NeuroRehabilitation Research Laboratory

Center for Biomedical Research in Music

Kinematic changes following constraint-induced therapy compared to rhythmic-based training in stroke.

Crystal Massie, MSOT,[1] Matt Malcolm, PHD, OTR,[1] Michael Thaut, PHD,[2]

[1]NeuroRehabilitation Research Laboratory and Occupational Therapy Department [2]Center for Biomedical Research in Music, Colorado State University

Colorado State University

College of Applied Human Sciences

Background and Purpose

Recovery of skilled arm function remains a critical focus of stroke rehabilitation because these deficits are among the most debilitating and persistent impairments. The limited efficacy of conventional approaches has likely resulted from two primary deficiencies in intervention strategies: (1) limited attention to learned non-use because traditional neurorehabilitation has focused on passive facilitation of movement, and (2) conventional therapies have placed limited emphasis on improving parameters of quality of movement such as compensatory trunk movement. Dramatic conceptual shifts are emerging in stroke rehabilitation based on interconnected motor learning and neurophysiological principles. The brain's short-term and long-term plasticity has opened new doors to introduce concentrated practice models based on motor learning and sensorimotor facilitation, resulting in substantial and lasting gains in motor function.[1, 2]

As a result of the conceptual shift in stroke rehabilitation, forced-use paradigms such as constraint-induced therapies (CIT) have been extensively developed and researched over the last decade to target learned non-use.[2-5] CIT effectively incorporates important motor learning principles of massed practice, verbal feedback, and grading of functional task practice, and has resulted in dramatic increases in the amount of hemiparetic arm use. This approach, however, falls short of addressing the second historic limitation in neurorehabilitation: quality of movement.

Rhythmic models of motor entrainment, such as rhythmic auditory stimulation (RAS), represent a prominent new approach to stroke rehabilitation that emphasizes quality of movement. RAS enhances motor control in rehabilitation by facilitating planning and execution through a strong entrainment and synchronization effect of repetitive rhythmic sensory signals on the motor system. Research supports RAS as an intervention to improve arm function. Thaut et al.[6] has demonstrated that temporal cueing during a reaching task results in immediate improvements in elbow active ROM, movement speed, and stability of the reaching trajectory. Rhythmic-auditory cuing of arm movements has also been demonstrated as an effective adjunct to rehabilitation programs aimed at improving hemiparetic arm movements by Whitall et al.[7]

The goal of this project was to contrast CIT and RAS as intensive upper-extremity interventions for survivors of stroke. We conducted two separate studies to determine the impact of CIT and RAS on quantitative and qualitative parameters of functional motor performance.

Methods

Participants: All participants met typical minimum motor inclusion criteria for intensive movement-based therapy.[4]

Group	N	Gender	Mean Age (years ± sd)	Time Since Stroke (years ± sd)	Side of Stoke
CIT	10	7 male	61 ± 14.7	2.7 ± 2.0	5 RCVA
RAS	5	5 male	72.5 ± 6.5	0.8 ± 0.5	3 RCVA

Outcomes:
1. Kinematic:
   a. Segmental contribution to reach: shoulder, elbow, and trunk
   b. Movement Time (sec): 4 reaching cycles
2. Functional: Wolf Motor Function Test (WMFT)

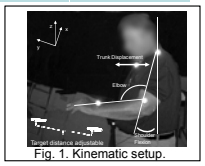

Fig. 1. Kinematic setup.

Kinematic Data Setup: Subjects were asked to reach between two targets as fast as possible. A 3-camera Peak Motus motion analysis system captured the movement at a rate of 60 Hz.

Statistical analysis: Statistical analyses were completed separately on means of pre- and post-CIT and RAS measures of the affected side. Dependent sample *t*-tests were used for all comparisons (α=.05).

Interventions

Constraint-Induced Therapy
- 10 consecutive weekdays: 6hr/day
- Massed practice of functionally-based activities
- Task parameters were manipulated
- Global feedback provided
- Subjects wore a restraining mitt 90% of waking hours
- Examples of activities include making lunch, playing checkers, washing windows

Fig. 2 CIT example training tasks

Rhythmic Auditory Stimulation
- 10 consecutive weekdays: 3hr/day
- Subjects were instructed to move between targets by touching the digits of their affected hand to the assigned targets.
- Different target arrays were selected to systematically increase difficulty or to access differing degrees of freedom
- Five to ten 30-second trials were completed for a given target array
- Digital metronome provided temporal cue

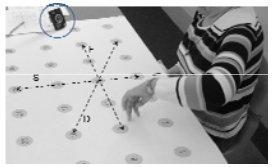
Fig. 3 RAS training template.

Results

Segmental Contribution of Total Reaching Movement

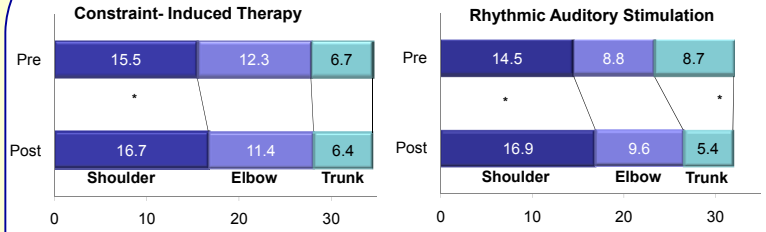

Fig. 4. Following CIT, participants used significantly (*) more shoulder flexion ($p < .05$), yet the changes in trunk and elbow were not significant. Following RAS, increases in shoulder flexion contributed significantly more to the total movement distance ($p < .05$). Amount of trunk movement decreased significantly post-RAS training ($p < .05$). Elbow extension did not significantly change.

Segment	% Change Post-CIT	% Change Post-RAS
Shoulder	+ 7.7 %, p = .034	+ 16.5 %, p = .004
Elbow	- 7.3 %, p = .22	+ 9.1 %, p = .385
Trunk	- 4.5 %, p = .67	- 37.9 %, p = .032

Movement Time

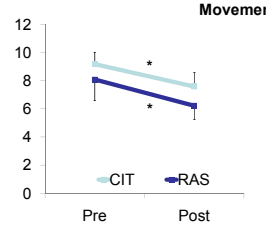

Fig. 5. Participants in both interventions (CIT and RAS) had significant post-training decreases in total reaching time ($p < .05$). **CIT** participants had a **17%** reduction in movement time; **RAS** participants had a **23%** reduction.

Functional Outcome: Wolf Motor Function Test

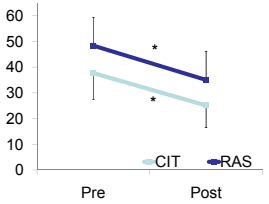

Fig. 6. Participants in both interventions had significant decreases in task completion time during the functional testing ($p < .05$). These decreases indicate a **33%** improvement for **CIT** and a **28%** improvement for **RAS**.

Conclusions

- Post-CIT improvements limited to functional outcomes:
  - ✓ Decreased movement time during continuous reaching and task completion
  - ✓ Increased use of shoulder flexion during reach
  - ✓ No impact on compensatory trunk movement
- Post-RAS improvements in **quality** and **functional outcomes**:
  - ✓ Decreased movement time during continuous reaching and task completion
  - ✓ Increased use of shoulder flexion during reach
  - ✓ Decreased compensatory trunk movement
- The unique and perhaps complimentary benefits of RAS and CIT calls for a synergistic investigation to compare these interventions alone and in combination.

References

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