person with cerebral palsy is often smaller than a normal person's stride length. Nevertheless, subjects in the therapist-guided and self-guided group showed an average stride length improvement of approximately 15.8%. While the self-guided group showed only ~8% increase, the therapist-guided group showed a 29.48% increase in stride length. Paired-samples t-test indicates that improvement of stride length in the therapist-guided group was statistically significant (t = -3.109, p = 0.014), whereas the other groups did not show any significant differences.The second group included 18 athletes (all males) 19-28 years old. They were all AFL players, and none of them had a previous history of hamstring injuries or any other leg injuries that might complicate interpretation of the data.

- **RAC training increases velocity:** Velocity improvement between pretest and posttest was 36.49% in the therapist-guided group, 15.83% in the self-guided group, and 9.44% in the control group. A paired-sample t-test showed the improved velocity in the therapist-guided group was statistically significant (t = -3.029, p = 0.016), whereas the other groups showed no significant difference.

- **RAC training improves symmetry**: People with cerebral palsy typically display gait asymmetry, with different toe-off to heel strike cycles. Gait symmetry improved approximately 16.97% in the therapist group, and 9.92% in the self-guided group; control-group gait symmetry improved by only 0.91%. A paired-samples t-test indicated statistical significance for improved symmetry only in the therapist-guided group (t = -3.029, p = 0.016).

TABLE 2

Results of t Test for Cadence Depending on Control, TGT and SGT Groups

Group	*M*	*SD*	*t* value	2-tail significance
Control	1.1074	13.5551	0.245	0.813
TGT	−5.2667	28.0788	−.563	0.589
SGT	−5.2786	11.8615	−1.177	0.284

TABLE 3

Results of t Test of Stride Length Depending on Control, TGT and SGT Groups

Group	*M*	*SD*	*t* value	2-tail significance
Control	−5.2E-02	0.17948	−0.871	0.409
TGT	−0.20183	0.19474	−3.109	0.014*
SGT	−6.1E-0.2	0.19467	−0.829	0.439

* $p < 0.05$.

TABLE 4

Results of t Test for Velocity Depending on Control, TGT and SGT Groups

Group	*M*	*SD*	*t* value	2-tail significance
Control	− 2.8870	11.6944	−0.741	0.480
TGT	−11.1296	11.0245	−3.029	0.016*
SGT	−5.6179	9.2366	−1.609	0.159

* $p < 0.05$.

TABLE 5

Results of t Test for Symmetry Depending on Control, TGT and SGT Groups

Group	*M*	*SD*	*t* value	2-tail significance
Control	−8.0E-03	0.14251	−0.168	0.870
TGT	−0.13211	0.17020	−2.329	0.048
SGT	−8.0E-02	0.18258	−1.160	0.290

* $p < 0.05$.

Cadence, stride length, velocity, and symmetry of the therapist-guided training group and the self-guided training group. Journal of Music Therapy, XLIV (3), 2007, p. 207

Discussion: In this trial, and in clinical practice, people with cerebral palsy display not only unique gait, but also characteristic whole-body movement patterns. It was obvious that each child had distinct and elaborate movement characteristics. Individual gait problems were much more complex than the researchers expected, due to subject-specific deformation of bone structures, abnormal muscle contracture at each of the major joints, balance, and equilibrium variations. As a result, the investigators concluded that this study demonstrated only that the use of RAC music could stabilize and enhance the gait performance of children with cerebral palsy. In light of the poor results of conventional therapy, that may be enough to improve quality of life for some individuals.

> **"While the self-guided [cerebral palsy] group showed only an ~8% increase in stride length, the therapist-guided group showed a 29.48% increase (p = 0.014)."**

If the participant was cognitively under six years old, the training was most successful when presented as an interesting game, such as pretending to be a soldier or walking to shop at imaginary stores. If a participant's cognitive function was less than one year, free walking in a spacious room with a suitable sound presentation system was most appropriate for encouraging them to walk as they pursued a toy or an attractive object.

Therapy using music-enhanced movement

In the Handbook of Neurologic Music Therapy,[31] Thaut and colleagues define the various techniques they researched and developed to treat sensorimotor movement disorders. In addition to RAS, which helps to improve movements that are intrinsically rhythmical, they assert that non-rhythmic elements of music including pitch, dynamics, and melody can provide spatial, temporal, and force cues for functional movements. Termed patterned sensory enhancement (PSE), this technique uses specifically chosen musical patterns to augment movements such as arm swing, postural alignment and hip flexion, all of which are essential to natural gait. Recent studies have shown PSE used in conjunction with RAS and other conventional forms of therapy is more effective than rhythmic cueing alone.

Research such as that performed by Anna A. Bukowska and colleagues[32] has shown PSE as successful in enhancing treatment of patients with Parkinson's when used in conjunction with other forms of music therapy. In Bukowska's 2015 pilot study, they sought to analyze the effects of combining three music therapy techniques – RAS, PSE, and therapeutic instrumental music performance (TIMP) – in treating patients with Parkinson's.

Study purpose: Building on the history of research showing the effects of RAS therapy on Parkinson's gait and stability rehabilitation, this study seeks to show improvement in spacio-temporal gait parameters and stability by incorporating the three music therapy techniques: RAS, PSE, and TIMP, a technique where the patient plays musical instruments to facilitate various functional movements.

Participants: Fifty-five subjects were chosen for the study. All participants needed to satisfy three specific criteria: 1) in Hoehn and Yahr stage 2 or 3 of Parkinson's, 2) be able to walk independently with no aid, and 3) be on stable pharmacological treatment throughout the duration of the study.

The participants were divided into 2 groups: 30 – experimental, 25 – control.

- The experimental group underwent 45-minute music therapy treatment sessions four times a week for four weeks. In each session, RAS, PSE, and TIMP techniques were applied using a metronome, rhythmic music, and percussion instruments for practicing pre-gait, gait, balance, and various daily life activities.
- The control group participants were asked to remain active and perform daily life activities between measures.

Study details: The music applied during treatment of the experimental group was chosen by the music therapist with consideration to pitch, dynamics and harmony, meter, tempo, and rhythm in order to organize spacio-temporal movement patterns and send impulses to participants' muscles to initiate and continue movement. The music included an embedded metronome to enhance the effects of the rhythmic tempo. Treatment consisted of performing of daily activities, gait and balance training, and exercises with various musical instruments.

To assess efficacy of the rehabilitation procedures used, nine measures of spacio-temporal gait and stability in the two groups were taken right before and right after the four-week period.

***The Biodex Gait Trainer™ 3** is a highly sophisticated treadmill with an instrumented deck that provides mobility-impaired patients with real-time visual biofeedback of their gait pattern. Sensors under the Gait Trainer's track detect patient footfalls, step after step, and present those footfalls to the patient in real time on a large, heads-up LCD display depicting step length, step speed and step symmetry, and actual vs. desired footfalls.*

The Gait Trainer 3 enables music-assisted therapy to enhance rehabilitation of patients with Parkinson's disease and other neurological disorders.

Results: Nine spatio-temporal parameters of gait were calculated and compared using the Optoelectrical 3D Movement Analysis System BTS Smart. The comparison between results in the experimental group before the four weeks of treatment and after showed statistically significant changes in the majority of the parameters ($p < 0.05$). Duration of swing phase, cadence, step length, velocity, and stride length were markedly higher in the second measure than in the first. Duration of stance phase, the time of double support and the stride time were significantly lower in the second measure compared to the first.

The only measure that did not change significantly was the width of step, which is largely dependent on individual anatomy.

For the control group, the only measures that were significantly higher in the second measure were step length, velocity, and stride length.

Conclusion: The results showed that combining the three sensorimotor therapy techniques in the treatment of patients with Parkinson's disease can be used as an effective treatment program to improve gait and other rhythmical activities during rehabilitation. The significant improvement in the majority of the spatio-temporal gait measurements in the experimental group compared to the control group makes a strong case for incorporating PSE with other therapy techniques to improve overall quality of movement and postural control in individuals with Parkinson's.

Bringing music therapy into broader practice

Although this paper presents 20 years of success in treating gait issues in many challenging diseases and conditions through music-enhanced therapy, there is surprisingly limited access to music therapists to treat this growing population. Also, music therapists have not had access to biomedical data that will prove effectiveness in the plan of care. Omitted in this review was the range of complex devices and systems cobbled together in laboratories around the world in order to deliver sensorimotor music therapy and document results.

Examples of the systems used by the investigators in these studies illustrate the complex hardware, software, and analytical skills once necessary to track the effects of music-based therapy.

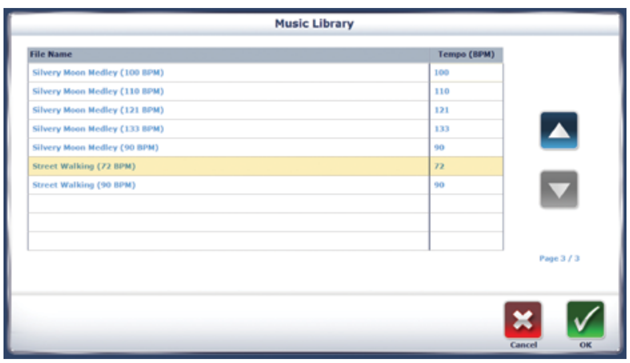
- In one TBI study, "gait parameters were recorded with four sensors per foot placed at the heel, 1st metatarsal, 5th metatarsal, and toe, imbedded in insoles worn in the subject's shoe. Sensors were connected by wire to a microprocessor attached to the patient's gait belt… After each trial, gait data was downloaded from the microprocessor to a PC to compute speed, cadence, stride length, and symmetry of each experimental walk."
- In another study, investigators used a MIDI based music software program to "provide variable tempo changes of recorded music to accommodate the various cadences of each participant's gait… A metronome was used to confirm the accuracy of the tempo and assist in synchronizing participants during the warm-up activity…"

- A third study utilized “Duration discrimination, anisochrony detection with tones, and anisochrony detection with music (to) allow estimating thresholds of duration discrimination of two tones and to detect an interval embedded in an isochronous sequence of tones or in a musical excerpt. Thresholds are estimated using a maximum-likelihood adaptive procedure implemented in MATLAB…. and corresponded to the midpoint of the psychometric curve defined as a probability of 63.1% of correct detection.”

Clearly, such hardware, software, and analysis are incompatible with routine therapy.

The music-enhanced Gait Trainer

Recently, to enhance rehabilitation of patients with Parkinson’s disease and other neurological disorders, Biodex integrated sensorimotor music therapy-informed compositions into the Gait Trainer 3.



The Biodex Gait Trainer 3 *music library screen.*

In clinical trials, researchers have shown music-enhanced RAC to be a successful adjunct to conventional gait therapy with a metronome in people with Parkinson’s disease, cerebral palsy, and a recent stroke. The Gait Trainer presents those patients with auditory stimuli, in the form of rhythmic song selections with a very pronounced 4/4 downbeat, that induce them to synchronize their steps with the rhythm.

The Gait Trainer also includes a selection of music therapy-informed compositions specially designed to expand rhythm-based therapy using spatial, temporal, and force cues. These specially composed songs apply musical patterns to augment functional movements such as arm swing, posture, longer or higher steps, hip rotation, etc. as well as step synchronization.

Practicing music-assisted therapy with the Biodex Gait Trainer 3

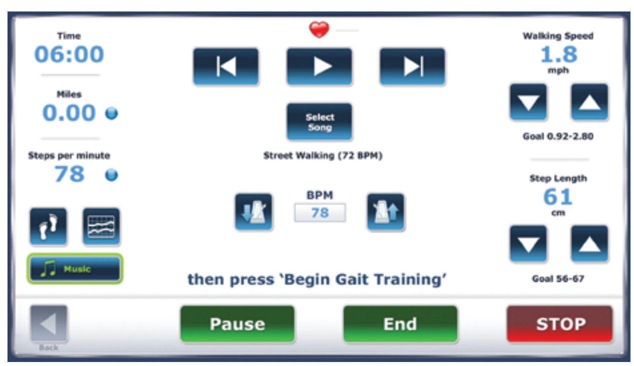
During the initial assessment, a clinician assesses the patient’s gait by asking them to walk on the Gait Trainer at their fastest comfortable speed, and recording that pace.

They then align the patient’s speed with a matching song tempo (beats per minute) from the music library or by uploading their unique compositions to the Gait Trainer.

To meet this challenge, the Biodex music therapy option offers music like “Animals Everywhere,” composed for implementation at 70, 80 or 90 beats per minute. That melody offers a baseline at half tempo to help patients relax into a more open gait pattern while the clinician makes only slight belt speed adjustments to cue slowed, long strides (walking cadence) without having to adjust tempo.

As patients train with the music therapy-informed compositions, their repeated striding to the beat of prescribed music taps induces entrainment – enhancing neuroplasticity and encouraging lasting effects.

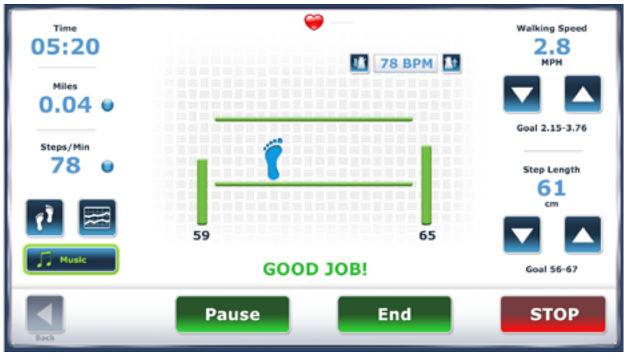
When accomplished, entrainment is clearly displayed on the Gait Trainer’s histogram screen as the patient’s steps are superimposed for longer and longer periods.



The Biodex Gait Trainer 3 *music player screen*

When each music-guided training session ends, the clinician can print a detailed session and multi-session trend report, documenting song title, starting bpm and % change of the song tempo, plus parameters such as gait speed, step length, and step length variability.

After each session, the patient can be sent home with prescribed music therapy songs – either from the Gait Trainer music library or uploaded to the system by the music therapist – to their smartphone or iPod, enabling the continuation of therapy outside the clinic.



The Biodex Gait Trainer 3 *footfall screen showing patient step-by-step results in real-time.*

The Biodex Gait Trainer 3 *histogram screen showing patient results in real-time with progress over the course of the session.*

The mounting evidence showing the benefit of music therapy techniques on individuals with Parkinson's disease and other neurological conditions calls for expansion of music integration into gait-training therapy. By providing a method of easily administering music-supported gait therapy and recording patient progress, the music option for the Gait Trainer 3 represents a major stride toward bringing the benefits of neurological music therapy into broader clinical practice.

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