

# Remote rehabilitation training using the combination of an exergame and telerehabilitation application: A case report of an elderly chronic stroke survivor

Dorra Rakia Allegue  
Ecole de réadaptation  
Université de Montréal  
Montreal, Canada

Dahlia Kairy  
Ecole de réadaptation  
Université de Montréal  
Montreal, Canada

Johanne Higgins  
Ecole de réadaptation  
Université de Montréal  
Montreal, Canada

Philippe Archambault  
McGill University  
Montreal, Canada

[Dorra.rakia.allegue@umontreal.ca](mailto:Dorra.rakia.allegue@umontreal.ca)  
(contact author)

Francois Michaud  
Université de Sherbrooke  
Sherbrooke, Canada

William Miller  
University of British Columbia  
British Columbia, Canada

Shane Norman Sweet  
McGill University  
Montreal, Canada

Michel Tousignant  
Université de Sherbrooke  
Sherbrooke, Canada

**Abstract**— Access to remote rehabilitation services is now possible thanks to advanced technology solutions such as exergames and telerehabilitation-applications. This pretest/posttest single case study, conducted with one participant with a chronic stroke (3 years) aimed at collecting preliminary evidence regarding feasibility and efficacy of using a telerehabilitation application combined with an exergame on upper limb function, motivation and quality of life after stroke. Forty-two sessions (including 8 videoconferencing sessions) took place over a two-month period. The results showed significant improvement of upper limb motor function and an increase of the affected upper limb amount of use in activities of daily life. However, no significant change was recorded regarding the impact on quality of life and motivation. These preliminary results allow us to have a first glimpse of the potential of this program and better inform a larger scale study.

**Keywords**— Telerehabilitation, exergame, upper-limb, stroke

## I. INTRODUCTION

Patients with stroke have difficulty accessing external conventional rehabilitation services for a variety of reasons, including fatigue, lack of services and distance to travel[1]. Telerehabilitation combined with exergames provides a new approach that may counter the accessibility problems and optimize motor recovery of the upper limbs, even in the chronic phase post-stroke. The objectives of this study were: 1/ to determine the feasibility of using a telerehabilitation application combined with an exergame 2/ to collect preliminary efficacy data of such a remote rehabilitation service on upper limb function, motivation and quality of life in a chronic stroke survivor.

## II. METHODOLOGY

### A. Study design and intervention

This is a pretest/posttest single case study design of a 63-year-old male stroke survivor (3 years) who does not live in the same city as the research team. This case study was developed in the context of a larger study prior to starting a randomized clinical trial to contribute to developing the evaluation and intervention protocols. The participant was invited to complete the remote rehabilitation program for two

months using a telerehabilitation application combined with a virtual reality game. The program included 5 sessions (30 minutes) of upper limb exergame training (20 hours in total over 2 months) and one videoconferencing session (1 hour) with a clinician per week. We used the Jintronix©-exergame which includes 6 types of upper limb exercises with different levels of difficulty (number of rounds, repetition, time, speed, precision and shape of objects). For the telerehabilitation-system, we used Reacts© which allows videoconferencing and secure sharing of participant's health information.

### B. Outcomes measures

Descriptive data concerning the intervention (number of sessions, duration) were documented at the end of each week. Progress was assessed remotely at baseline, at the end of two-month intervention and after a one- and two-month follow-up period, using the Fugl-Meyer Upper Extremity Assessment (FM-UEA)[2] as a primary outcome. Since the intervention could also affect upper limb function, motivation and participant quality of life, we also included secondary measures such as the Motor Activity Log (MAL)[3], the Stroke Impact Scale-16 (SIS)[4] and the Treatment Self-Regulation Questionnaire-15 (TSRQ)[5]. All evaluations were conducted remotely, so we could only measure the motor function component of the FM-UEA. The motor function score was adjusted to 60 as we removed the reflex activity components from the total score of 66.

## III. CONCEPTUAL FRAMEWORK

We used the self-determination theory[6] as a conceptual framework to guide the intervention in order to empower the participant and solicit his interest and motivation for the treatment plan that we propose in our intervention. Through the combination of the telerehabilitation system (Reacts©) and the Jintronix© gaming system, we aimed to foster patient-clinician interaction throughout the rehabilitation program, and to develop a partnership relationship based on information sharing and trust. It is in this perspective that the self-determination theory was integrated, its constructs helped us develop a discussion plan which the clinician refers to during videoconferenced meetings. This theory states that humans

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naturally tend to achieve changes that respect and enable the satisfaction of their three basic psychological needs, namely: 1) autonomy, 2) connectivity and 3) competence[6]. There are two regulation processes predicting behavioral engagement and maintenance: the behavior emanating from intrinsic motivation and the internalization of extrinsic motivation[6]. These regulation processes were targeted in the form of subscales in the TSRQ [5]. The use of this questionnaire allows us to investigate the impact that the motivation could have had on adherence to the program and its effectiveness.

#### IV. RESULTS

The participant completed 42 sessions of 29 hours active game, over a two-month period. The data collected presented here are those that collected at the end of the intervention. The follow-up data has not yet been collected as the study is ongoing. The FM-UEA scores exhibited a significant increase in motor function component from 49 to 55 (mean score difference = 6) at the total score of 60, which is within the estimated clinically important difference ranges of 4.25 to 7.25[7]. The MAL showed a change in mean score of 0.88 and 0.95, in both the how well scale and amount scale respectively. The change in how well scale (mean score difference = 0.88) is not clinically meaningful (estimated clinically important difference is between 1.0 and 1.1[3]). The amount scale of MAL increased up to 2.45, close to the score of 2.5 predicting 50% or greater recovery[8]. The SIS showed no difference in scores between before and after the intervention. The TSRQ showed no difference in the scores of the subscales such as autonomous motivation, introjected regulation and amotivation. However, the external regulation subscale showed an increase in the scores from 6 to 10.

#### V. DISCUSSION

The data collected to date answers part of our objective which was to collect feasibility data regarding using a telerehabilitation application combined with an exergame for remote upper limb training in a chronic stroke survivor. The participant adhered completely to the program, completing 29 hours of active sitting game instead of 20 hours as prefixed to the program. A minimum of 15 hours is suggested for an intervention to result in a moderate improvement in activities related to daily living following a stroke [9]. No adverse events occurred during the first weeks of intervention. However, the patient reported an increased feeling of heaviness in the affected upper limb during the 4th week. The clinician in charge suggested stretching postures to the participant that he could apply at the beginning and the end of the games to prevent any discomfort. These were demonstrated during the videoconferenced sessions and relieved the discomfort.

The FM-UEA scores showed a significant clinical change in motor function component, suggesting that the Jintronix© exergames could affect upper limb motor recovery after stroke, even in chronic phase. The Motor Activity Log amount subscale has also recorded an increase in the mean score from 1.5 to 2.45. However no meaningful difference was observed in the how well subscale and neither in the SIS. This suggests

that training with a telerehabilitation system combined with an exergame could improve motor recovery after stroke and increase the affected upper limb amount of use in activities of daily life but may not significantly affect the quality of the movement occurring during activities. At the motivational level, the TSRQ showed an increase in the external regulation subscale score which could positively impact on health behaviors and explain the change in the amount of use of the affected arm in activities of daily life. However, external regulation usually leads to short-term changes because the person's choices are under the control of certain consequences (I want others to approve of me) [5] and are not a consequence of their own desires (I feel pressure from others to do so ) [5]. The follow-up data, as well as data from the larger RCT will allow us to better understand the behavioral facets on which this intervention acts and whether the motor function changes lead to long-term recovery (after 2 months).

To sum up, these preliminary results allow us to have a first glimpse of the potential of this program, however we must be cautious in our interpretations. First, our primary scale the FM-UEA was administered remotely and the validity of this outcome measure when used remotely has not yet been studied. In addition, the results of the larger randomized clinical trial on which this study is based, will allow us to confirm our findings.

#### VI. CONCLUSION

The combination of the Jintronix© and Reacts©-applications could provide an effective therapeutic alternative for chronic stroke survivors. The data collected through this study would give us a first glimpse into the factors impacting on the effectiveness of such an approach.

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