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Physiotherapy Section

Effects of Task-oriented Training and Arm Ability Training with Rhythmic Auditory Stimulation on Upper Extremity Function and Quality of Life After Stroke: A Randomised Clinical Study

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ABSTRACT

Introduction: Stroke is the most common cause of disability, and about 70%-80% of patients present with upper limb impairments affecting daily activities, which are associated with reduced Quality of Life (QoL). The haemorrhagic strokes account for 10-15%, and the ischaemic strokes for about 85%. The most challenging consequences for stroke patients are the loss of upper-limb function, often accompanied by cognitive deterioration. This existing dysfunction is not only about weakness but also about a complex interaction between impaired fine motor control and diminished muscle strength, and it is widely accepted that these deficits have the greatest impact on a stroke survivor's ability to achieve functional independence.

Aim: To find the effects of task-oriented and arm-ability training with Rhythmic Auditory Stimulation (RAS) on enhancing upper extremity dexterity and health-related well-being among post-stroke survivors.

Materials and Methods: This randomised clinical study was conducted at the Outpatient Department of Jaya College of Physiotherapy, Thiruninravur, Tamil Nadu, India, from November 2025 to January 2026. A total of 50 stroke subjects were randomly allocated to two groups using a lottery method. Group A (n=25) received task-oriented training with RAS, and Group B (n=25) received arm ability training with RAS. Both groups received treatment for three weeks, five days/week. Outcome measures were the Modified Standardised Nine Hole Peg Test (mS-NHPT), Fugl-Meyer Assessment Upper Extremity (FMA-UE), and Stroke Specific QoL Scale (SS-QoL). The Statistical Package for Social Sciences (SPSS) software version 26.0 was used. The paired-sample t-test, the unpaired-sample t-test and the Chi-square test of independence for gender variance. A p-value<0.01 was considered statistically significant.

Results: Significantly greater enhancements in outcomes were observed in both groups. There were pronounced enhancements in group B compared to group A, with a p-value<0.001. Both interventions were individually effective on mS-NHPT, FMA-UE, and SS-QoL among subacute stroke subjects.

Conclusion: Arm ability training with RAS shows significantly marked gains compared to task-oriented training with RAS and has a considerable effect on upper extremity function and life quality among stroke survivors.

Keywords: Fine motor skills, Hemiplegia, Physical functional performance

INTRODUCTION

Severe arm deficits are frequently observed in patients with post-stroke; the degree of impairment is determined by day-to-day functioning, upper limb function, and motor ability indices across both gross and fine skills [1]. The ability to use relatively isolated fingers and hand movements effectively to grasp and handle objects and to interact with the environment is referred to as dexterity [2]. Stroke often results in motor impairment of the upper extremity, which is a leading cause of adult disability, lowers the QoL and impedes Activities of Daily Living (ADLs) [3].

Numerous therapeutic approaches for upper extremity rehabilitation- including proprioceptive neuromuscular facilitation, neurodevelopmental therapy, bobathe, brunnstrom, mirror therapy, virtual reality, muscle re-education, and sensory-motor approaches- have demonstrated improvements in motor function. However, more efficient rehabilitation techniques that combine these approaches with the effects of RAS are still urgently needed to support patients with compromised upper extremity function in their motor, sensory, and cognitive recovery [4]. Common syndromes among stroke survivors are characterised by decreased cognition and goal-directed action, which together disrupt the overall QoL, health, and functional recovery [5].

The RAS acts on the temporal lobe via the auditory system, regulating motor timing and coordination associated with auditory rhythm and goal-directed action. Rhythmic music increases limbic system activity and elicits positive emotional responses; combining motor and musical training can thereby alters brain neuroplasticity [6]. According to Kalidasan V et al., neurophysiological research has shown that audiomotor pathways interacts through reticulospinal connections, which are responsible for the influence of rhythmic auditory cues on motor function at the brainstem level, thereby enhancing motor abilities and functional motor performance and contributing to the realisation of the Sustainable Development Goal 3 (SDG-3) Good Health and Well-Being of post-stroke survivors [7].

Task-orientated training emphasises ADL with the principles of motor learning with neuromuscular mechanisms that govern the movement of the nervous system, and works under the principle of neural plasticity that enables better functional outcomes, restoring hand functions among the stroke survivors [8]. A task-oriented therapy focuses primarily on improving functional activities through goal-directed practice and repetitions of functional tasks, and the therapy focuses on restoring functional status rather than the impairments [9,10].

Arm-ability training helped stroke patients regain physical dexterity, particularly those with mild to moderate arm paresis who struggled with motor control due to inefficiencies in the sensorimotor integration required for dexterity. The training was designed to target various capacities and offered the possibility that gains or improvements in motor skills would also lead to improved motor performance under various conditions or circumstances [11].

Based on the existing literature, there was limited comprehensive evidence comparing the effects of task-oriented training and arm-ability training. The therapeutic outcome measures used to enhance neuroplasticity through widespread rehabilitation therapies remained suboptimal, highlighting the need for more effective interventions for stroke rehabilitation [12]. Thus, this study analysed the implementation of music-based neurorehabilitation, such as RAS, in conjunction with each specified training. The combined effects of task-oriented training, arm-ability training, and RAS activated the auditory cortex, providing an auditory feedback mechanism based on the principles of motor learning to address these gaps in stroke recovery. Hence, the study focused on the effects of TOT and AAT with RAS on the upper extremity functional recovery in stroke subjects.

MATERIALS AND METHODS:

This randomised clinical study was conducted at Jaya College of Physiotherapy, Thiruninravur, Tamil Nadu, India, with a study duration from November 2025 to January 2026. The study protocol was approved by the Institutional Ethics Committee (Reg. No: EC/JCP/08/2025). The Clinical Trials Registry – India (CTRI No.) CTRI/2025/11/097225.

Inclusion criteria: Patients with

- Both haemorrhagic and ischaemic unilateral MCA strokes upon first manifestation;
- Age group 30 to 60 years;
- Both genders with a Body Mass Index (BMI) of 25.0 to 35.0 kg/m^2;
- MMSE ≥24 (21 for illiterate [13]);
- Brunnstrom stages of recovery from III-VI [14];
- Presence of endocrine disorders such as Diabetes Mellitus (DM) and hypertension;
- Ability to sit independently for 30 minutes.

Exclusion criteria: Patients with

- Parkinson's disease, Alzheimer's disease, and other neurological disorders and musculoskeletal problems like recent fractures and deformities;
- Systemic disorders or diseases, joint pain (either in one or two joints involving the shoulder), marked somatosensory impairment;
- Visual and auditory deficits;
- Associated disorders impacting arm function; and
- Mental health disorders.

Sample size calculation: The sample size calculation was conducted using the software G* Power software, with a significance level for type I error (α=0.05) and type II error (β=0.10). The required sample size was estimated to be approximately 25 participants per group i.e., 50 participants for the entire study.

Study Procedure

A total of 50 samples were randomly allocated by lottery method in two study groups, A and B (n=25), based on inclusion and exclusion criteria. The outcome measures were hand dexterity, functional ability, and Quality of Life (QoL). Pre- and post-intervention assessments were done using the mS-NHPT [15-17], the FMA-UE [18], and the SS-QOL [19]. The data were statistically analysed.

Group A received Task-oriented Training (TOT) with RAS, five days per week for three weeks, 50 min/session [20]. Participants sat comfortably in a back-support armchair, feet placed firmly on the floor, and their trunk upright against the backrest. After 10 minutes of warm-up exercises, each participant performed 30 minutes of the selected functional tasks. Continuous practice of TOT was carried out for every 10 minutes, followed by a 2-minute rest interval.

The functional tasks included: drinking a glass of water; raising a glass of water to a 90-degree shoulder flexion angle with the elbow extended; stacking paper cups on top of one another; transferring five crystals from the table into a box; wiping a table with the elbow extended; performing grasp-and-release of a tennis ball (6 cm diameter); and using a spoon for eating.

Based on an individual's ability, progression was achieved by increasing the difficulty of variables such as distance, speed, and resistance. Feedback and assistance were provided to ensure that participants performed the tasks completely and accurately.

The RAS was delivered using either a smartphone or a music system. Participants were instructed to perform each activity in synchrony with a sequence of metronome beats or the rhythm of a song. For example, while wiping the table with a towel, the patient was asked to synchronise their movements with the beats: elbow flexion on the first beat and elbow extension on the next beat; they continued this pattern for a total of 10 repetitions [21,22].

Group B received arm-ability training with RAS, five days per week for three weeks, 60 minutes per session [23].

1. Targets were positioned at 3-50 mm wide and 18-23 cm away. The targets were elevated 30 cm above the table surface, numbered and struck with a stylus.
2. Tapping involved the rapid alternating movements of the index finger, middle finger, and thumb on the sensor.
3. Participants performed a cancellation task by marking assorted-sized circles on the table surface with a pen.
4. Coin turning involved manipulating coins with diameters of 18 and 23 mm in diameter.
5. Maze tracking involved following a maze path using a stylus, accompanied by music
6. The bolts and nuts task involved picking up and manipulating bolts of three different sizes (12 mm, 3 mm, and 5 mm).
7. Smaller objects were placed accurately into designated positions.
8. Larger containers and objects of varying sizes were placed into designated positions.

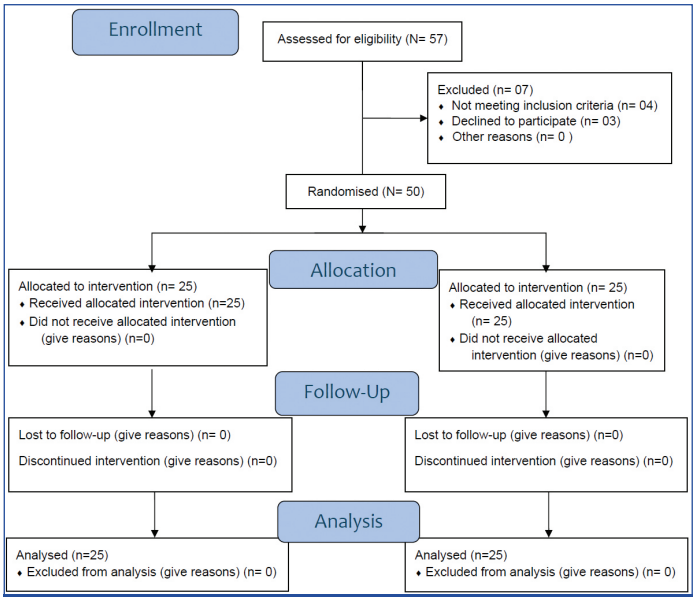
The RAS was delivered using a smartphone or music system. Using sequences of beats, patients performed the given activities in synchrony with a series of metronome beats or the rhythm of a song. For example, maze tracking was performed in time with the musical rhythm.

By implementing and integrating RAS into rehabilitation frameworks for stroke survivors, auhtors highlighted SDG 10 (reduced inequalities) and the necessity of ensuring that persons with disabilities have equitable access to effective rehabilitation techniques.

The study Consolidated Standards of Reporting Trials (CONSORT) flowchart is presented in [Table/Fig-1].

Outcome Measures:

Dexterity: The mS-NHPT with auto-timer was quick and easy to administer and represented an advanced method of recording the time taken to complete the task as a measure of finger dexterity. The setup consisted of two pegboards arranged analogously in a virtual environment. An additional, similar nine-hole pegboard was used in place of the original peg container. The pegs were transferred from the primary pegboard to the holes of the target pegboard. A precise sequence for selecting the pegs in the virtual



[Table/Fig-1]: CONSORT diagram of the study.

setting was implemented. The double pegboard was placed on the table between the participant's arms, with pegs filled in the lateral pegboard towards the hand to be assessed and at the midline, the empty medial pegboard. The Hall sensor detected a magnetic field once the pegs were placed into the lateral pegboard.

Pegs on the lateral pegboard (no. 1 to no. 9) were picked up uni-manually one at a time. When the first peg, no. 1, was picked up, the cycle and timer started. The pegs were moved and placed into the medial pegboard holes and then returned to the lateral pegboard (from no. 9 to no. 1) one by one. When peg no. 1 was finally placed back into the lateral pegboard, the timer stopped, and the monitor displayed the duration in seconds. The time taken to complete the test was reported [24].

Functional ability: Functional ability after stroke was assessed using the FMA-UE. The FMA-UE is a standardised tool for evaluating UE motor functions, Joint mobility and coordination. The FMA-UE had 33 items focusing on reflex activity, volitional movement within and outside synergy, and coordination/speed. The scoring for each item is on a 3-point scale (0: cannot perform, 1:performs partially, 2: performs fully), and the maximum score that can be obtained is 66 points. Scores are interpreted as follows: mild impairment (50-66), moderate impairment (35-49), and severe impairment (<35) [25,26].

Quality of Life (QoL): Health-related QoL of stroke patients was assessed with the SS-QoL, a patient-focused assessment tool. The total score ranges from 49 to 245 points, across 12 domains, with higher scores indicating a better functional status. The 12 domains are mobility, energy, upper extremity function, work/productivity, mood, self-care, social roles, family roles, vision, language, thinking and personality [27].

STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS version 26.0. The dependent (paired-sample) t-test was used to compare within each group A and B. The independent or unpaired sample t-test was used to find the difference between the groups. The Chi-square test of independence for gender variance. The p-value <0.01 was considered statistically significant.

RESULTS

The average age of group A was 45.9±1.7 years, and group B yielded an average age of 46.4±1.8 years, with a between-group mean variation of 0.5 years. The participants of all groups were generally middle-aged adults (from the late 30s to late 50s).

The BMI of group A had a mean of 28.3 kg/m^2 (SD=2.9), and group B had a mean value of 28.8 kg/m^2 (SD=2.4), which showed a slightly higher value. The BMI ranges among all groups were approximately 23.0-34.0 kg/m^2, which implies the study population was at risk of stroke occurrence [Table/Fig-2].

Demographic details		Sample size	Mean±SD	t-value	p-value
Age (in years)	Group A	25	45.920±1.787	-0.97	0.35
	Group B	25	46.420±1.854		
BMI	Group A	25	28.39 ±2.08	-0.55	0.58
	Group B	25	28.82±2.48		

[Table/Fig-2]: Demographic details- average age and body mass index. "Independent t-test", Significance; <0.01 Statistically significant; *SD: Standard deviation;

The gender distribution, which across the groups showed comparable consistency, with males predominantly represented in all groups compared to females are shown in [Table/Fig-3]. Group A comprised an 88% male cohort; group B had 92% males. Only about 8-12% of female participants were included in each group. The participant distribution was uniform across groups.

Gender		Sample size	χ^2	p-value
Male	Group A	22	0.02	0.88
	Group B	23		
Female	Group A	03	0.20	0.65
	Group B	02		

[Table/Fig-3]: Gender distribution of participants. Chi-square test of independence Significance; p<0.01 Statistically Significant

In group A, the average time taken to complete the mS-NHPT reduced from 115.5±3.1 seconds before interventions to 98.6±3.2 seconds after intervention, showing an improvement of 16.8 seconds (t=-49.27, p-value <0.001); the mean FMA-UE increased from 33.12±6.5 points to 45.12±2.06 points with a variation of 12.0 points (t=10.96, p-value <0.001); and the SS-QoL improved from 152.2±12.5 points before intervention to 159.4±12.6 points after intervention, with an average difference of 7.2 points (t=37.63, p-value <0.001) [Table/Fig-4]. The above findings indicate measurable and statistically significant gains in mS-NHPT, FMA-UE, and SS-QoL for subacute stroke subjects with TOT with RAS.

Outcome measures		N	Mean±SD	t-value	p-value
mS-NHPT (seconds)	Pre-test	25	115.55±3.11	49.27	p<0.001
	Post-test	25	98.69±3.25		
FMA-UE	Pre-test	25	33.12±6.58	10.96	p<0.001
	Post-test	25	45.12±2.06		
SS-QoL	Pre-test	25	152.20±12.5	37.63	p<0.001
	Post-test	25	159.40±12.60		

[Table/Fig-4]: Group A- Task-oriented training with Rhythmic Auditory Stimulation (RAS)
Significant difference between the outcome measures within group; Paired t-test Significance; <0.01 Statistically significant; *mS-NHPT: Modified nine hole peg test; FMA-UE: Fugl-meyer assessment- upper extremity; SS-QoL: Stroke specific quality of life

For group B the average time to complete the mS- NHPT reduced from 113.7±3.1 seconds to 88.3±2.4 seconds before and after intervention, an average of 25.4 seconds (t=-42.368, p-value <0.001) [Table/Fig-5]; the FMA-UE improved from 35.1±2.1 points before the intervention to 48.5±3.3 points after the intervention, with an average difference of 13.4 points (t=07.15, p-value <0.001); the SS-QOL increased from 152.3±10.5 points before the intervention to 160.5±11.0 points with an average improvement of 8.1 points (t=23.66, p-value <0.001). The analysis confirmed significant improvements supported by statistical evidence in terms of mS-NHPT, FMA-UE, and SSQoL for subacute stroke subjects with AAT with RAS.

Outcome measures		N	Mean±SD	t	p-value
ms-NHPT (seconds)	Pre-test	25	113.77±3.13	42.36	<0.001
	Post-test	25	88.36±2.49		
FMA – UE	Pre-test	25	35.12±2.19	07.15	<0.001
	Post-test	25	48.56±3.31		
SSQoL	Pre-test	25	152.36±10.52	23.66	<0.001
	Post-test	25	160.52±11.03		

[Table/Fig-5]: Group B- arm ability training with Rhythmic Auditory Stimulation (RAS)
Significant difference between the outcome measures within group; Paired t-test. Significance; <0.01 Statistically significant. *mS-NHPT: Modified nine hole peg test; FMA-UE: Fugl-meyer assessment- upper extremity; SS-QoL: Stroke specific quality of life

the mean improvement in mS-NHPT scores was 16.8±0.4 seconds in group A and 25.4±2.9 seconds in group B (t=-14.107, p-value <0.001); the FMA-UE scores were 10.8±0.4 points in group A and 13.4±2.7 points in group B (t=-3.39, p-value <0.001); and the SS-QOL scores were 7.2±0.9 points in group A and 8.1±1.7 points in group B (t=2.434, p-value <0.001), which showed that group B experienced a significantly greater enhancement compared to group A in terms of mS-NHPT, FMA-UE, and SSQoL for subacute stroke subjects in [Table/Fig-6].

Outcome measures		N	Mean±SD	t	p-value
mS-NHPT (seconds)	Group A	25	16.86±0.462	-14.107	<0.001
	Group B	25	25.42±2.93		
FMA-UE	Group A	25	12.0±2.80	-3.39	<0.001
	Group B	25	13.44±2.74		
SS-QoL	Group A	25	7.20±0.95	2.434	<0.001
	Group B	25	8.16±1.72		

[Table/Fig-6]: Comparison between group A- Task-oriented training versus group B- Arm ability training with Rhythmic Auditory Stimulation (RAS)
Significant difference between the outcome measures between the groups; Unpaired t-test. Significance; <0.01 Statistically significant; *mS-NHPT: Modified nine hole peg test; FMA-UE: Fugl-meyer assessment- upper extremity; SS-QoL: Stroke specific quality of life

DISCUSSION

The study aimed to compare the effects of task-oriented training and arm-ability training with RAS on upper extremity function and QoL among individuals with stroke. The outcome measures were dexterity, upper extremity function and QoL, which were assessed using mS-NHPT, FMA-UE and the 12-SS-QoL. The arm-ability training and task-orientated training with RAS were effective in terms of mean improvement in mS-NHPT in faster completion of the pegboard task after the intervention. The time duration (in seconds) for the task's completion was reduced after the intervention. The FMA-UE had shown a greater improvement among both groups, which enhanced functional ability among the stroke subjects. The SS-QoL had a marked enhancement in functional independence with considerable advancements in mobility, self-care, social roles, etc. Both the task-oriented training and arm-ability training, along with RAS, worked on the principle of motor learning and, with a biofeedback mechanism, have been shown to have a greater impact on dexterity, functional mobility and QoL among individuals with stroke.

Stroke prevention and community-based rehabilitation initiatives advanced the vision of SDG 11 for sustainable cities and communities by fostering environments that are sustainable and resilient, safeguarding both individual health and social well-being and promote equitable participation for people with disabilities. Various advanced techniques have emerged to enhance hand function and improve cognitive function among stroke survivors, yielding positive outcomes in patients with hemiparesis [28]. In a study done by Wang L et al., RAS improved fine motor tasks in subacute stroke, and it promoted cortical reorganisation, enhanced sensorimotor integration, and supported better movement execution [29].

In group A, TOT with RAS, the practised tasks were purposeful, meaningful, and familiar to the tasks of daily living and induced larger and more robust neuroplasticity by incorporating neural pathways through intensive, goal-directed activity and a smooth transition to ADLs [30]. Task-oriented training, combined with RAS, promotes activation of the primary motor and premotor cortices, the supplementary motor area, the basal ganglia, and also the cerebellum and creates rapid, temporally precise, accurate, and consistent integration between sensory input and motor output by accessing biological auditory-motor networks to enhance functional rehabilitation among stroke survivors [31,32].

The AAT combined with RAS yielded superior results compared to TOT with RAS. This improvement may be attributed to the structured, progressive, and repetitive nature of AAT, as indicated by the research of Elizabath A and Kalidasan V (2024), which likely enhanced neuromuscular coordination and sensorimotor integration [33]. Similarly, Baruah T and Hedge S (2025) reported that RAS activated cortical and subcortical motor circuits via auditory-motor entrainment, resulting in better timing and smoother execution of movements [34]. Moreover, task-specific interventions alone may lack the precision and grading required for certain fine motor improvements, supporting the idea that targeted arm training such as AAT may exert stronger effects on motor function recovery by providing more precise sensorimotor feedback.

The superior results observed in group B suggest that targeted arm-ability training may contribute more substantially to functional independence and social participation, thereby leading to improved quality of life. Increasing awareness of therapeutic exercises for stroke survivors aligns with SDG 4 (Quality education) by equipping individuals with essential, potentially life saving knowledge about stroke. The exercise protocols in this study also supported SDG 4 for stroke survivors by incorporating principles of motor learning and biofeedback techniques that promoted accessible learning, thereby strengthening the ability of stroke survivors to achieve healthier well-being within the community.

These findings indicated that both TOT and AAT approaches were effective when combined with rhythmic auditory cues and had shown a positive impact on upper extremity function and quality of life in subacute stroke survivors. However, AAT with RAS was significantly more effective than TOT with RAS. Rehabilitation strategies should focus not only on prevention and restoration of functional capacity and independence but also on enabling workforce reintegration, thereby advancing SDG 8, decent work and economic growth. This approach strengthened economic productivity, enhances work participation, and supports sustainable growth by transforming health recovery into social and economic resilience.

Limitation(s)

The present study involved a small sample size which may have limited statistical power and generalisability. The study did not specifically consider the dominance of the affected hand, which may have influenced functional outcomes. The RAS depended on the patient's auditory processing capacity and engagement with rhythm; not all patients responded equally to cueing. In addition, the follow-up period was limited; a longer duration might have had a greater impact on the neuroplastic changes in the brain, potentially leading to more pronounced improvements in functional independence and psychosocial outcomes for the patients involved.

CONCLUSION(S)

Both interventions produced measurable and statistically significant improvements in dexterity (mS-NHPT), upper limb motor function (FMA-UE), and quality of life (SS-QOL) within their respective groups. Arm-ability training with RAS demonstrated significantly greater gains in mS-NHPT, FMA-UE, and SS-QOL compared to Task-Oriented Training with RAS, indicating a substantial impact

on upper extremity function and quality of life among stroke survivors.

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