Feasibility of Home-based Virtual Reality Rehabilitation for the Upper Extremity in Subacute and Chronic Stroke

Study Protocol

NCT03559829

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The *Feasibility of Home-Based Virtual Reality Rehabilitation for the Upper Extremity in Subacute and Chronic Stroke Study* seeks to explore the safety, usability, and efficacy of a home based virtual reality biofeedback system to promote distal upper extremity (wrist and hand) recovery after stroke. The purpose of the study is to assess the feasibility of using a home-based virtual reality system to increase the dose of upper extremity rehabilitation in subacute and chronic stroke patients.

BACKGROUND

Stroke

Every year over 700,000 people in the US suffer at stroke. Upper extremity impairment is very common after stroke, and 15-30% of stroke survivors experience ongoing weakness in the affected arm (Van der Lee et al., 1999). The most common motor disorder which occurs after stroke is paresis, which is the inability to voluntarily activate motor neurons (Sathian et al., 2011).

Distal upper extremity strength is required to complete a number of activities of daily living (ADLs), including feeding, grooming, dressing, writing, and typing. The ability to perform such ADLs is strongly tied to quality of life (QOL) in stroke survivors (Wolf et al., 2006). However, even after intensive rehabilitation of the upper extremity, only 5-20% of patients achieve complete functional recovery (Nakayama et al., 1994).

Recent interventions for upper extremity rehabilitation in stroke including constraint induced movement therapy (CIMT) and robotic therapy. Constraint induced movement therapy involves immobilization of the non-paretic arm for 90% of waking hours and high-repetition task oriented training for at least six hours per day. Despite early studies showing some promise for motor recovery, a recent meta-analysis of 38 articles concluded that the evidence for the superiority of CIMT in comparison with other rehabilitative interventions is weak (Etoom et al., 2016).

Robot assisted arm training involves either passive movement of the affected upper extremity, or partial assistance through a movement pattern using an electromechanical device. Many of the robotic devices can also adapt as a patient recovers strength by providing less assistance or more complicated movements. While there are a number of such robots on the market, the results of studies examining facilitation of motor recovery have been mixed. A recent Cochrane Review concluded that robotic use may lead to improvements in strength and ability to perform ADLs, however they also cautioned that the quality of evidence was very low (Merholz et al., 2015).

In this pilot study, we propose to test a virtual reality home-based intervention as an alternative or supplement to traditional rehabilitation for upper extremity weakness after stroke. We are hoping to discover that the device is easily adopted by patients and increases the dose of rehabilitation, as well as potentially leads to motor recovery.

With the increasing affordability and accessibility of virtual reality (VR) systems, VR has emerged as a new platform for stroke rehabilitation. VR therapy involves using computer-based programs to simulate daily tasks and events. VR has shown promise in both allowing patients to practice activities that directly translate to their ADLs, as well as motivating them by providing a novel and interesting virtual environment. A recent Cochrane Review of VR based rehabilitation interventions concluded that it may be beneficial in improving upper limb function and ADL function, though it is unknown if these gains are sustained in the long term (Laver et al., 2015).

The RAPAEL Smart Glove is a biofeedback device designed for distal upper extremity rehabilitation in stroke survivors. It consists of a glove-shaped sensor device and a software application which can be used with either a large screen or a portable tablet. There are multiple ADL based training games, and the system tracks the motion and posture of the wearer's distal limb as they participate. Games can be selected to focus on certain movements, such as forearm pronation/supination, wrist flexion/extension, finger flexion/extension, etc based on the needs of the wearer.

A recent single-blinded, randomized controlled trial of 46 stroke survivors compared the Smart Glove combined with standard occupational therapy (OT) to dose matched conventional upper extremity OT. The primary outcome was change in the Fugl-Meyer (FM) assessment, with secondary outcomes including fine motor tasks and quality of life (QOL) measurements. The study found greater improvements in motor impairment and QOL in the Smart Glove group (Shin et al., 2016).

Primary Hypothesis
The Neofect Smart Glove VR system will be easily adopted for home-based use, and will increase the dose of upper extremity rehabilitation received by patients with subacute and chronic stroke.

Relevance
Regaining upper extremity function is very important for stroke survivors to increase their independence and ability to perform ADLs. The large majority of outpatient stroke rehabilitation currently takes place in a therapy clinic, however access is often limited by resource allocation, financial hardship, and transportation difficulties. The Smart Glove can provide an inexpensive and convenient means for stroke patients to continue their rehabilitation in the comfort of their own home.

Patient Population
Subacute and chronic stroke patients presenting with upper extremity weakness, as identified by Stanford physicians in clinic, will be eligible for participation in this study. Patients will be screened and selected from the population of people with strokes who are seen in the Stanford Neuroscience Clinic. Patients will be allowed to participate in any scheduled outpatient rehabilitation during the study. The doctor and/or research coordinator may introduce the

study to potential candidates in-person in the Stanford Neurology Clinic, and the research coordinator may contact potential candidates by phone after the doctor's referral.

Study Sites
The Stanford University Medical Center will be the Coordinating Center for this study. Stanford's CTRU and the Neurology Outpatient Clinic will be used for study visits and assessments.

Inclusion Criteria:
1) Age 18 and older
2) Diagnosis of stroke at least three months prior to enrollment
3) Unilateral upper extremity functional deficit after stroke
4) Presence of a score of at least 2 points on the medical research council scale for wrist flexion/extension or forearm pronation/supination
5) Able to provide informed consent
6) Caregiver who is willing to be trained in use of the Smart Glove

Exclusion Criteria:
1) Predisposing psychological disorders which could impede participation
2) Severe aphasia resulting in communication difficulties
3) Severe pain impeding upper extremity rehabilitation
4) Pre-existing neurological disorder that causes motor deficits (i.e. Parkinson's disease)

Study Procedures:
Once the participant has given informed consent and enrolled in the study, they will come to Stanford's CTRU or the Neurology outpatient clinic for a total of five visits, with one visit every two weeks.

Visit one will entail the participant and identified caregiver undergoing training on the use of the Smart Glove by the research coordinator and Neofect staff. This involves donning/doffing of the glove as well as instruction as to how to use the software program. The participant will be issued a Smart Glove and a tablet preloaded with the software. Subjects will also undergo baseline functional testing, including manual muscle testing (MMT), Fugl-Meyer assessment (FM), Jebson-Taylor hand function test (JTT), and Stroke Impact Scale (SIS). This first visit is expected to take 60-90 minutes. The participant will be expected to use the Smart Glove for 60 min per day for at least 5 days per week.

The subsequent three visits will be at two week intervals and will involve the participant bringing the device to the CTRU. The research coordinator will upload the data from the device as well as troubleshoot any device-related issues. These visits will last 15-30 minutes each.

The final visit will occur after eight weeks of Smart Glove use. In addition to downloading the data, the research coordinator will also repeat functional testing functional testing, including

manual muscle testing (MMT), Fugl-Meyer assessment (FM), Jebson-Taylor hand function test (JTT), and Stroke Impact Scale (SIS). This visit will last 45-60 minutes.

Fig 1: The RAPAEL Smart Glove™ system and the task-specific games of this system

Protocol Summary:

Day 0:

- Research coordinator with review the research consent form in detail with the participant and answer any questions about the study. After consent, the participant will be enrolled in the study.

Day 1:

- Smart Glove training for patient and caregiver
- Issuance of Smart Glove and tablet with preloaded software
- Baseline testing of the affected extremity:
    - Manual muscle testing (MMT)
    - Fugl-Meyer assessment (FM)
    - Jebson-Taylor hand function test (JTT)
    - Stroke Impact Scale (SIS)

Day 14:

- Download of patient use data from tablet
- Troubleshooting

Day 28:

- Download of patient use data from tablet
- Troubleshooting

Day 42:

- Download of patient use data from tablet
- Troubleshooting

Day 56:

- Download of patient use data from tablet
- Testing of the affected extremity:
    - Manual muscle testing (MMT)

- Fugl-Meyer assessment (FM)
- Jebson-Taylor hand function test (JTT)
- Stroke Impact Scale (SIS)

Neofect Smart Glove Device Description

The Neofect Smart Glove is a commercially available, non-invasive biofeedback based system for distal upper extremity rehabilitation. The Smart Glove is very lightweight and allows for easy movement of all distal upper extremity joints. It is made of an elastomer material that is simple to maintain and clean. The Bending Sensor is a variable resistor that changes as it is bent. The sensor is a 9-axis movement and position sensor that consists of 3 acceleration channels, 3 angular rate channels, and 3 magnetic field channels that measure wrist movements. They are connected to a computer system which can accurately compute the amount of individual finger movements. The available games provide various kinds of motion tasks such as ADL-related tasks presented in an entertaining manner. The learning schedule algorithm automatically adjusts to the optimal level of difficulty to balance challenge and motivation.

Fig 2: The Smart Glove

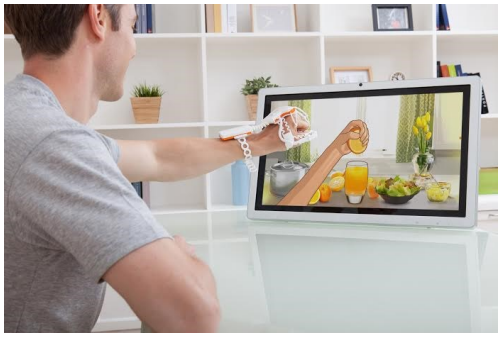
Fig 3: Using the Smart Glove in the VR environment

Risks
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Benefits
The participant may experience improvement in the function of their affected upper extremity.

Withdrawal
Each subject, the sponsor or its designee, and the investigator reserve the right at any time to terminate a subject's participation in the clinical investigation.
Possible reasons for study withdrawal:

1) Subject voluntarily withdraws consent
2) Subject develops an adverse event that would not allow him or her to continue in the study

3) Subject has an adverse event which in the opinion of the investigator warrants withdrawal from the study. The sponsor or its designee must be notified within 2 business days
4) A decision is made by the subject and/or investigator that the subject should be withdrawn from the study

Alternative to Participation:
There are several alternatives to participation that each potential study candidate should discuss with their physician. The alternatives including not participating and seeking no other treatment, or not participating and seeking a standard-practice treatment which is outpatient occupational therapy. Additionally, however, candidates should understand that choosing to participate is not mutually exclusive with receiving outpatient occupational therapy.

Data Collection, Transfer, and Storage
Clinical data: We will complete a stroke log that documents all patients who are treated with the Smart Glove. For patients who are considered but not enrolled in this trial, the reason for exclusion will be recorded. The data collection process will entail site staff completing case report forms (CRFs) for the initial capture of research data during patient encounters, and the data will be entered into a secure Stanford Redcap database. Clinical data obtained on the case report forms will include patient demographics, previous medical conditions, MMT, FM, JTT, and SIS scores.

References:

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