Evidence Table
Rhythmic Auditory Stimulation and Gait Training Post-stroke
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PICO: In adults suffering a stroke within the past 12 months is gait training with rhythmic auditory stimulation more effective than general gait training alone in improving symmetry of gait and Berg Balance scores?

Authors, Year, Publication	Title	Purpose and Design	Subjects	Intervention	Outcome Measures	Results	Conclusion/ Application	Comparison/ Analysis
Thaut MH, Leins AK, Rice RR, Argstatter H, Kenyon GP, McIntosh GC, Volay HV, Fetter M. *Neurorehabilitation and Neural Repair* 2007	Rhythmic Auditory Stimulation Improves Gait More Than NDT/ Bobath Training in Near-Ambulatory Patients Early Poststroke: A Single-Blind, Randomized Trial	To determine if RAS has a positive effect on gait training when compared to NDT/ Bobath training in subjects with hemiparesis 2° to stroke. RCT	RAS N=43 NDT N = 34	Both groups 3x/week; 1x/day RAS: auditory cuing with gait training; amount decreased throughout session to encourage transferability.	▪ Velocity (m/min) ▪ Stride Length (m) ▪ Cadence (steps/min) ▪ Symmetry (swing ratio) ▪ Measurements pre and post	▪ Velocity ↑ ▪ Stride-length ↑ ▪ Cadence ↑ ▪ Gait symmetry ↑	RAS can positively affect gait parameters in subjects with hemiparesis.	External cuing. Do not know if cuing was unilateral or bilateral cuing. Did not do a very good job describing specific intervention. Makes it harder to compare to other studies.
Schauer M, Mauritz KH *Clinical Rehabilitation* 2003	Musical Motor Feedback (MMF) in Walking Hemiparetic Stroke Patients: Randomized Trials of Gait Improvement	To determine if MMF has a greater positive effect on gait than conventional gait training alone in subjects with hemiparesis 2° to stroke. RCT	N = 23 MMF Age 59±12 DPS 53 Cntl Age 61±12 DPS 67	15 sessions 20 min/day 5 days/week Insoles with sensors connected to portable music device. Speed of music directly controlled by gait of subject. Both groups received 45 min/day NDT/Bobath.	▪ Velocity (m/s) ▪ Cadence (strides/min) ▪ Symmetry deviation (%) ▪ Heel-on-toe-off distance (mm) Pre and post Measurements taken without MMF	**MMF** ▪ Velocity ↑ ▪ Stride-length ↑ ▪ Symmetry deviation ↓ ▪ Increased heel-on-toe-off ↑ **Control** ▪ Cadence ↑	MMF can positively affect gait parameters in subjects with hemiparesis.	Need more description of intervention. Different from other studies. Auditory stimulus is dependent upon the subject's movement. Subject creates the timing instead of the cuing creating the timing. Cadence did not significantly increase for MMF; did for control.
Jeong S, Kim MT *Applied Nursing Research* 2007	Effects of a Theory-Driven Music and Movement Program for Stroke Survivors in a Community Setting	To determine if and how music-based exercise program affects physiological, psychological, and social outcomes in subjects post-stroke. Also, a feasibility study. RCT	RAS N = 16 Age 58.0 ± 7.192 YPS = 5.437 ± 4.530 Cntl N = 17 Age = 62.2 ± 8.158 YPS = 7.294 ± 5.30	8 week community program; 2 hours/ week; stretching, singing, instructor-led exercise routines; repetitive movements coordinated with rhythms; upper and lower body; RAS home program	ROM affected side: shoulder flexion, ankle flexion, ankle extension, back scratch test, Profile of Mood States, Relationship Change Scale, Stroke Specific Quality of Life Scale Pre and post intervention measurements	**RAS** ▪ Shoulder flexion ↑ ▪ Ankle flexion/ extension ↑ ▪ Flexibility ↑ ▪ Mood States ↑ ▪ Interpersonal relationship scores ↑ **Cntl** ▪ Ankle extension ↓ ▪ Upper arm flexibility ↓	Changes were statistically significant but small. Intervention seemed to prevent loss of function. RAS able to be implemented through community exercise program.	More detailed description of intervention needed. Much longer time post-stroke than most of the other studies; years vs days. Community based: individuals need to be more independent for this application
Thaut MH, McIntosh GC, Rice RR *Journal of Neurological Sciences* 1997	Rhythmic Facilitation of Gait Training in Hemiparetic Stroke Rehabilitation	To determine if RAS has a positive effect on gait training when compared to NDT training in subjects with hemiparesis 2° to stroke. RCT	RAS N =10 DPS = 16.1±4 Cntl N = 10 DPS = 15.±4	6 wks; 5 days/wk; 60 min/day RAS: auditory cuing with gait training; amount decreased throughout session to encourage transferability.	▪ Velocity (m/min) ▪ Stride Length (m) ▪ Cadence (steps/min) ▪ Symmetry (swing ratio) ▪ Medial gastroc EMG Measurements pre and post	▪ Velocity ↑ ▪ Stride-length ↑ ▪ Variation in medial gastroc EMG ↓	RAS can positively affect gait parameters in subjects with hemiparesis.	Longer duration of study vs. other Thaut study. Do not know if cuing was unilateral or bilateral cuing. Did not do a very good job describing specific intervention.

Authors, Year, Publication	Title	Purpose and Design	Subjects	Intervention	Outcome Measures	Results	Conclusion/ Application	Comparison/ Analysis
Hayden R, Clair AA, Johnson G, Otto D *International Journal of Neuroscience* 2009	The Effect of Rhythmic Auditory Stimulation (RAS) on Physical Therapy Outcomes for Patients in Gait Training	To determine effect and feasibility of using RAS during gait training with subjects post-stroke. Wanted to determine dosage effect of RAS Cohort	Age 55-80 yrs 30 sessions w/ RAS N = 5 20 sessions w/ RAS N = 5 10 session w/ RAS N = 5	Toe-tapping to music. Walking without RAS. More toe-tapping. Marching. Walking with RAS.	▪ Single-limb stance ▪ Cadence ▪ Velocity ▪ Stride Length ▪ Time-Up-And-Go ▪ Forward Head Tilt ▪ Functional Reach Measured at sessions 1, 11, 21, 30	▪ Single-limb stance ↑ ▪ Cadence ↑ ▪ Velocity ↑ ▪ Stride Length ↑ ▪ Forward Head Tilt ↑ No difference between groups except for single-limb stance	RAS is feasible and can positively influence gait parameters. Still unsure about dosage effect.	Very little information about subjects given. Similar to other studies: conducted in inpatient rehab. Drop out was a problem. May not have been large enough N to show differences between groups.
Roerdink M, Lamoth CJC, Kwakkel GK, van Wieringen PCW, Beek PJ *Physical Therapy* 2007	Gait Coordination After Stroke: Benefits of Acoustically Paced Treadmill Walking	To determine the effect of incorporating auditory stimuli w/ treadmill training on the gait of subjects post-stroke. Cross-Sectional	10 subjects post-stroke Age = 46-78 yrs Months post-stroke = 3-104 9 healthy controls	3 trials at 3 different speeds without auditory cuing. 3 trials at 3 different speeds with auditory cuing.	▪ Stride frequency ▪ Stride length ▪ Stride time ▪ Step witdth ▪ Spatial asymmetry ▪ Temporal asymmetry ▪ Interlimb coordination	1st 4 gait parameters were different between subjects post-stroke and controls **Post-stroke w/ auditory cuing** ▪ Spatial asymmetry ↓ ▪ Temporal asymmetry ↓ ▪ Interlimb coordination ↑	Cuing had positive effect on gait. Subjects post-stroke can adjust walking speed to match pacing even when faster or slower than comfortable pace.	Compared subjects post-stroke to controls. Then compared effect of auditory stimuli on both groups. Bilateral cuing via headphones. Used treadmill instead of over-ground. More control over velocity but treadmill may also have an effect. Longer time since stroke yet still an effect on gait.
Pelton TA, Johannsen L, Chen H, Wing AM *Neurorehabilitation and Neural Repair* 2010	Hemiparetic Stepping to the Beat: Asymmetric Response to Metronome Phase Shift During Treadmill Gait	To determine how subjects post-stroke adapt to phase shifts during treadmill walking with RAS. Cross-Sectional	N = 8 subjects post-stroke Age = 51-91 MPS = 9-108	Treadmill walking at comfortable speed w/ metronome matched to heel strike. 5 trials of 100 steps. 4 phase shifts during each trial. Subject asked to rematch heel strike to metronome.	▪ Average phase control (ms) ▪ Period control ▪ Limb symmetry (ms)	Subjects took more time to adapt to phase shift when paretic side had to initiate compensation.	7 of 8 subjects post-stroke were able to adjust and match changes but needed increased time for compensation with paretic side.	Also a treadmill study and longer time since stroke than inpatient rehab studies. Most of the subjects still had the ability to adjust gait to an auditory stimulus.
Roerdink M , Lamoth CJC, van Kordelaar J, Elish P, Konijnenbelt M, Kwakkel G, Beek PJ *Neurorehabilitation and Neural Repair* 2009	Rhythm Perturbations in Acoustically Paced Treadmill Walking After Stroke	To determine the amount of auditory cuing that results in the best synchronization of heel strike to pulse. Also assessed how subjects compensate for phase shifts.	Subjects post-stroke N = 11 Age = 42-71 MPS = 4-65 Healthy controls N = 10	Session 1: Treadmill walking at comfortable speed w/o RAS Session 2: Treadmill walking w/ RAS. Given ipsilateral and bilateral. Session 3: Treadmill walking w/ RAS and phase shifts in RAS.	▪ Step length ▪ Step width ▪ Step time ▪ Step Symmetry ▪ Ability to adjust to perturbations: ◦ Accuracy ◦ Speed	Subjects post-stroke: All gait parameters worse than controls. Bilateral cuing: both groups showed increased step width and better coordination.	Subject post-stroke have more difficulty matching auditory information but show improved coordination with bilateral cuing.	Treadmill study and longer time since stroke than inpatient rehab studies. Showed impact of different amounts of cuing. Bilateral resulted in better coordination.

Abbreviations and Definitions
RAS = Rhythmic auditory stimulation; Cntl = Control Group; MMF = Musical motor feedback
DPS = Days post-stroke; MPS = Months post-stroke; YPS = Years post-stroke
Average Phase Control (ms): how far off the heel strike was from matching the pulse
Period Control: "proportional asynchrony error from the target pulse"
Limb symmetry (ms): comparison of time between heel strikes between paretic and non-paretic side