# *Virtual reality training to improve upper limb motor function in multiple sclerosis: A feasibility study*

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***Abstract*****—** Study objective was to evaluate the safety and feasibility of Virtual reality (VR) motor and cognitive training with the innovative Oculus-rift device in Patients with Multiple Sclerosis (PwMS). 30 PwMS practiced two VR games that require arm and shoulder movements. Following the VR training session participants completed questionnaires and the physiotherapist in charge of the training session completed a report assessing exercise performance, fatigability and safety of the training. Patients and examiner reported overall significant satisfaction regarding the VR training session and experience. Minimal adverse effects were recorded. Examiner reported that the VR training provided a suitable solution for PwMS. VR was found feasible and safe to use for PwMS.

***Keywords— Virtual reality, Multiple sclerosis, Motor-Cognitive training***

## I. INTRODUCTION

VR training presents a motivational and effective out-patient treatment approach with unique tracking and monitoring capabilities for targeted neurorehabilitation. VR was reported to improve range of motion and muscle strength in MS patients with upper limb function deficits. Since 2016 immersive VR headsets such as Oculus Rift became available for consumer use and the technology became accessible for medical use via medical VR start-ups (e.g. VRHealth Ltd.). Immersive VR is considered a fourth-generation computing system and differs from third generation systems (e.g. Kinect) in its ability to fully control and monitor both the patient and his/her environment, and to generate closed biofeedback loops for rehabilitation. Oculus Rift station with touch controllers was used in this study. VRHealth applications for motor and cognitive rehabilitation that provide guided motion trainer with different cognitive tasks were applied. VRHealth's software-only medical devices are physical medicine and rehabilitation software, intended for tracking motion and movement kinematics and guiding patients in the performance of physical and cognitive exercises according to the treating medical practitioner's guidelines.

VRHealth software-only medical devices are cleared for marketing in the U.S. by the Food and Drug Administration (FDA), Europe (EC certification) and Israel (AMAR). All data from the study's raining was collected in real-time to a medical server, including raw motion data and event marks from within the game. The study protocol was approved by the ethic committee in Sheba Medical Center.

## II. OBJECTIVES

Evaluate the safety and feasibility of VR motor and cognitive training with an Oculus rift station in MS patients with upper limb motor dysfunction. Collect raw data and performance-related questionnaires assessing the quality and relevance of data and training provided by the platform in order to improve the system and to better structure future studies. Raw data was collected at 90 Hz at six degrees of freedom in a Cartesian coordinate system. From this raw data VRHealth software provides data as movement speed, acceleration, movement action time, movement response time and number of mistakes in the required performance.

## III. METHOD

Thirty MS patients, with moderate weakness in upper extremity muscles as defined by the British Medical Research Council (BMRC) - grade 4 in two muscle groups, or grade 3 in one muscle group were included in the study. Patients with visual, cognitive and/or hearing impairments were excluded from the study. Patients practiced two games that require arm and shoulder movements in various directions, including reaching forward towards moving targets. Training could be performed either while sitting or standing, according to patient convenience. Training started with a motor trainer called "Balloon Blast" which is an upper extremity and full body rehabilitation and Active Shoulder ROM Assessment Application. In this game the patient needs to pop a line of balloons with a swipe of a sword, using both hands. Following a five-minute rest, training was resumed with the second trainer termed "Color Match" which is a Motor Cognitive Training and Evaluation Application. In this game the patient wears two virtual gloves in different colors and is required to hit light bulbs whose color matches the color of their glove. Initial speed and game area were set to medium level, which was defined as 3.6 seconds between a light goes on until it

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goes off and allows the patient to act between that gap. Dynamic speed was turned on (i.e. required speed adaptation according to performance). During the training data was recorded to provide range of motion, quality of motion, action time, response time, and omission and commission mistakes. Omission mistakes were defined as light bulbs that were not touched in the given time, and Commission mistakes were defined as light bulbs that were touched with the wrong hand. Data analysis was performed automatically by the software and showed a summarizing graph after each session. For each trainee, the strong and the weak upper extremity were trained separately. Training session duration was 30 minutes. Exercise performance, fatigability and safety of the training were assessed by the patient and the trainer by targeted questionnaires that are covering the feasibility to perform the VR accurately and any intervention-related adverse events. Specifically, each subject answered four questionnaires with a choice from 1 to 4; 1 = strongly disagree, and 4 = strongly agree. In order to assess the intervention-related safety and adverse effects, the patients were asked to rate with the same criteria also the adverse effects which they were experienced from a list of anticipated adverse effects (fatigue, dizziness and nausea). Other effects have also been documented.

## IV. RESULS

For the Balloon blast game, subjects reported that the game was fun (3.73±0.52), simple to understand (3.67±0.71), simple to perform (3.43±0.86), challenging (3.10±1.03) and a task they would repeat (3.63±0.72). Similarly, for the Color match game, subjects reported that the game was fun (3.47±0.78), simple to understand (3.6±0.72), simple to perform (3.53±0.73), challenging (3.17±1.02) and a task they would repeat (3.4±0.97). For the overall VR experience, patients reported that during the VR training session they felt physical exertion (2.3±1.09), cognitive exertion (2.5±1.04) and that training was focused (3.2±0.89). Patients reported high level of agreement with the following statements: Practicing in a form of a game is appropriate for me (3.63±0.61); Practicing in VR allowed me to focus on the training without distractions (3.70±0.53); I was interested in the information that was presented to me after the VR training session (2.8±1.06); The information that was presented to me after the VR training session gave me added value on my condition (2.6±1.07);
Using this tool at home will help me adhere to practicing over time (3.33±0.88); if I had a tracking tool on my cognitive condition based on VR, I would like to use it at home (3.57±0.68). The training examiner reported that the VR software provided a suitable solution for most of the practicing MS patients (86.67%) For two patients, the cable of the head-mounted display interrupted the training (6.67%) and two patients felt fatigue and stopped the training session before it was over (6.67%). No other intra-operative complications occurred during the training sessions (86.67%). The adverse effects data was summarized as follows: fatigue (1.9+0.96), temporary dizziness (1.57±0.77) and temporary nausea (1.17±0.46). Unanticipated adverse effects were not reported. All of the anticipated adverse effects are temporary adverse effect which may occur following the use of VR technology. These adverse effects cannot cause any serious injury or deterioration in the patient's health and are naturally disappear within a short time.

## V. CONCLUSION

The VRHealth medical software and training found to be safe, fun, simple to understand, simple to perform, challenging and a training that patients would like to perform at their own home. Aside from minor anticipated and temporary adverse effects, caused by the use of VR technology, no other adverse effects were reported. The training is performed under trainer supervision, which allows safe training with adjustments to the physical and cognitive states of the patient. The VRHealth medical-software found to be very good solution for engaging patients to perform training that can be fun and helpful for upper extremities weakness and cognitive training. The data collected can help design future studies for VR assessment and training for MS patients.

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