RESEARCH PAPER

Effectiveness Of Sensory Reweighting Balance Training With Rhythmic Auditory Stimulation On Cognitive-Motor Interference And Balance In Stroke Survivors: A Randomized Controlled Trial

Parth Prajapati [1], Darpan Vanavi [2], Urja Vaidya[3], Avinash Singh[4], Garima Singh[5*], Leo Rathinaraj Antony Soundararajan[6], Nitika Jesingh[7], Navita Sharma[8]

[1]Assistant Professor, Parul institute of Physiotherapy and Research, Parul University, Vadodara, Gujarat-391760
[2]Assistant Professor, Parul institute of Physiotherapy and Research, Parul University, Vadodara, Gujarat-391760
[3]Assistant Professor, Parul institute of Physiotherapy, Parul University, Vadodara, Gujarat - 391760
[4]HOD & Professor, Rabindranath Tagore University, Mendua, Post: Bhojpur, Near Bangrasiya Chouraha, on the Bhopal-Chiklod Road, District Raisen (PIN: 464993)
[5]Associate Professor, School of Biomedical Sciences and Technology- Galgotias University, Greater Noida-203201 Uttar Pradesh, India
[6.]Adjunct Professor, Saveetha College of Physiotherapy, SIMATS Deemed University, Chennai 600077.
[7]Assistant Professor, School of Allied Health Sciences,Galgotias University, Greater Noida 203201
[8.]Assistant Professor, Physiotherapy department, School of allied health sciences, galgotias university, Plot No. 2, Sector 17-A, Yamuna Expressway, Opposite Buddha International Circuit, Greater Noida, Gautam Buddh Nagar, Uttar Pradesh - 203201

ABSTRACT

Background:Stroke frequently results in impairments in balance, mobility, and cognitive-motor coordination, which increase fall risk and reduce functional independence. Sensory integration plays an essential role in maintaining postural control through appropriate weighting of visual, vestibular, and somatosensory inputs. Rhythmic auditory stimulation (RAS) has been reported to improve motor coordination and gait performance in individuals with neurological disorders.

Objective:To investigate the effectiveness of sensory reweighting balance training combined with rhythmic auditory stimulation on cognitive-motor interference and balance in stroke survivors.

Methods:A randomized controlled trial was conducted involving 46 stroke survivors, who were randomly allocated into an experimental group (n = 23) and a control group (n = 23). The experimental group received sensory reweighting balance training combined with rhythmic auditory stimulation, while the control group received conventional balance training. Both groups participated in supervised physiotherapy sessions five times per week for six weeks. Outcome measures included the Dual-Task Timed Up and Go (DT-TUG), Berg Balance Scale (BBS), and Activities-specific Balance Confidence (ABC) Scale. Assessments were performed at baseline and after the intervention. Data were analyzed using paired t-tests and independent t-tests with a significance level of $p < 0.05$.

Results:Both groups demonstrated significant improvements in DT-TUG, BBS, and ABC scores following the intervention ($p < 0.05$). However, the experimental group showed significantly greater improvements compared with the control group. Post-intervention analysis revealed significant differences between groups in DT-TUG ($p = 0.001$), BBS ($p = 0.002$), and ABC Scale ($p = 0.001$).

Conclusion:Sensory reweighting balance training combined with rhythmic auditory stimulation significantly improves balance performance, functional mobility, and balance confidence in stroke survivors compared with conventional balance training. This combined intervention may be an effective rehabilitation strategy to reduce cognitive-motor interference and enhance functional independence following stroke.

Keywords: Stroke rehabilitation, sensory reweighting, rhythmic auditory stimulation, balance training, cognitive-motor interference

How to cite this article: Prajapati P, Vanavi D, Vaidya U, Singh A, Singh G, Soundararajan LRA, Jesingh N, Sharma N. Effectiveness Of Sensory Reweighting Balance Training With Rhythmic Auditory Stimulation On Cognitive-Motor Interference And Balance In Stroke Survivors: A Randomized Controlled Trial .Int J Drug Deliv Technol. 2026;16(1s): 257-261; DOI: 10.25258/ijddt.16.1s.32

Source of support: Nil.

Conflict of interest: None

INTRODUCTION

Stroke is one of the leading causes of long-term disability worldwide and often results in impairments in motor control, balance, and gait. These impairments significantly limit functional independence and increase the risk of falls among stroke survivors. Post-stroke motor deficits are frequently associated with disturbances in sensorimotor integration and postural control, which are essential for maintaining balance during daily activities[1]. Epidemiological reports indicate that approximately 60% of stroke survivors experience difficulties in walking and balance, primarily due to motor weakness, sensory deficits, and impaired coordination[2]. Consequently, improving balance and mobility remains a major goal of stroke rehabilitation.Postural control is a complex process that relies on the integration of multiple sensory systems, including

**Author for Correspondence:* *Garima Singh*

visual, vestibular, and somatosensory inputs. The central nervous system continuously processes these inputs to maintain stability and orientation in space. The ability to dynamically adjust the relative contribution of these sensory inputs according to environmental demands is known as sensory reweighting[3]. In individuals with stroke, damage to cortical and subcortical structures can disrupt this sensory integration mechanism, resulting in impaired balance and increased postural instability. Research has shown that hemiparetic stroke patients demonstrate abnormal sensory reweighting and difficulty selecting the most appropriate sensory information to maintain postural stability[4]. Such deficits may lead to excessive dependence on visual cues or impaired proprioceptive processing, thereby compromising functional mobility.

Rehabilitation strategies that target sensory integration and balance training have therefore gained increasing attention in neurorehabilitation. Sensory reweighting balance training involves manipulating visual, vestibular, and somatosensory inputs during postural tasks to improve the central nervous system's ability to adapt to sensory conflicts and maintain equilibrium. Studies using computerized dynamic posturography have demonstrated that stroke survivors exhibit significantly lower equilibrium scores and poorer Berg Balance Scale performance compared with healthy individuals, indicating deficits in sensory organization for balance control[4]. Therefore, interventions designed to enhance sensory reweighting may contribute to improved balance and functional mobility in stroke rehabilitation.

Another promising approach in neurological rehabilitation is rhythmic auditory stimulation (RAS). RAS is a technique derived from neurologic music therapy that uses rhythmic auditory cues, such as metronome beats or rhythmic music, to facilitate movement timing and coordination. The underlying mechanism of RAS is based on auditory-motor entrainment, a process in which rhythmic auditory stimuli synchronize with motor responses to enhance movement patterns and improve neuromuscular coordination. Neurophysiological studies suggest that auditory rhythms can activate multiple cortical and subcortical motor networks, including the premotor cortex, basal ganglia, and cerebellum, thereby improving motor timing and gait performance[5].

Evidence from clinical trials and systematic reviews indicates that rhythmic auditory stimulation can significantly improve gait parameters and balance performance in individuals with stroke. A systematic review and meta-analysis analyzing randomized controlled trials reported that RAS interventions significantly improved gait velocity, step length, cadence, and balance outcomes such as the Berg Balance Scale in stroke survivors[6]. These improvements are thought to occur because rhythmic cues provide an external timing mechanism that facilitates motor planning and coordination during walking and postural tasks.

In addition to motor deficits, stroke survivors often experience impairments in cognitive-motor integration. Many daily activities require individuals to perform motor tasks while simultaneously processing cognitive information, a phenomenon known as dual-task or cognitive-motor interference. Stroke-related damage to attentional networks and executive functions may reduce the ability to manage such simultaneous demands, leading to decreased balance performance and increased fall risk during dual-task situations. Studies have shown that dual-task conditions can significantly deteriorate gait and balance performance in stroke survivors compared with single-task conditions[7].

While previous research has demonstrated the benefits of sensory integration training and rhythmic auditory stimulation individually, limited studies have explored the combined effects of sensory reweighting balance training and rhythmic auditory stimulation on cognitive-motor interference and balance performance in stroke survivors. Integrating rhythmic auditory cues into sensory reweighting balance exercises may enhance sensorimotor synchronization and promote more efficient postural control strategies during complex tasks. Therefore, investigating such combined interventions may provide valuable insights into improving functional mobility and reducing fall risk in stroke rehabilitation.

The present study aims to evaluate the effectiveness of sensory reweighting balance training combined with rhythmic auditory stimulation on cognitive-motor interference and balance in stroke survivors. Understanding the potential benefits of this integrated approach may contribute to the development of more effective and evidence-based rehabilitation strategies for individuals recovering from stroke.

METHODOLOGY

STUDY DESIGN

This study was designed as a randomized controlled trial (RCT) with two parallel groups: an experimental group and a control group

PARTICIPANTS

Thirty stroke survivors were recruited from neurorehabilitation centers.

SAMPLE SIZE: 50

SAMPLING TECHNIQUE: simple random

INCLUSION CRITERIA

Age between 40–70 years
First episode of stroke (ischemic or hemorrhagic)
Ability to stand independently for at least 1 minute
Mini-Mental State Examination score ≥ 24

EXCLUSION CRITERIA

Severe musculoskeletal disorders affecting balance
Severe visual or vestibular disorders
Other neurological conditions

INTERVENTION

Group A: Sensory Reweighting Balance Training Combined with Rhythmic Auditory Stimulation

Sensory Reweighting Balance Training[12]

Participants in the experimental group received a structured intervention program combining sensory reweighting balance training and rhythmic auditory stimulation (RAS). Sensory reweighting training aims to enhance the central nervous system's ability to integrate visual, vestibular, and somatosensory inputs for maintaining postural control.

Phase 1: Static Balance Training (Visual Manipulation)

Standing with eyes open
Standing with eyes closed
Standing while focusing on moving visual targets
Standing with visual distractions

Phase 2: Somatosensory Manipulation Training

Standing on foam surface
Standing on balance board
Single-leg stance on foam
Weight shifting on unstable surfaces

Phase 3: Vestibular Stimulation Training

Head rotation while standing
Head nodding during standing
Walking while turning the head
Gaze stabilization exercises

Phase 4: Dynamic Balance Training
Weight shifting in multiple directions
Tandem standing and tandem walking
Reaching outside base of support
Stepping over obstacles
Sit-to-stand training

Phase 5: Dual-Task Balance Training
Standing while counting backward
Walking while naming objects
Balance tasks while performing arithmetic calculations

Rhythmic auditory stimulation (RAS)[16]
During balance exercises, rhythmic auditory stimulation was provided using a metronome or rhythmic auditory cues delivered through speakers.
Participants performed stepping, marching, and balance tasks synchronized with rhythmic auditory cues. The tempo was gradually increased to encourage improved gait rhythm, step length and movement timing.
Training Duration 45 minutes, 5 days per week for 6 weeks.

Table 1. Baseline Demographic Characteristics of Participants (n = 46)

Variable	Experimental Group (n=23) Mean ± SD	Control Group (n=23) Mean ± SD	Test Value	p-value
Age (years)	58.3 ± 7.2	59.1 ± 6.8	t = 0.41	0.68
Height (cm)	165.4 ± 6.1	166.2 ± 5.8	t = 0.50	0.62
Weight (kg)	69.3 ± 8.5	70.1 ± 7.9	t = 0.37	0.71
BMI (kg/m²)	25.3 ± 2.8	25.5 ± 3.1	t = 0.21	0.83
Stroke Duration (months)	8.4 ± 3.2	8.7 ± 3.0	t = 0.33	0.74

Table 2: Gender Distribution

Gender	Experimental	Control	χ^2 value	p-value
Male	14	13	0.09	0.76
Female	9	10		

Overground walking practice
Training Duration: 45 minutes, 5 days per week for 6 weeks.

OUTCOME MEASURES
Dual-Task Timed Up and Go Test (DT-TUG)
Berg Balance Scale (BBS)
Activities-specific Balance Confidence Scale (ABC Scale)
Static standing balance exercises
Weight-shifting activities
Sit-to-stand training
Functional reaching tasks

Group B: Conventional Balance Training
The training program included
:

STATISTICAL ANALYSIS
Statistical analysis was performed using IBM SPSS Statistics version 25.0. The level of statistical significance was set at $p < 0.05$.
Descriptive statistics were used to summarize participant characteristics and baseline clinical variables. Continuous variables such as age, DT-TUG score, Berg Balance Scale score, and Activities-specific Balance Confidence score were presented as mean ± standard deviation (SD), while categorical variables such as gender were expressed as frequency and percentage.
Prior to inferential analysis, the normality of the data distribution was assessed using the Shapiro–Wilk Test. Since the data followed a normal distribution, parametric tests were applied for further analysis.
To evaluate within-group changes in outcome measures from pre-intervention to post-intervention, the Paired t-test was used separately for both the experimental and control groups.
To compare between-group differences in outcome measures after the intervention, the independent t-test was applied.

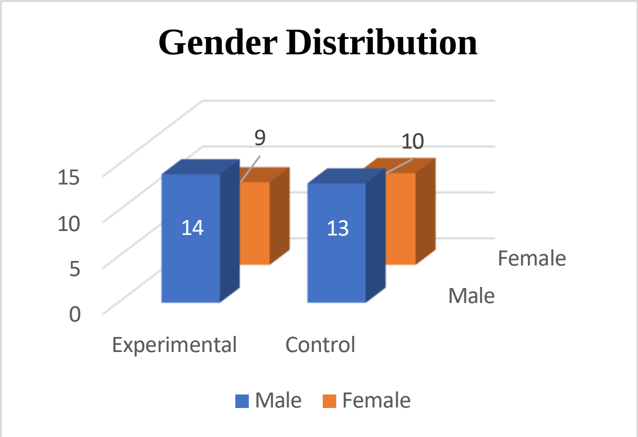


Table 3. Within-Group Comparison of Outcome Measures - group A

Outcome Measure	Pre-test Mean ± SD	Post-test Mean ± SD	t-value	p-value
DT-TUG (sec)	21.8 ± 3.4	16.2 ± 2.9	9.14	<0.001
BBS (score)	37.4 ± 5.2	46.8 ± 4.7	10.27	<0.001
ABC Scale (%)	52.3 ± 9.4	71.6 ± 8.7	11.15	<0.001

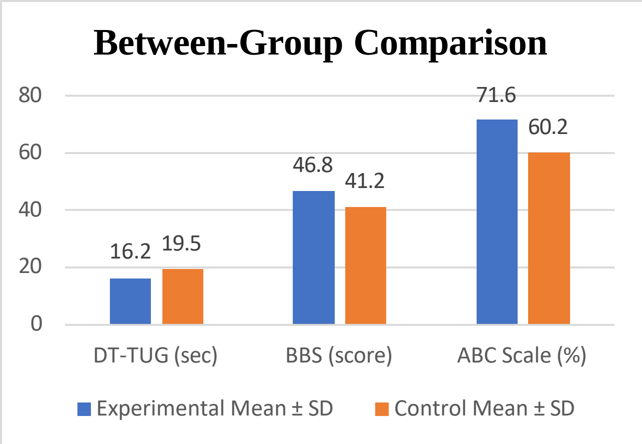
Table 4. Within-Group Comparison of Outcome Measures - group B

Outcome Measure	Pre-test Mean ± SD	Post-test Mean ± SD	t-value	p-value
DT-TUG (sec)	22.1 ± 3.6	19.5 ± 3.1	3.12	0.02

BBS (score)	36.9 ± 5.5	41.2 ± 5.1	3.45	0.01
ABC Scale (%)	51.8 ± 10.1	60.2 ± 9.5	3.02	0.03

Table 5. Between-Group Comparison After Intervention (Independent t-test)

Outcome Measure	Post-test Experimental Mean ± SD	Post-test Control Mean ± SD	t-value	p-value
DT-TUG (sec)	16.2 ± 2.9	19.5 ± 3.1	3.79	0.001
BBS (score)	46.8 ± 4.7	41.2 ± 5.1	3.93	0.002
ABC Scale (%)	71.6 ± 8.7	60.2 ± 9.5	4.17	0.001



RESULT

A total of 46 stroke survivors completed the study, with 23 participants in each group. Baseline demographic characteristics were comparable between groups with no statistically significant differences ($p > 0.05$).

Within-group analysis using the paired t-test revealed significant improvements in Dual-Task Timed Up and Go (DT-TUG), Berg Balance Scale (BBS), and Activities-specific Balance Confidence (ABC) scores in both groups following the intervention ($p < 0.05$). However, the experimental group demonstrated significantly greater improvements compared with the control group.

Between-group comparison using the independent t-test showed statistically significant differences in post-intervention scores for DT-TUG ($t = 3.79$, $p = 0.001$), BBS ($t = 3.93$, $p = 0.002$), and ABC scale ($t = 4.17$, $p = 0.001$), indicating the superiority of sensory reweighting balance training combined with rhythmic auditory stimulation.

DISCUSSION

The present study investigated the effectiveness of sensory reweighting balance training combined with rhythmic auditory stimulation on cognitive-motor interference and balance in stroke survivors. The results demonstrated significant improvements in Dual-Task Timed Up and Go (DT-TUG), Berg Balance Scale (BBS), and Activities-specific Balance Confidence (ABC) scores in both groups following the intervention. However, the experimental group showed significantly greater improvements compared with the control group, indicating the beneficial effects of integrating sensory reweighting balance training with rhythmic auditory stimulation.

Balance impairment is a common consequence of stroke due to deficits in motor control, proprioception, and sensory integration. Effective postural control requires appropriate integration of visual, vestibular, and somatosensory inputs. Damage to cortical and subcortical structures after stroke disrupts this sensory integration process, resulting in impaired balance and increased fall risk. Sensory reweighting training aims to improve the central nervous system's ability to adaptively adjust the relative contribution of sensory inputs for maintaining postural stability. Previous research has emphasized that rehabilitation programs targeting sensory integration can significantly improve balance and functional mobility in stroke patients.

The findings of the present study are consistent with recent stroke rehabilitation research that highlights the role of sensory-based interventions in improving postural control. Studies investigating sensory integration and proprioceptive training have demonstrated significant improvements in balance performance and motor function in individuals with stroke. Enhancing proprioceptive input and sensory feedback may promote neuroplastic changes in sensorimotor pathways, leading to improved motor coordination and postural stability.

Rhythmic auditory stimulation (RAS) has emerged as an effective rehabilitation technique for improving motor control in neurological conditions. RAS provides external rhythmic cues that facilitate synchronization between auditory signals and motor responses, thereby improving movement timing and coordination. Evidence suggests that rhythmic auditory cues activate neural networks involving the premotor cortex, basal ganglia, and cerebellum, which play critical roles in motor planning and execution. A randomized controlled study reported that rhythmic auditory stimulation significantly improved motor function in stroke patients compared with conventional therapy, supporting its role as an effective adjunct intervention in stroke rehabilitation.(rujin tain et.al)

Similarly, research evaluating rhythmic auditory stimulation during gait training has demonstrated improvements in gait speed, cadence, and balance performance in stroke survivors. A randomized controlled trial investigating RAS-based gait training found significant improvements in functional mobility and walking performance following a four-week intervention program.(Bernhard Elsner et.al) These findings support the present study, where participants receiving rhythmic auditory cues demonstrated greater improvements in mobility and balance outcomes.

Recent research also suggests that combining rhythmic auditory stimulation with other forms of sensory feedback may further enhance rehabilitation outcomes. A randomized controlled trial comparing rhythmic auditory stimulation alone with rhythmic auditory stimulation combined with vibrotactile feedback found significant improvements in balance and gait parameters, including Berg Balance Scale and Timed Up and Go scores. (su-jin kim et.al) This highlights the importance of multisensory stimulation in promoting motor recovery following stroke.

Another important finding of the present study is the improvement observed in dual-task performance. Stroke survivors often experience cognitive-motor interference when performing simultaneous cognitive and motor tasks. This interference may lead to reduced balance performance and increased fall risk during daily activities. The improvement in DT-TUG scores observed in the experimental group suggests that sensory reweighting balance training combined with rhythmic auditory stimulation may enhance attentional control and motor coordination during dual-task conditions. External rhythmic cues may reduce cognitive load by providing temporal guidance for movement execution, allowing individuals to perform motor tasks more efficiently.

The improvement in Activities-specific Balance Confidence scores further indicates that the intervention positively influenced psychological aspects of balance, including confidence and fear of falling. Improved balance confidence is an important outcome in stroke rehabilitation because fear of falling often leads to reduced participation in physical activity and functional tasks.

Overall, the findings of this study suggest that integrating sensory reweighting balance training with rhythmic auditory stimulation provides a comprehensive approach to improving balance, mobility, and cognitive-motor performance in stroke survivors. The combination of sensory manipulation and rhythmic cueing may enhance sensorimotor integration and facilitate neuroplastic adaptations in the central nervous system.

CONCLUSION

The results of this study indicate that sensory reweighting balance training combined with rhythmic auditory stimulation is an effective intervention for improving balance, functional mobility, and cognitive-motor performance in stroke survivors. This integrated approach may serve as a valuable strategy in stroke rehabilitation programs aimed at reducing fall risk and enhancing functional independence.

REFERENCE

1. Langhorne P, Bernhardt J, Kwakkel G. Stroke rehabilitation. Lancet. 2011;377(9778):1693-1702.https://pubmed.ncbi.nlm.nih.gov/21571152/

2. Mehrholz J, et al. Electromechanical and robot-assisted arm training for improving activities of daily living after stroke. Stroke. 2014.https://pubmed.ncbi.nlm.nih.gov/24876001/

3. Horak FB. Postural orientation and equilibrium: neural control of balance. Age Ageing. 2006;35(Suppl 2):ii7-ii11.https://pubmed.ncbi.nlm.nih.gov/16926210/

4. Bonan IV, et al. Abnormal sensory integration affects balance control in hemiparetic patients after stroke. Clin Neurophysiol.https://pubmed.ncbi.nlm.nih.gov/22189728/

5. Thaut MH, McIntosh GC. Neurologic music therapy: rhythmic auditory stimulation in gait rehabilitation. Front Neurosci. 2014.

6. Wang L, Peng J, Xiang W, Huang Y, Chen A. Effects of rhythmic auditory stimulation on motor function and balance ability in stroke: systematic review and meta-analysis. FrontNeurosci.2022.https://www.frontiersin.org/articles/10.3389/fnins.2022.1043575/full

7. Plummer P, et al. Cognitive-motor interference during gait after stroke: a systematic review. Stroke. 2013.https://pubmed.ncbi.nlm.nih.gov/23471215/

8. Shumway-Cook A, Woollacott M. Motor control and learning in rehabilitation.

9. Peterka RJ. Sensorimotor integration in human postural control. J Neurophysiol. https://pubmed.ncbi.nlm.nih.gov/16339096/

10. Pollock A, et al. Interventions for improving balance after stroke. Cochrane Database Syst Rev.https://pubmed.ncbi.nlm.nih.gov/24992073/

11. Kleim JA, Jones TA. Principles of experience-dependent neuroplasticity. J Speech Lang Hear Res.https://pubmed.ncbi.nlm.nih.gov/18230848/

12. Wang Y, et al. Visual and visual-proprioceptive training improve gait via sensory reweighting after chronic stroke: a randomized controlled trial.

13. Kaya Kara O, et al. Sensory training combined with motor training improves trunk proprioception in stroke patients: a randomized controlled trial.

14. Kim JH, et al. Effects of cognitive sensory motor training on lower extremity muscle strength and balance in post-stroke patients: a randomized controlled study.

15. Park JH, et al. Balance training with weight shift-triggered electrical stimulation for stroke patients: a randomized controlled trial.

16. Thaut MH, McIntosh GC. Neurologic music therapy and rhythmic auditory stimulation in rehabilitation. Front Neurosci. https://pubmed.ncbi.nlm.nih.gov/20631804/

17. Thaut MH, et al. Rhythmic auditory stimulation improves gait more than NDT in stroke rehabilitation. Neurorehabil Neural Repair.https://pubmed.ncbi.nlm.nih.gov/16287973/

18. Podsiadlo D, Richardson S. The Timed “Up & Go”: a test of basic functional mobility for frail elderly persons. J Am Geriatr Soc. 1991.https://pubmed.ncbi.nlm.nih.gov/1991946/

19. Ng SS, Hui-Chan CW. The timed up and go test: reliability and association with lower limb impairments in stroke survivors. Arch Phys Med Rehabil. 2005. https://pubmed.ncbi.nlm.nih.gov/15759233/

20. Berg KO, et al. Measuring balance in the elderly: validation of an instrument. Can J Public Health. 1992. https://pubmed.ncbi.nlm.nih.gov/1468055/

21. Blum L, Korner-Bitensky N. Usefulness of the Berg Balance Scale in stroke rehabilitation. Phys Ther. 2008.https://pubmed.ncbi.nlm.nih.gov/18218822/

22. Powell LE, Myers AM. The Activities-specific Balance Confidence (ABC) Scale. J Gerontol A Biol Sci Med Sci. 1995.https://pubmed.ncbi.nlm.nih.gov/7794775/

23. Botner EM, et al. Measurement properties of the Activities-specific Balance Confidence Scale among individuals with stroke. Physiother Can. 2005. https://pubmed.ncbi.nlm.nih.gov/16097412/