Feasibility and Expert Acceptance of a Virtual Reality Gait Rehabilitation Tool

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Figure 1: (Left) Setup of the HTC Vive headset, controllers, trackers, and desktop computer. (Right) Third person view of the patient’s avatar represented with virtual body tokens for the head, hands, and feet. A virtual mirror is placed in the environment to assist patients to perceive their movement, while trying to overcome obstacles (e.g., barriers).

ABSTRACT

We present LocomotiVR, a Virtual Reality tool designed with physiotherapists to improve the gait rehabilitation in clinical practice. The tool features two interfaces: a VR environment to immerse the patient in the therapy activity; and a desktop tool operated by a physiotherapist to customize exercises and follow the patient’s performance. Results revealed that LocomotiVR presented promising acceptability, usage, and engagement scores. These results were supported by qualitative data collected from participating experts, which discussed high levels of satisfaction, motivation, and acceptance to incorporate the LocomotiVR in daily therapy practices. Concerns were related to patient safety and lack of legal regulation.

Index Terms:  
Human-centered computing—Human computer interaction (HCI)—Interaction Paradigms—Virtual Reality

1 INTRODUCTION

Gait rehabilitation is a post-injury process that helps patients regain balance and locomotion [1] while decreasing the risk of falls and improving patients’ quality of life. Visual inspection is a common clinical practice during physical rehabilitation, which makes it hard for professionals to collect quantitative data on patients’ performance during rehabilitation exercises. This limitation can lead to inaccurate assessments of physical abilities, less than the optimal suggestion of therapeutic activities, and longer rehabilitation processes. Moreover, it can also affect the patients’ motivation and raise doubts about the benefits of rehabilitation, especially when exercises are repetitive and tedious. Thus, more innovative approaches are necessary.

For example, Virtual Reality (VR) combined with gamification techniques has revealed to simultaneously increase the participation and motivation of patients and the frequency, duration, and intensity of gait rehabilitation exercises [2]. Furthermore, VR allows the design of personalized environments that support different types of gait exercises, while also providing audio-visual biofeedback in real-time to allow more quantifiable therapies. Although several studies point to VR as a viable and effective solution to improve spatiotemporal and functional gait parameters, there is still a low adoption and acceptance of VR in clinical practice [3]. To investigate this problem, it is fundamental to understand how relevant stakeholders, particularly physiotherapists, are open to accepting VR technology in their clinical practice and if they find VR feasible for gait rehabilitation [3]. To better understand the feasibility and expert acceptance of VR in gait rehabilitation, we developed a novel low-cost, portable, engaging, and interactive system for gait rehabilitation that uses the HTC Vive and Vive Trackers to place the user in a virtual gym while tracking head, hands, and feet.

2 METHODS

This work followed a user-centred design process with five sequential stages: (i) identification of needs and requirements of rehabilitation professionals for gait rehabilitation; (ii) development of an immersive VR tool that allows users to perform different gait exercises; (iii) development of a desktop tool to set up and customize gait rehabilitation sessions, access important gait parameters, and visualize virtual sessions from third-person and/or patients’ viewpoints; (iv) evaluation of the VR tool to customize gait parameters, visualize motion, provide visual and audio feedback about task performance, and measure gait parameters; and (v) feasibility testing session with physiotherapists to evaluate the tool and its acceptability.

In the first stage, we conducted several observational sessions, semi-structured interviews, and focus group discussions next to 3
physiotherapists (15, 19, and 33 years of experience) to identify
the most common exercises used during gait rehabilitation sessions,
barriers and facilitators of clinical use and acceptance regarding VR
and gamification, and listing the needs and requirements of experts
in gait rehabilitation.

The second and third stages comprised the development of Lo-
comotiVR, composed of an immersive VR and a desktop tool. All
software was built using Unity 3D (2018.4.26) and C# scripting
programming language. In addition to the HTC Vive headset and
controllers, which track the head and hands, we included Vive Track-
ers and Track straps attached to the user’s feet (Figure 1 (A)).

Figure 2: VR gait rehabilitation exercises: (A) overcoming barriers,
(B) forward walking with third and (C) first person views, and (D)
zigzagging traffic cones.

The patient’s avatar was represented with a minimalist set of
body segments following Kondo et al. [4] (Figure 1). The VR tool
included three gait rehabilitation exercises: overcoming barriers,
forward walking, and zigzagging traffic cones (Figure 2). When pa-
tients perform a faulty movement, such as stumbling upon a barrier,
touching the edges of the aisle or hitting a traffic cone, LocomotiVR
provides corrective visual and audio feedback (Figure 2 (A) and
(B)). All exercises can be personalized by the professional to fit
the patients’ rehabilitation needs. The desktop tool provides the
therapist access to the third and first person views of the patient
inside the 3D environment (Figure 2 (B) and (C)), a control panel
with rehabilitation session parameters, and a progress panel to track
patient performance in real time. The interface enables the control
of the exercise setup (time, number of repetitions, the height of
the barriers on the “Barriers” exercise), viewpoint customization,
3D environment selection, body tracking settings, or metric display
(cadence, balance, stride length).

The fourth stage consisted of evaluating the ability of the VR tool
to customize gait parameters, visualize motion, provide visual and
audio feedback about task performance, and measure gait parameters.
For this purpose, we demonstrated and explained the features of Lo-
comotiVR to all participants belonging to the testing sampling group
of 9 physiotherapists (9 to 33 years of experience). Afterwards, each
participant used the VR tool as a patient for all rehabilitation exer-
cises. Next, participants were asked to set a rehabilitation session
and supervise it while others completed the exercises.

In the fifth and final stage, we used the Unified Theory of Ac-
ceptance and Use of Technology (UTAUT) questionnaire (7-point
Likert Scale, 1 meaning “strongly disagree” and 7 “strongly agree”)
and semi-structured interviews to measure the tool’s acceptability,
satisfaction, and motivation.

3 FINDINGS
We employed a user-centred design approach to inform the develop-
ment of the immersive VR system. This process resulted in design
guidelines that should be followed when designing VR rehabilitation
tools: (i) the system should require little effort to learn and use; (ii)
the tool should provide a useful experience and be embedded in
current rehabilitation practices; (iii) it should provide reliable data
and meaningful visualisations from each session; (iv) the system
should allow customization of the exercises to fit the wide range
of patients’ needs and their abilities; (v) it should utilize unique
features related to VR. Furthermore, the VR tool should serve not
only as a tool for patient rehabilitation but to also enable physiother-
apists to partake in the virtual therapy sessions. Still regarding the
requisites of LocomotiVR, the professional referred that the system
should be highly configurable with multiple settings that allow more
exercise-related information to be displayed on the screen.

During the feasibility and acceptance study, all participants suc-
cessfully used both tools (VR and desktop) for the three immersive
exercises. Participants’ comments during the study highlighted
that both tools were engaging and useful concerning acceptability,
satisfaction, and motivation. Afterwards, participants answered
the UTAUT questionnaire. All physiotherapists reported that both
tools are easy to use as they could effortlessly interact with the VR
and desktop interfaces, providing positive responses regarding per-
formance expectancy (M=5.00, IQR=2.00), facilitating conditions
(M=6.67, IQR=1.00), usage intentions (M=6.25, IQR=1.75), and
effort expectancy (M=6.50, IQR=1.00). Participants reported that
the facilitating conditions were positive (M=6.67, IQR=1.00); they
demonstrated adequate technical skills to operate the VR tool and
showed openness to adopt the VR and desktop tools in their working
environment. Participants reported a positive perception of trustworth-
iness (M = 5.00, IQR = 2.00) and mentioned that the level of trust
would easily increase the more they used the system. All partici-
pants considered that the proposed VR tool exerts a significant social
influence upon patients (M=6.00, IQR=2.00) and emphasized that
the VR environments were captivating, which could help keep pa-
tients motivated and engaged. However, most participants reported
concerns about the safety of their patients, the possible side effects
of malfunctions associated with LocomotiVR and the lack of formal
regulation and safety standards for VR technologies. Legal concerns
were most affecting (M=3.00, IQR=3.00) while the outcome for
ethical reservations was slightly above neutral (M=3.67, IQR=2.00).

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