

Applications of Rhythmic Auditory Stimulation in Gait Rehabilitation Following Stroke: A Scoping Review

Nikhil H M¹, Nikita Das², Yesho Deepa³, Belle Sharvani⁴, Dr. Manjunatha H⁵

¹Department of Physiotherapy,

¹BPT, Akash Institute of Physiotherapy, Rajiv Gandhi University of Health Science, Devanahalli Bengaluru, India

²Lecturer, Akash Institute of Physiotherapy, Rajiv Gandhi University of Health Science, Devanahalli Bengaluru, India

³Lecturer, Akash institute of Physiotherapy, Rajiv Gandhi University of Health science, Devanahalli Bengaluru, India

⁴Associate Professor, Akash institute of Physiotherapy, Rajiv Gandhi University of Health Science, Devanahalli Bengaluru, India

⁵Professor, Akash Institute of Physiotherapy, Rajiv Gandhi University of Health Science, Devanahalli Bengaluru, India

Corresponding Author: Nikhil HM

DOI: <https://doi.org/10.52403/ijrr.20260802>

ABSTRACT

Stroke is one of the leading causes of long-term disability worldwide, and gait impairment is a major factor affecting mobility, independence, and quality of life in stroke survivors. Rhythmic Auditory Stimulation (RAS) is a treatment method used with conventional physiotherapy by providing rhythmic auditory cues such as metronome beat or music that helps to improve walking performance. This review aimed to evaluate the effectiveness of Rhythmic Auditory Stimulation on gait training in individuals with stroke. A literature review was conducted using studies published between 2015 and 2026 that were identified through electronic databases, including PubMed, Google Scholar and Scopus. Studies involving adults aged 18 years and above with stroke and evaluating the effects of RAS on gait-related outcomes were included. The reviewed evidence demonstrated that combining RAS with conventional rehabilitation improved gait speed, cadence, step length, stride length,

gait symmetry, balance, and functional mobility compared with conventional therapy alone. Rhythmic auditory cues also enhanced movement synchronization, increased patient participation, and promoted more efficient walking patterns. Overall, the findings suggest that Rhythmic Auditory Stimulation is a safe, effective, and clinically useful adjunct to conventional physiotherapy for improving gait in individuals with stroke.

Keywords: Rhythmic Auditory Stimulation, Gait Training, Gait Parameters, Stroke Rehabilitation.

INTRODUCTION

Stroke is major neurological disorder and one of the leading causes of death and long term disability across the world [1].

The world stroke Organization (WHO) reports that approximately 12.2 million people experience a new stroke each year worldwide, and more than 101 million people living with the effect of stroke. In India, stroke is a significant health problem,

with an estimated 1.8 million new stroke cases occurs annually.

Stroke is caused by an interruption of blood flow to the brain resulting from either a blocked or ruptured blood vessel. As a result, many stroke survivors experience motor impairments such as muscle weakness, spasticity, gait dysfunction, impaired balance, poor coordination and reduced functional mobility. These impairments significantly affect independence in activities of daily living and reduce overall quality of life [1].

Among the various impairments caused by stroke, gait impairment is one of the most common functional limitations following stroke [3,4]. Stroke survivors often demonstrate reduced walking speed, shorter stride length, decreased cadence, poor gait symmetry, impaired weight shifting and an increased risk of fall [5]. These gait abnormalities restrict community mobility and limit participation in daily activities [5]. Therefore, restoration of Gait pattern is considered one of the primary goals of stroke rehabilitation [3-5].

Physiotherapy plays a vital role in enhancing mobility and promoting independence among stroke survivors [2-6]. Conventional rehabilitation approaches, including strengthening exercises, balance training, task-oriented activities, gait training, treadmill training, and functional mobility exercises, form the foundation of post-stroke rehabilitation and contribute to improvements in gait and functional mobility, play a crucial role in improving gait and mobility in individuals after stroke [6].

Although these interventions improve walking ability. Despite undergoing conventional physiotherapy, many stroke patients continue to demonstrate impairments in gait rhythm, coordination, timing, and symmetry, highlighting the need for complementary rehabilitation approaches to further improve walking ability [2,6].

Rhythmic Auditory Stimulation (RAS) is a neurological rehabilitation technique that uses rhythmic sounds, such as a metronome or music with a steady beat to help

individuals coordinate their movements with an external rhythm [7]. During RAS, patients walk while synchronizing their steps with a metronome beat or rhythmic music. The rhythmic sounds act as external timing cue, helping the individual match each step with the beat. Through auditory-motor synchronization, RAS enhances motor learning, promotes neuroplasticity, and improves gait performance [7,8].

Aim: To review the effectiveness of Rhythmic Auditory Stimulation (RAS) in enhancing gait training outcomes among individuals with stroke.

LITERATURE REVIEW

Article 1: Gonzalez Hoelling S. et al. (2024) conducted systematic review by comparing Rhythmic Auditory Stimulation (RAS) with conventional rehabilitation in stroke patients. The study evaluated functional ambulation status, walking capacity, and various gait-related parameters. The findings indicated that incorporating Rhythmic Auditory Stimulation (RAS) alongside conventional rehabilitation may provide additional benefits in enhancing gait function and mobility outcomes following stroke.

Article 2: Ahmed G.M. et al. (2023) conducted a randomized controlled trial by comparing treadmill training combined with Rhythmic Auditory Stimulation to treadmill training alone. The study evaluated walking speed, step length, and gait cycle as outcome measures and found that combining Rhythmic Auditory Stimulation (RAS) with treadmill training produced significantly greater improvements in gait compared with treadmill training alone.

Article 3: Choi J. and Kim J.H. (2021) conducted a randomized controlled trial by comparing multidirectional step-up training with RAS to step-up training alone. Functional Ambulation Category (FAC), walking ability, and gait parameters were assessed, and the findings suggested that Rhythmic Auditory Stimulation (RAS) is an

effective adjunct to conventional rehabilitation for improving gait performance following stroke.

Article 4: Ghai S. (2019) performed a randomized controlled trial involving 40 individuals with stroke, who were assigned randomly to either a gait training program incorporating Rhythmic Auditory Stimulation (RAS) or a conventional gait training intervention. The study evaluated gait outcomes using measures such as gait velocity, stride length, cadence, and the Timed Up and Go (TUG) test. The results indicated that RAS-based auditory cueing produced significant improvements in gait velocity, cadence, and stride length, suggesting that it may be an effective approach for enhancing gait performance in individuals recovering from stroke.

Article 5: Cha et al. (2018) conducted a randomized controlled trial in which participants received 30 minutes conventional rehabilitation along with 20 minutes of gait training using Rhythmic Auditory Stimulation (RAS). The outcomes were evaluated using the 10-Meter Walk Test and the Timed Up and Go (TUG) test. The results indicated that Incorporating Rhythmic Auditory Stimulation (RAS) as an adjunct to gait training significantly enhanced walking performance relative to conventional gait training alone.

Article 6: Lee S. et al. (2018) conducted a randomized controlled trial to investigate the effects of bilateral Rhythmic Auditory Stimulation (RAS) combined with conventional physiotherapy in individuals with stroke. Gait performance was assessed using gait symmetry measures and the Timed

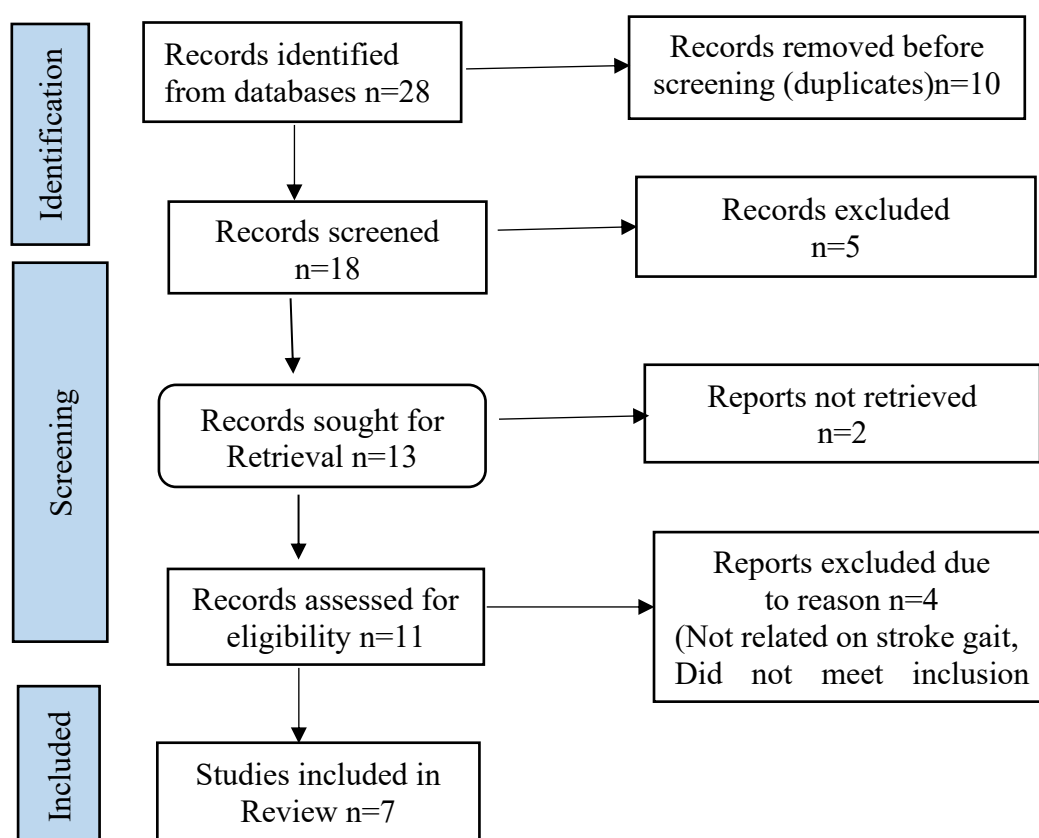
Up and Go (TUG) test. The results demonstrated that the addition of bilateral RAS to conventional physiotherapy led to significant improvements in gait symmetry and gait speed compared with conventional physiotherapy alone.

Article 7: Song G. and Ryu H.J. (2016) carried out a randomized controlled trial involving 40 individuals with stroke, who were randomly allocated to either a Rhythmic Auditory Stimulation (RAS)-assisted gait training group or a conventional gait training group. Participants in both groups underwent 30-minute training sessions, five times per week, over a four-week period. Gait performance was evaluated using the 10-Meter Walk Test (10MWT) and the GAIT Rite system, which measured gait speed, cadence, and step length. The study found that the RAS-assisted gait training group demonstrated significantly greater improvements in gait speed, cadence, and step length compared with the conventional gait training group, although both groups experienced positive gains following the intervention.

MATERIALS & METHODS

A review done by using electronic databases like pub med, google scholar, Scopus and published papers from 2015 to 2026, involving adults(>18years) with stroke and evaluating the effect of RAS on gait training were included. A total of 28 articles were identified, and 10 duplicates records were removed. The remaining studies were screened according to the inclusion criteria. After full-text assessment, 7 eligible studies were included in the final review and analysed.

Fig 1: PRISMA flowchart.



RESULT

The evidence reviewed suggests that Rhythmic Auditory Stimulation (RAS) is an effective adjunct to conventional gait rehabilitation in individuals recovering from stroke.

Most studies reported significant improvements in gait parameters, including walking speed, cadence, step length, stride length, and gait symmetry following RAS intervention. RAS improved walking speed

by 30%, cadence by 15%, step length by 20%, stride length by 20%, and gait symmetry by 125%. Patients who received gait training with rhythmic auditory cues generally demonstrated better walking performance than those receiving conventional therapy alone.

Overall, the findings indicate that incorporating RAS into stroke rehabilitation can enhance gait performance and promote better functional mobility.



Fig 2: The Figure represent the maximum improvement reported across the included studies

DISCUSSION

Stroke is a major cause of disability, and gait impairment greatly affects functional independence and quality of life^[1]. Although conventional physiotherapy improves gait through strengthening exercises, balance training, and task-oriented exercises, many stroke survivors continue to experience reduced walking speed, gait asymmetry, impaired balance, and poor functional ambulation^[2,6].

Recent advances in stroke rehabilitation have identified Rhythmic Auditory Stimulation (RAS) as an effective adjunct to conventional gait training^[3]. RAS uses rhythmic auditory cues, such as a metronome or rhythmically structured music, to synchronize movement with an external rhythm, thereby improving gait performance. The use of rhythmic cues helps enhance gait speed, cadence, stride length, gait symmetry, balance, and motor control, resulting in a more coordinated and efficient walking pattern^[4].

Thaut and Rice (2025) highlighted RAS as an important Neurologic Music Therapy technique that promotes auditory-motor synchronization and supports neuroplasticity. By improving the connection between auditory input and motor output, RAS facilitates better movement coordination and contributes to improved walking ability in stroke survivors. Elsner et al. (2019) demonstrated that Rhythmic Auditory Stimulation is effective in improving gait performance in individuals with chronic stroke, indicating that RAS can be beneficial even during the later stages of recovery^[8].

RAS can be applied in hospitals, community-based rehabilitation settings, and tele-rehabilitation programs using a metronome or rhythmically structured music. It is simple application, low cost, and ease of implementation make it a practical intervention that can be incorporated into routine stroke rehabilitation to improve gait performance and functional mobility.

The effectiveness of Rhythmic Auditory Stimulation (RAS) largely depends on the patient's ability to understand, process, and

synchronize body movements with rhythmic auditory cues during gait training. Patients who can synchronize their walking with rhythmic auditory cues are more likely to show improvements in gait speed, coordination, and overall walking ability^[5].

However, patients with severe cognitive impairment, hearing loss, or reduced attention and concentration may find it difficult to perceive or respond appropriately to rhythmic auditory cues. Therefore, the effectiveness of RAS may be reduced in these individuals during gait rehabilitation^[16].

In addition, the auditory tempo should be individualized according to each patient's gait characteristics and walking ability. Selecting an appropriate rhythm that closely matches the patient's natural cadence allows better synchronization of movement, whereas using the same tempo for all patients may reduce the effectiveness of the intervention. Therefore, adjusting the auditory cue to the individual's gait pattern is essential for achieving optimal rehabilitation outcomes^[14,15].

Although RAS effectively improves gait-related parameters, it should be used as an adjunct to conventional physiotherapy rather than as a standalone treatment^[14,15].

Overall, the available evidence indicates that RAS is a practical and effective adjunct to conventional physiotherapy, contributing to improved gait performance, functional mobility, and independence in individuals recovering from stroke^[17].

CONCLUSION

The reviewed literature indicates that Rhythmic Auditory Stimulation (RAS) is an effective addition to conventional physiotherapy for improving gait performance in individuals with stroke.

The reviewed studies consistently reported improvements in gait speed, cadence, step length, stride length, gait symmetry, balance, and functional mobility following RAS-based gait training. By enhancing auditory-motor synchronization and promoting

neuroplasticity, RAS supports better motor relearning and walking performance.

However, it should be used as a complementary intervention rather than a replacement for conventional rehabilitation, with the rhythm individualized according to each patient's gait pattern. Overall, the available evidence supports the incorporation of RAS into stroke rehabilitation programs to enhance gait recovery, improve functional independence, and promote a better quality of life in stroke survivors.

Declaration by Authors

Ethical Approval: Not required. This study is a scoping review based on previously published literature and did not involve human participants, animals, or collection of primary data.

Acknowledgement: I would like to express my heartfelt gratitude to my friends, Amrutha TJ, N Nishwanth for their constant encouragement and unwavering support throughout my academic journey.

Source of Funding: None

Conflict of Interest: No conflicts of interest declared.

REFERENCES

1. Murphy SJ, Werring DJ. Stroke: causes and clinical features. *Medicine (Abingdon)* [Internet]. 2020;48(9):561–6. <http://dx.doi.org/10.1016/j.mpmed.2020.06.002>
2. Ali I, Bhatti R. Effectiveness of physiotherapy in post-stroke rehabilitation. 2025.
3. Lee S, Lee K, Song C. Gait training with bilateral rhythmic auditory stimulation in stroke patients: A randomized controlled trial. *Brain Sci* [Internet]. 2018;8(9):E164. <http://dx.doi.org/10.3390/brainsci8090164>
4. Song G-B, Ryu HJ. Effects of gait training with rhythmic auditory stimulation on gait ability in stroke patients. *J Phys Ther Sci* [Internet]. 2016;28(5):1403–6. <http://dx.doi.org/10.1589/jpts.28.1403>
5. Shin Y-K, Chong HJ, Kim SJ, Cho S-R. Effect of rhythmic auditory stimulation on hemiplegic gait patterns. *Yonsei Med J* [Internet]. 2015;56(6):1703–13. <http://dx.doi.org/10.3349/ymj.2015.56.6.1703>
6. Mainka S, Wissel J, Völler H, Evers S. The use of rhythmic auditory stimulation to optimize treadmill training for stroke patients: A randomized controlled trial. *Front Neurol* [Internet]. 2018; 9:755. <http://dx.doi.org/10.3389/fneur.2018.00755>
7. Thaut CP, Rice R. Rhythmic Auditory Stimulation (RAS®). In: *Handbook of Neurologic Music Therapy*. Hömberg V; Oxford: Oxford University Press; 2025. p. 99–114.
8. Elsner B, Schöler A, Kon T, Mehrholz J. Walking with rhythmic auditory stimulation in chronic patients after stroke: A pilot randomized controlled trial. *Physiother Res Int* [Internet]. 2020;25(1): e1800. <http://dx.doi.org/10.1002/pri.1800>
9. Gonzalez-Hoelling S, Bertran-Noguer C, Reig-Garcia G, Suñer-Soler R. Effects of a music-based rhythmic auditory stimulation on gait and balance in subacute stroke. *Int J Environ Res Public Health* [Internet]. 2021;18(4):2032. <http://dx.doi.org/10.3390/ijerph18042032>
10. Ahmed GM, Fahmy EM, Ibrahim MF, Nassief AA, Elshebawy H, Mahfouz MM, et al. Efficacy of rhythmic auditory stimulation on gait parameters in hemiplegic stroke patients: a randomized controlled trial. *Egypt J Neurol Psychiatr Neurosurg* [Internet]. 2023;59(1). <http://dx.doi.org/10.1186/s41983-023-00606-w>
11. Cha Y-J, Kim J-D, Choi Y-R, Kim N-H, Son S-M. Effects of gait training with auditory feedback on walking and balancing ability in adults after hemiplegic stroke: a preliminary, randomized, controlled study: A preliminary, randomized, controlled study. *Int J Rehabil Res* [Internet]. 2018;41(3):239–43. <http://dx.doi.org/10.1097/MRR.0000000000000295>
12. Choi J, Kim J-H. Effects of multi-directional step-up training with rhythmic auditory stimulation on gait and balance ability in stroke patients. *WSEAS Trans Environ Dev* [Internet]. 2021; 17:758–63. <http://dx.doi.org/10.37394/232015.2021.17.72>
13. Lee Y, Shin S. Improvement of gait in patients with stroke using rhythmic sensory stimulation: A case-control study. *Medicina* [Internet]. 2022;58(9).

- <http://dx.doi.org/10.3390/medicina58091186>
14. Ghai S, Ghai I. Effects of music-based rhythmic auditory cueing training on gait and posture post-stroke: A systematic review and dose-response meta-analysis. *Scientific Reports* [Internet]. 2019;9. <http://dx.doi.org/10.1038/s41598-019-38723-3>
 15. Gonzalez-Hoelling S, Reig-García G, Bertran-Noguer C, Suñer-Soler R. The effects of rhythmic auditory stimulation on functional ambulation after stroke: a systematic review. *BMC Complement Med Ther* [Internet]. 2024;24(1):45. <http://dx.doi.org/10.1186/s12906-023-04310-3>
 16. Zhao Y, Xu H, Fu J. Integrating rhythmic auditory stimulation in intelligent rehabilitation technologies for enhanced post-stroke recovery. *Front Bioeng Biotechnol* [Internet]. 2025;13(1649011):1649011. <http://dx.doi.org/10.3389/fbioe.2025.1649011>
 17. Braun Janzen T, Koshimori Y, Richard NM, Thaut MH. Rhythm and Music-Based Interventions in Motor Rehabilitation: Current Evidence and Future Perspectives. *Front Hum Neurosci*. 2022;17;15:789467. doi: 10.3389/fnhum.2021.789467.
- How to cite this article: Nikhil H M, Nikita Das, Yeshe Deepa, Belle Sharvani, Manjunatha H. Applications of rhythmic auditory stimulation in gait rehabilitation following stroke: a scoping review. *International Journal of Research and Review*. 2026; 13(8): 23-29. DOI: <https://doi.org/10.52403/ijrr.20260802>
