

Design and preliminary testing of an XR-based gait feedback therapy protocol for chronic stroke

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Background

Gait impairments are common in those recovering from a chronic stroke, which mostly impose restriction on mobility and independence of the individual. Rehabilitation, therefore, plays an essential role in the improvement of functional walking patterns for quality-of-life improvement. Conventionally, training on treadmills or with the use of mirror therapy does not provide either real-time feedback or particularly engaging environments to optimize motor learning. Now, in these therapies, Extended Reality (XR) technologies offer a new solution by integrating real-time visual feedback and interactive elements into the therapy session. Allowing patients to see what they are doing and track their progress with real-time feedback, XR creates an immersive environment. This paper illustrates the design and protocol proposal of an XR-based system for gait feedback during chronic stroke rehabilitation.

Methodology

XR Device Technical Features

The XR-based gait feedback system is designed as a light, portable solution integrated with smart glasses or a VR headset equipped with a downward-facing camera. Key features include:

Real-Time Foot Monitoring: A downward-facing camera tracks the user's foot movements and stride patterns in real-time. Augmented visual overlays display alignment markers and stride symmetry feedback within the user's field of view.

Augmented Reality (AR) Visualizations: Customizable overlays of footstep alignment guides, gait trajectory arrows, and pressure distribution heatmaps mean better patient insight into their gait patterns. Stride length or step symmetry deviations produce immediate alerts.

Data Analysis and Tracking: It records session data, including step counts, stride times, and gait symmetry ratios. A companion app will summarize these metrics, showing therapists progress over time, to help them modify the goals of therapy.

Interactive Features for Engagement: Patients engage in gamified visual elements, such as stepping on virtual targets, which preserve interest and motivation within repetitive tasks.

Accessibility and Portability: The device is a light AR headset and smartphone-compatible for usability across clinical settings or at home.

Study Design and Treatment Protocol

The single-group pretest-posttest design will pilot the effects of the XR gait feedback system on mobility and functional walking. The protocol will be completed in ten therapy sessions over five weeks, once a week, each time 30 minutes. This study will examine these mobility and functional walking among chronic stroke patients before and after 8 weeks of training using XR.

Pretest and Posttest Measures

Outcome is measured using three validated mobility assessments:

Timed Up and Go (TUG) Test: This test measures dynamic balance and agility by recording the time taken by a patient to stand up from a sitting position, walk 3 meters, turn around, and walk back to the chair.

6-Minute Walk Test (6MWT): Measurement of endurance and walking ability, measuring distance in six minutes under standardized conditions.

Gait Analysis Metrics: The XR device will, therefore, be used in recording stride length, step time, and gait symmetry during sessions to provide more biomechanical information.

Therapy Sessions

Each session will start with a 5-minute warm-up and 20 minutes walking on a treadmill using the XR device, followed by a 5-minute cool-down. Participants will be encouraged to follow the AR cues for stride length correction and step symmetry. System feedback will direct them in real-time to improve coordination and posture.

CONCLUSION

The proposed XR-based gait feedback system is a fresh and potentially transformative approach in the area of gait rehabilitation for chronic stroke patients. This device, with real-time visual feedback, augmented reality cues, and advanced data analytics, overcomes some of the main limitations of traditional rehabilitation methods: poor engagement due to lack of feedback and poor precision in gait analysis. Its portability and interactive features make it suitable for use in both clinical and home-based settings, increasing accessibility and patient adherence.

Strengths of the design include integration of real-time feedback, which may promote motor learning through immediate error correction opportunities (Lewek et al., 2018). The ability to track and analyze quantitative gait parameters enhances its clinical utility in line with best practices identified in digital rehabilitation tools (Chen et al., 2022). Moreover, the gamified and interactive design potentially elevates the motivation of patients, which is an important factor for adherence to stroke rehabilitation programs (Laver et al., 2017).

However, the system also presents limitations. Initial costs associated with XR technology may hinder its adoption, particularly in resource-limited settings. Furthermore, patients and therapists may require training to effectively utilize the device, and its applicability to individuals with severe motor impairments remains uncertain.

To address these challenges, future research should focus on the conduction of randomized controlled trials in order to validate the efficacy of the device in larger and more diverse cohorts. Features such as haptic feedback and the ability for cloud-based tele-rehabilitation will further increase its impact. Further, reduction in production costs and exploration of scalable deployment models will be important for wide adoption.

Finally, this XR-based gait feedback system shows considerable promise as a novel, engaging, and effective means of stroke rehabilitation. Therefore, XR technologies, continuing to evolve themselves, surely open up all the more exciting frontiers for individually tailored, data-driven therapeutic interventions with potentials of notably improving patient outcome and their quality of life.

References:

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