

Telerehabilitation of upper extremities with target based games for persons with Parkinson's disease

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Abstract— A telerehabilitation system for physiotherapy of upper extremities has been developed for patients with Parkinson disease. The gamification system (with Kinect™ sensor) has been applied in a daily clinical practice; 28 patients with Parkinson's disease were included in the pilot study, 26 patients finished the “Fruit picking” game. The preliminary patients' feedback (objective measurements, games score) and the results of the clinical tests (MDS-UPDRS part III (27 vs 29), Jebsen hand test, 9 Hole Peg Test, Box & Blocks Test - 48 vs 52) were encouraging (faster daily activities for up to 10%).

I. INTRODUCTION

Parkinson's disease (PD) is a degenerative disorder that affects the nervous system. Its symptoms such as rigidity, bradykinesia (low movement speed and amplitude), resting tremors, freezing of gait, dyskinesia and cognitive and behavioral problems are often associated with the disease, heavily influencing the patient's quality of life (QoL). Besides medication, the physiotherapy ameliorate symptoms, increase movement functionalities, motor performance in general and thus increase the QoL.. Currently degeneration of dopaminergic neurons that triggers changes in the basal ganglia network [1] is mainly treated by L-DOPA and dopamine agonists. However, the rapid progress of the disease is difficult to follow by changing the dose of medication. Therefore physiotherapy has become important in individuals with PD as people with PD retain more than $\frac{3}{4}$ of all activities [2]. Physiotherapy significantly increases participation and contributes to the quality of movement, physical capacity and manual activities. Recently exercise based computer games [3] have been introduced as a rehabilitation tool to the people with PD and this field is rapidly developing as the commercial games have been found too fast and too complex [3] and most of the applications do not allow remote data management and control of the game on the basis of the functional performance outcomes.

The objective of the presented feasibility study was to developed hand skill exergaming program for the telerehabilitation application.

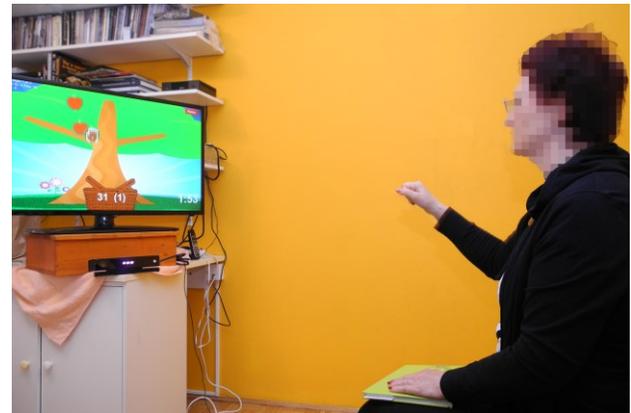


Fig. 1. A person with Parkinson's disease is taking a target based exercise at home. The game requires full cooperation and can adapt the difficulty level in real-time during the exergaming.

II. METHODOLOGY

A. Target based game and Telerehabilitation system

A serious [9] game “Fruit picking” was designed as a target based task, requesting from the user to raise the arm and pick the moving targets, apples growing slow/fast on the tree using the Unity 3D game engine (Unity Technologies, San Francisco, CA, USA). The 3D infrared camera (Kinect 2, Kinect SDK 2.0 Microsoft Corporation, Redmond, WA, USA) tracked the motion of the arm, hand, trunk and head of the participant.

The computer games supported physiotherapy has been designed as a supporting system to the conventional physiotherapy enabling the participants to perform target based movements without specific instructions and therapists' assistance. Besides, the protocol was designed to enable the continuation of physiotherapy at home – telerehabilitation. As the data is being recorded on a local computer and transferred to the data server, the data are available for further analysis and adjustment of the parameters of exergaming.

B. Study design

The goal of the “Fruit picking” game was to collect apples falling from the tree (Fig. 1). The difficulty level was defined by the speed of the apple ripening and falling; more successful user advanced faster to the higher level. The participants took 10 training therapies in three weeks. Each session lasted for

maximum 30 min. Clinical evaluation of functional performance was done by MDS-UPDRS part III [5], Box & Block Test (BBT), 9 Hole Peg Hole Test [6] and Jebsen's Test [4] at the patient admission and after physiotherapy.

The study was approved by local ethics committee in accordance with the principles of the Declaration of Helsinki on biomedical research on human beings and the principles of Slovenian Code of medical ethics. All participants provided a written consent.

C. Subjects

In the feasibility study 28 patients with Parkinson's disease (aged 54-80, 67 ± 7 years old and duration of disease 6 ± 4 years) participated. Inclusion criteria: Parkinson disease with the level 2-3 in the Hoehn and Yahr Scale [7]. All tests were performed in the morning 30 min - 1 hour after the dose of medicine intake.

III. RESULTS

Participants demonstrated significant progress in some of the Jebsen's test [4]. After physiotherapy all the participants needed less time for writing a letter (24.0 ± 15.5 s to 20.6 ± 13.5 s), stimulated feeding (9.4 ± 3.8 s to 8.5 ± 2.1 s) and moving light objects (4.4 ± 1.2 s to 3.9 ± 0.9 s) (Fig 4). Clinical test MDS-UPDRS III [5] demonstrated promising results after the physiotherapy (29.5 ± 10.3 to 27.3 ± 10.4), in spite of the high standard deviation (Fig. 5). However, only one participant had less acceptable score according to MDS-UPDRS III (45 to 50). The 9 Hole Peg Hole Test (9HPT) showed slight improvement; also one of the participant performed poor at this task (28.0 s to 26.5 s). The BBT score of the participants significantly changed after the physiotherapy (47.2 ± 10.7 to 51.6 ± 11.3) in favor of the improvement functionality.

Jebsen tests

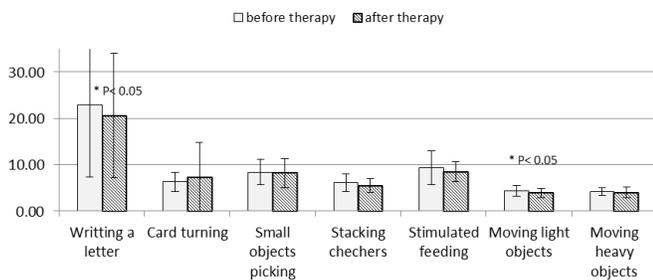


Fig. 4. Clinical outcomes of the Jebsen test

IV. DISCUSSION

Participating subjects demonstrated clinically significant progress in all test; larger standard deviation was present, most likely due to the small number of participants (28). The Jebsen test [4] demonstrated improvements in accuracy at small range movements; writing a letter has become quicker, stimulated feeding and moving light objects. These outcomes suggest that patients with PD may be able to perform exergaming alone at home and achieve improved clinical functionalities despite of

the disease progress. Extending the period or increasing the amount of exergaming may not necessarily bring additional improvement of motor functions [8], notwithstanding, the patients were highly motivated.

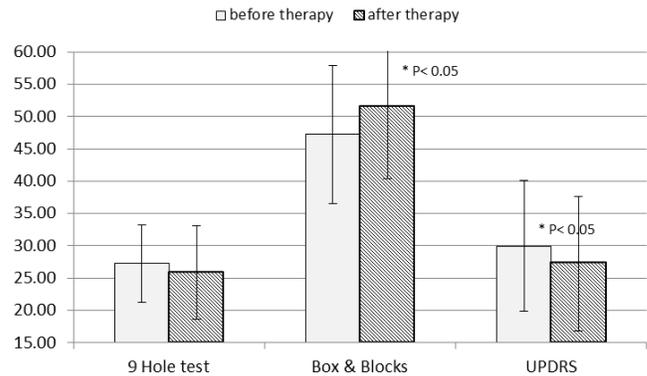


Fig. 5. The results obtained with clinical tests (9HPT, BBT, MDS-UPDRS III). Clinical test Box & Blocks demonstrated overall improvement. The UPDRS showed slight improvement with high standard deviation. The patients were faster and more successful at the 9 Hole peg test.

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