

Final report summary:

Can listening to an out of step beat help walking after stroke?

Phase shifts in metronome-cued training of hemiparetic gait

PROJECT CODE: TSA 2009-06

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Why did we fund this research?

Over 70% of stroke survivors will experience lower limb weakness due to their stroke¹, and this can affect their ability to walk.

On average, stroke survivors walk more slowly than healthy people without stroke² and are more prone to falls³.

Stroke survivors with walking problems caused by lower limb weakness on one side (called hemiparetic gait), can have uneven step length, and step timing⁴, and use more energy to walk⁵. They may also have problems altering their walking speed⁶, and turning to their weaker side⁷.

In hemiparetic gait, rehabilitation of walking is generally aimed at balancing the stroke survivor's posture and weight-bearing on each leg^{8,9}. However, research has shown that stroke survivors with hemiparetic gait who listen to the sound of a metronome have a more even step, and can adjust their walking speed more easily^{10,11}. A metronome is a device that makes a regular, repeated sound which is typically used by musicians to help them time how fast a piece of music should be played.

Research in healthy people without stroke has also shown that altering just a single beat of a metronome (either faster or slower), making all beats that follow arrive sooner or later respectively (called phase shift), can assist them when they need to adapt their walking patterns¹². A study has suggested this is possible for stroke with hemiparetic gait too¹³.

The current study is investigating what the differences are between stroke patients and healthy people in their response to a phase shifted metronome; what metronome set up will help stroke survivors best; and whether the metronome technique could be used as a home-rehabilitation tool.

As problems walking can affect a stroke survivor's ability to get around independently to complete basic tasks of daily living, it is vital that safe, effective methods of rehabilitation in the home are found.

What did the researchers do?

Seven separate experiments were conducted during this project, with three addressing the original research questions. Experiment A investigated the effects of changing the tempo (speed) of a metronome beat used to assist stepping on the spot in hemiparetic stroke survivors. Experiment B investigated the ability of healthy people without stroke to compensate for a phase shift of metronome beat to their ability to step on the spot. Experiment C investigated the use of metronome cued stepping in retraining hemiparetic stroke survivors in a home rehabilitation programme.

Experiments A and B each recruited 15 hemiparetic stroke survivors and 15 healthy people without stroke as participants, whilst Experiment C recruited 15 hemiparetic stroke survivors only.



Experiments A and B each consisted of a single lab session for every participant in which walking or stepping on the spot was recorded on an infra-red motion capture system (Vicon) and with 'force plates' in the floor of the lab. The Vicon system picked up signals from reflective markers placed on participants' bodies, and the force plates picked up when and how heavily participants stepped on them. Used together, both systems meant that the movement and forces on the joints of participants (especially the hips, knees and ankles) could be estimated.

Experiment C was primarily conducted in stroke survivors' homes. The metronome cue was embedded in music tracks that were provided to participants on an mp3 player, a computer download or CD, according to the participants' preference.

The experiment took place over twelve weeks, which included six weeks of training. Training weeks involved participants stepping on the spot for 15 minutes a day on five days of the week. During training, participants received weekly visits at home by a researcher. This was in order to provide encouragement, answer any queries, and to provide progression to the training by increasing the tempo of the music cues.

What did the research find?

In 2013, the findings of Experiment A were published in the journal, *ISRN Rehabilitation*¹⁴, and found that hearing and being cued by a single beat metronome was beneficial to some aspects of patients controlling their stepping on the spot. Importantly, this positive effect was immediate. It was not a trained response.

Further findings from this study showed that the use of a dual tone metronome did not appear to be more beneficial than a single tone, and some patients found it off-putting.

Analysis of Experiment B is ongoing as part of a separate grant, and analysis of Experiment C is ongoing as part of a further collaboration.

The findings from a further experiment conducted as part of this project grant were published in 2014¹⁵ in the journal, *Frontiers in Human Neuroscience*. That experiment investigated the use of a phase shifted metronome on the walking ability of eight healthy participants. It added a visual metronome cue to the heard metronome cue provided to participants, and found no added benefit to stepping ability.

In conclusion, this study has led to important progress in understanding how the use of a metronome could aid in stepping after stroke, and has led to further collaborations to continue the work.

What does this mean for stroke survivors?

This study found that hearing and being cued by a single beat metronome was beneficial to some aspects of stroke survivors' controlling their stepping on the spot. Importantly, this positive effect was immediate, and wasn't a trained response.

Findings from this study may inform whether a metronome could benefit the walking ability of stroke survivors in the future.

References

1. Lawrence, E. S., Coshall, C., Dundas, R., Stewart, J., Rudd, A. G., Howard, R., & Wolfe, C. D. (2001). Estimates of the prevalence of acute stroke impairments and disability in a multiethnic population. *Stroke*, 32(6), 1279-1284.
2. Wright, R. L., Bevins, J. W., Pratt, D., Sackley, C. M., & Wing, A. M. (2016). Metronome cueing of walking reduces gait variability after a cerebellar stroke. *Frontiers in Neurology*, 7, 84.
3. Nyberg, L., & Gustafson, Y. (1997). Fall prediction index for patients in stroke rehabilitation. *Stroke*, 28(4), 716-721.
4. Chen G, Patten C, Kothari DH, Zajac FE. *Gait & Posture* 2005;22(1):51-6.
5. Waters RL, Mulroy S. *Gait & Posture* 1999;9(3):207-31.
6. Jonkers I, Delp S, Patten C. *Gait & Posture* 2009;29(1):129-37.
7. Lamontagne A, Paquette C, Fung J. *Neurorehabilitation and Neural Repair* 2007;21(1):62-7.
8. Carr JH, Shephard RB. *Stroke rehabilitation: Guidelines for exercise and training to optimise motor skill*. 3rd ed. Butterworth-Heinemann; 2002.
9. Shumway-Cook A, Woollacott MH. *Motor control: Theory and practical applications*. 2nd ed. Lippincott Williams and Wilkins; 2001.
10. Roerdink M, Lamoth CJ, Kwakkel G, van Wieringen PC, Beek PJ. *Physical Therapy* 2007;87(8):1009-22.
11. Prassas S, Thaut M, McIntosh G, Rice R. *Gait & Posture* 1997;6(3):218-23.
12. Chen HY, Wing AM, Pratt D. *Gait & Posture* 2006;23(3):307-14.
13. Pelton, T. A., Johannsen, L., Chen, H., & Wing, A. M. (2010). Hemiparetic stepping to the beat: asymmetric response to metronome phase shift during treadmill gait. *Neurorehabilitation and Neural Repair*, 24(5), 428-434.
14. Wright, R. L., Masood, A., MacCormac, E. S., Pratt, D., Sackley, C. M., & Wing, A. M. (2013). Metronome-cued stepping in place after hemiparetic stroke: Comparison of a one-and two-tone beat. *ISRN Rehabilitation*, 2013
15. Wright, R. L., Spurgeon, L. C., & Elliott, M. T. (2014). Stepping to phase-perturbed metronome cues: multisensory advantage in movement synchrony but not correction. *Frontiers in human neuroscience*, 8, 724.

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