CASE REPORT

Effect of Choice Stepping Reaction Time (CSRT) Training using Act-React on Reaction Time and Coordination in a Parkinson's Disease Patient: A Case Study

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ABSTRACT

Background: Parkinson's disease (PD) is a neurodegenerative disorder characterized by motor symptoms such as bradykinesia, rigidity, and postural instability, which contribute to delayed reaction times and poor coordination. This study aimed to evaluate the effectiveness of a 2-week Choice Stepping Reaction Time (CSRT) training using the Act-React software in improving reaction time, coordination, and balance in individuals with Parkinson's disease.

Case Summary: A 65-year-old male presented with slowness of movement and balance difficulties diagnosed as idiopathic Parkinson's with Hoehn & Yahr Stage 2.5, who received intervention including 20-minute CSRT training sessions using Act-React software along with Conventional Physiotherapy over two weeks. Study outcomes were assessed using the Choice Stepping Reaction Time Test (CSRTT), Four-Square Step Test (FSST), Timed Up and Go (TUG) Test, and Balance Error Scoring System (BESS).

Outcome Measure: Post-intervention, the patient demonstrated a 55.56% improvement in reaction time (6.3s to 2.84s), an 18% reduction in TUG time (14.8s to 12.1s), a 16% improvement in FSST time (11.4s to 9.6s), and a 25% reduction in BESS errors (12 to 9 errors).

Conclusion: CSRT training using Act-React significantly improved reaction time, functional mobility, coordination, and balance in a Parkinson's disease patient. This intervention shows promise as a rehabilitation tool for addressing motor deficits in PD.

Keywords: Parkinson's disease, Choice Stepping Reaction Time, Act-React software, reaction time, coordination, balance, postural instability.

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INTRODUCTION

Parkinson's disease (PD) is the second most prevalent neurodegenerative ailment in older adults, resulting from the progressive impairment of the basal ganglia. It is defined by primary motor symptoms, including resting tremor, rigidity, postural instability, and bradykinesia [1]. Bradykinesia, a prominent symptom of Parkinson's disease (PD), is commonly characterized by reduced movement speed. Still, it is also linked to diminished spontaneous movements, reduced movement amplitude, and prolonged reaction times (RT) [2, 3].

Reaction time and coordination are critical for maintaining balance and preventing falls, especially in individuals with PD. Delayed reaction times can result in inadequate responses to environmental cues, leading to instability and increased fall risk. Therefore, interventions that target these deficits are essential for improving the quality of life in PD patients [4].

Traditional rehabilitation approaches, such as physiotherapy and cue-based interventions, have shown promise in improving gait performance [5]. However, understanding the effectiveness of reaction time-based interventions in modulating step initiation and movement execution remains an area of ongoing research. Recent studies have reported promising effects of reactive step training (e.g., repeated perturbations) and volitional step training (e.g., stepping onto step targets in multiple directions) for reducing falls in people with PD [6].

The choice stepping reaction time test is an evaluation tool used to determine an individual's ability to initiate and carry out a step quickly. The individual must move as fast as they can on one of the multiple targets that are positioned in front of them [7]. A significant research gap exists in the development of accessible and cost-effective interventions to assess and improve reaction time in Parkinson's disease. Exergaming and training setups are often not feasible for widespread use due to cost and accessibility limitations [8, 9]. The Act-React software provides an engaging platform for CSRT training, utilizing a dual-task approach with visual cues to enhance functional and efficient motor responses.

This study aimed to evaluate the effectiveness of a 2-week CSRT training program using Act-React in improving reaction time, coordination, and balance in a Parkinson's disease patient. The objectives were to assess improvements in functional mobility and coordination using standardized tests (TUG, FSST), measure changes in balance and postural stability using BESS, and explore the feasibility of integrating CSRT training into early-stage PD rehabilitation programs.

Patient Information:

A 65-year-old male with right-hand dominance presented with slowness of movement, difficulty in balance, and delayed step initiation leading to occasional near-falls. Independent in activities of daily living, but reports slowness and increased fear of falling. No family history of neurodegenerative conditions. Non-smoker, non-alcoholic. Lives with spouse, supportive home environment. Diagnosed as idiopathic Parkinson's disease (Hoehn & Yahr Stage 2.5) with a history of diabetes for 8 years and on medications, taking levodopa-carbidopa combination therapy. No known drug allergies.

Physical Examination:

Patient Height: 168 cm, Weight: 74 kg, BMI: 26.2 kg/m², reduced spontaneous movements and diminished facial expressions, with increased rigidity in both upper and lower limbs (cogwheel type), Bradykinesia - Present, affecting initiation and execution of movements and speech. Impaired Postural reflexes, mild resting tremor predominantly in the left hand, difficulty with rapid alternating movements, shuffling gait, reduced arm swing, occasional freezing episodes, increased cadence, and increased sway noted in the standing position. Able to balance with eyes open, and bilateral stance on a firm surface without support.

Diagnostic and Assessment:

A 65-year-old male with idiopathic Parkinson's disease (Hoehn & Yahr Stage 2.5) participated in this study. He had no severe cognitive impairment and was able to follow instructions for the training protocol. Choice Stepping Reaction Time Test (CSRTT) was used to measure stepping reaction time using Act-React. The test involves responding to visuoauditory cues by stepping on colored targets. The reaction time is recorded from cue prompt to step completion with good Test–retest reliability (intraclass correlation coefficient =0.74, 95% CI=0.45–0.88, p<0.001) [10] Four-Square Step Test (FSST) as shown in figure A used to assesses dynamic balance and coordination with its Interrater (intraclass correlation coefficient [ICC] = 0.99) and test-retest reliability were high (ICC = 0.78) [11]. Timed Up and Go (TUG) Test, as shown in Figure B- Evaluates functional mobility and fall risk. Excellent Test-retest and intra-examiner reliability (0.95 ≤ intra-class correlation coefficient (ICC)≤0.99) [12]. Balance Error Scoring System (BESS), as shown in Figure C, Measures postural stability through error count. The BESS demonstrated moderate to high reliability (interclass correlation coefficient = 0.87) and low to moderate validity (sensitivity = 34%, specificity = 87%) [13].

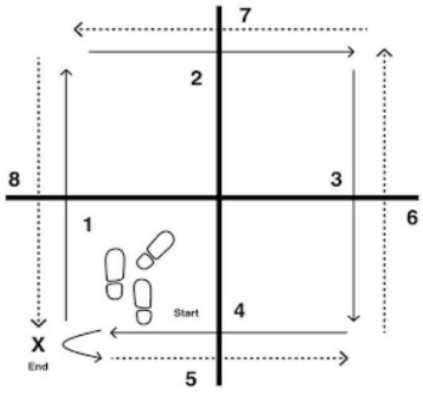


Figure A: Four-Square Step Test

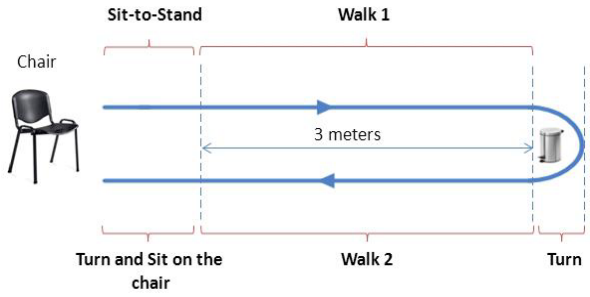


Figure B: Timed up and Go Test

BESS Score Card (# of errors)	Firm Surface	Foam Surface
Double Leg Stance		
Single Leg Stance		
Tandem Stance		
Total Scores		
BESS Total		

Figure C: Balance Error Scoring System

Interventions:

Baseline data were collected as follows: Reaction Time - 6.3 Seconds, Four Square Step Test – 11.45 seconds, Timed Up and Go Test – 14.8 seconds, and Balance Error Scoring System – 12 errors were recorded.

The Choice Stepping Reaction Time (CSRT) Training was conducted on a clear, non-slippery floor space over 2 weeks, with five sessions per week, each lasting 20 minutes. The training protocol was designed to enhance reaction time, dynamic balance, and coordination by integrating visuo-auditory cues with stepping tasks. Three colored bottles (Red, Green, and Blue) were placed at equal distances in front of the participant. Custom-developed stopwatch-based app "Act-React" was used for reaction time measurement with Warm-up (5 minutes), including gentle mobility exercises for the lower limbs (ankle circles, knee lifts, weight shifts) to prepare for stepping movements, followed by CSRT Training Session (20 minutes), including standing in a comfortable stance with feet hip-width apart.

Patient was instructed to step toward a specific-colored bottle using the correct foot as fast as Possible. Example cues:

- "Right Red" → Step onto the Red bottle with the right foot
- "Left Blue" → Step onto the Blue bottle with the left foot
- The reaction time (one lap- from cue to foot placement) was recorded using "Act-React". After each session, the therapist provided real-time feedback on reaction time, accuracy, and balance. If the participant hesitated or made an incorrect step, the trial was repeated to reinforce learning. Cool-down (5 minutes), including gentle stretching for the lower limbs to prevent fatigue and enhance flexibility.

Progressive Difficulty Levels

- Week 1: Single-step tasks with moderate-speed cues.
- Week 2: Increased cue speed and introduction of dual-task challenges.

Figure D: Shows participant performing CSRT Training

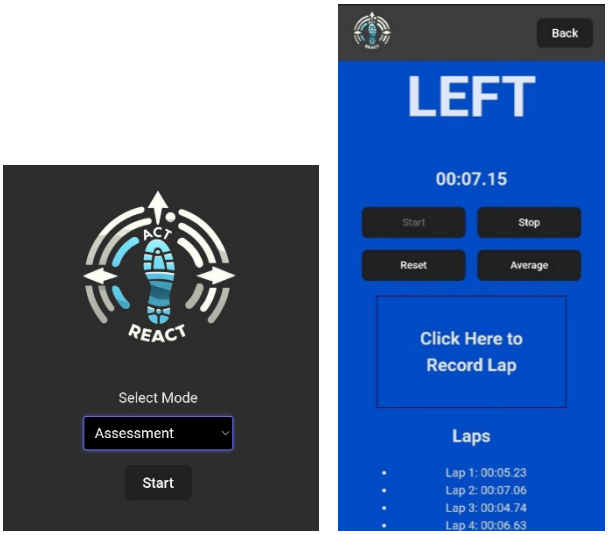
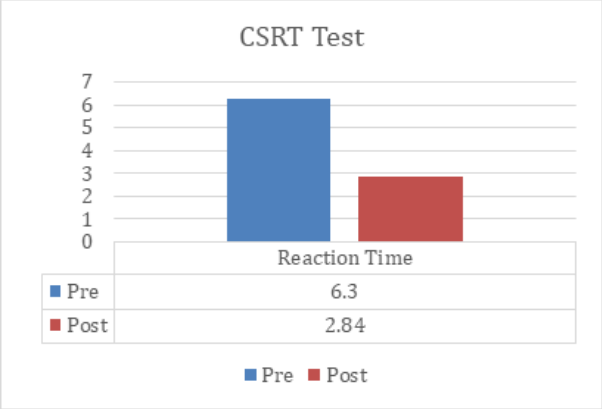


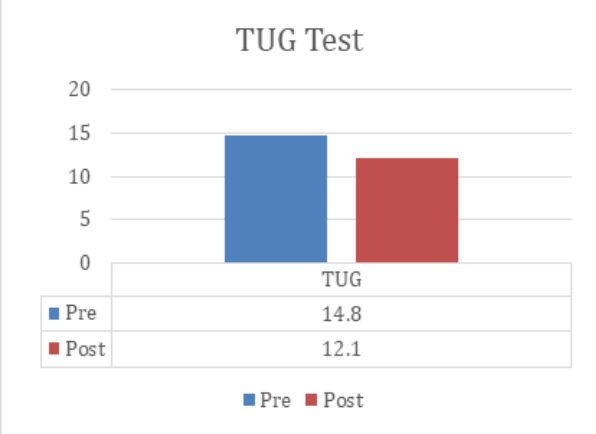
Figure E: Shows Act-React software model

Follow-up and Outcomes:

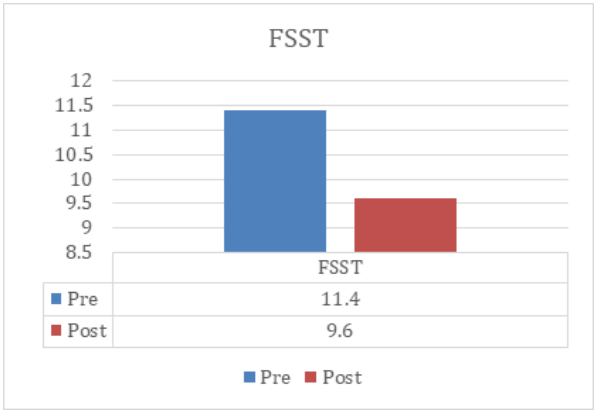
The 2-week Choice Stepping Reaction Time (CSRT) training using Act-React demonstrated significant improvements across all measured outcomes. Reaction time improved by 55.56% (6.3s to 2.84s), indicating enhanced cognitive-motor integration. Functional mobility, assessed by the Timed Up and Go (TUG) Test, showed an 18% reduction in completion time (14.8 seconds to 12.1 seconds), suggesting improved mobility and a reduced fall risk. Coordination, evaluated through the Four-Square Step Test (FSST), improved by 16% (11.4s to 9.6s), reflecting greater motor control. Additionally, postural stability, measured by the Balance Error Scoring System (BESS), improved with a 25% reduction in errors (12 to 9 errors). These results collectively highlight the effectiveness of CSRT training in addressing key motor deficits in Parkinson's disease. After completion of the 2-week CSRT training, the patient was advised to continue with conventional physiotherapy and a home exercise program. At a 3-week telephonic follow-up, the patient reported that the improvements in mobility and step initiation were maintained, with no new falls or adverse events. However, mild bradykinesia persisted during daily activities.



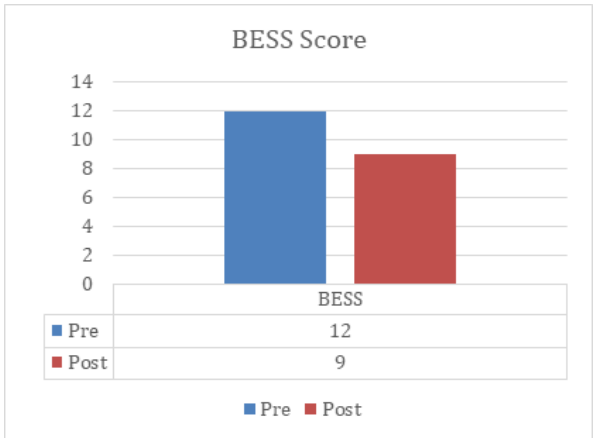
Graph 1: CSRT Test reaction time improved by 55.56%.



Graph 2: TUG Test Mobility time recorded 18 % improvement.



Graph 3: FSST Coordination improved by 16%.



Graph 4: Balance error reduced by 25% . indicating improved postural stability.

DISCUSSION

The findings from this study demonstrate that CSRT training using Act-React is an effective protocol for improving reaction time, functional mobility, coordination, and balance in Parkinson's disease patients. The integration of visuoauditory cues and cognitive-motor tasks addresses key motor deficits and enhances dual-task performance, which are critical for reducing fall risk and improving daily functioning.

The results align with previous studies, such as Pelicioni et al. 2023 [6], which found that combined reactive and volitional step training improved balance recovery and stepping reaction time in PD patients. Similarly, Okubo et al. 2016 [4] reported that step training interventions significantly reduced fall rates and improved reaction time and balance in older adults.

The improvement in reaction time (55.56%) suggests that the Act-React software effectively trains cognitive-motor integration, which is often impaired in PD patients. The reduction in TUG time (18%) and FSST time (16%) indicates enhanced functional mobility and coordination, which are essential for navigating daily activities. The decrease in BESS errors (25%) further supports the effectiveness of CSRT training in improving postural stability.

However, this study has limitations, including a small sample size (single case study), a short-term intervention period, and the lack of a control group. Future studies should explore larger-scale trials with diverse PD populations, investigate long-term effects, and examine the impact of CSRT training on other neurological conditions.

CONCLUSION

CSRT training using Act-React significantly improved reaction time, functional mobility, coordination, and balance in a Parkinson's disease patient. This intervention shows promise as a rehabilitation tool for addressing motor deficits in PD and warrants further investigation in larger clinical trials.

Conflict of Interest:

The author declares that there is no conflict of interest regarding the publication of this paper.

Ethical Considerations:

Ethical approval was not required for this study as it involved a single-case experimental design with no invasive procedures or risks to the participant. The participant provided informed consent before participating in the study.

Intellectual Property Statement:

The Act-React software used in this study is a proprietary tool developed specifically for this research. The software, including its design, functionality, and methodology, is the intellectual property of the author and their affiliated institution. Unauthorized use, replication, or development of similar software based on this work is strictly prohibited without prior written consent from the authors. For

inquiries regarding the use of the software, please get in touch with the corresponding author.

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