Virtual rehabilitation system for people with Parkinson’s disease

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ABSTRACT

Patients that suffer from Parkinson’s disease (PD) have different symptoms such as tremors, stiffness and slowness in the execution of first movements and absence of balance control. Traditional therapies show improvements in posture control, mobility and gait. Currently, the use of video games with low cost devices such as Nintendo® Wii Balance Board® and Kinect increases the rehabilitation process in PD patients against traditional rehabilitation. However, video games are designed for healthy people, and they are not appropriate in balance rehabilitation therapy. In this paper, we describe ABAR system, a custom, motivational and adaptive tool to rehabilitate PD patients, to help them recover from balance disorders and regain postural control. To achieve this goal, we will test patients at the beginning and at the end of the clinical study. Clinical tests include: Anterior Reach Test, the Time “Up and Go”, the Stepping Test, the 30-second Sit-to Stand Test and functional reach test.

1. INTRODUCTION

Currently, Parkinson’s disease (PD) affects approximately four million people worldwide; on average one out of 500 people has PD (UCB 2012). The main problems in PD patients are postural control, fear of falls (Bloem 2001) and balance disorders. As a result, patients have alterations in the daily life activities (ADL), increasing healthcare costs of countries and causing a high risk of mortality (Adkin 2003).

Other problems related to postural control in PD patients (depending on their pathology) are muscular stiffness, visuo-space injuries, loss of confidence, trembling and mobility reduction (Michalowska 2005) and postural control; these problems cause a reduction of physical and cognitive level (Carne 2005).

In the area of new technologies, systems based on virtual reality (VR) are promising tools in the field of motor rehabilitation (Burdea 2003). Nowadays, there are a lot of applications focused on functional motor rehabilitation for upper and lower extremities. This type of tools increases the performance of the rehabilitation process against traditional rehabilitation, which can be sometimes boring, tedious and repetitive (Merola 2011).

Balance Retraining Therapy (BRT) with postural biofeedback is a physical therapy to reduce dizziness and balance disorders (Nichols 1997) and can be applied increasing the steadiness, symmetry and dynamic stability. Systems used in BRT are composed of low cost components that expert clinicians can use easily. To obtain a low cost BRT researchers are using force platforms such as Nintendo® WBB (Gil-Gómez et al., 2011; Shih et al. 2010; Shih 2011) or devices such as Microsoft Kinect® which also focuses on PD patients (Esculier et al. 2012).

In our study we are creating a new system, Active Balance Rehabilitation (ABAR) with the help of clinical specialists in balance rehabilitation. The clinical specialists are physiotherapist and geriatricians of a hospital. The goals of ABAR system are: 1) to obtain a customizable tool for both the therapist and PD patients; 2) to provide and adaptive system for balance rehabilitation capable of showing the evolution of patients; 3) to offer a high motivational system within the virtual rehabilitation process. We hypothesize that
ABAR system increases the balance performance during the rehabilitation process in PD patients. Also, patients with other diseases associated with balance and postural problems could benefit from ABAR system.

2. METHODS

2.1 Interface

ABAR system was designed and developed using Conitec 2D and 3D game engine and it uses low cost devices such as a Nintendo® Wii Balance Board® (WBB), a bluetooth dongle, a loudspeakers, a 47” LCD TV and a standard PC. We selected a WBB because it is a device with specific characteristics, that can be used in the process of rehabilitation of parkinson’s patients. Its characteristics are: intuitive interaction, easy to manage, portable, connection using Bluetooth and finally a low price.

The tool was programmed by lite-C program, using the script editor of Gamestudio A8. Visual feedback was obtained with virtual environments which were designed using Adobe Photoshop CS5 to create layers, backgrounds, virtual objects, buttons, text and also sprites. Audio feedback was included with a set of specific words (left, right, up, down, center, position).

The ABAR system consists of five specific games according to balance that patients will have to make: sitting position, standing in a static position and standing in a dynamic position. In a standing static position, the WBB will be placed on three different positions: tandem standing position (Figure 1a) standing position (Figure 1b) and floor standing position (Figure 1c).

In sitting position, the patient should do antero-posterior and lateral weight transfersences. To perform that, we designed the game “Ladybug” where the patient must capture randomly each x seconds a virtual candy appearing in four positions. At the first stage, the therapist selects the suitable parameters for the session (Figure 2, left), afterwards, the patient is placed on the WBB and plays (Figure 2, center); if the patient hits the target, the virtual environment displays a transparent candy and emits a sound cue to reinforce the motivation of patients, and if the patient misses the target, the system emits a characteristic sound cue to encourage him. Finally, after finishing the session, the game displays the number of hits/misses obtained (Figure 2, right). We can consider this information as a visual feedback that improves motivation of patients in the balance rehabilitation process.

While standing in a static position, the patient makes lateral weight transfersences and steps with right or left foot onto the WBB; to achieve this purpose, we have developed three specific games that therapist can select in every session: the motorboat, the burglar and the ghost buster, respectively. These games were developed with clinical experts according to the movements used in traditional rehabilitation program. (Figure 3) provides screenshots of the different games.
In the Motorboat game (Figure 3a) the patient stands on the WBB and makes weight transferences to the left and to the right, according to the different targets that ABAR displays. In this game, the patient is required to have a good accuracy to hit the virtual target, because he needs to maintain the position and next to transfer his weight on the left or on the right. For this reason, the therapist needs to select the correct parameters to improve motivation of patients. In the Burglar game (Figure 3b), the therapist places the WBB in tandem position and the PD patient places one foot in front of the other in order to play the game; the subject moves the light beam toward the thief. The weight transferences are made forwards and backwards. In the Ghostbuster game (Figure 3c), the patient steps with his feet the WBB in order to reach the ghost being displayed; the level of difficulty is determined by the speed of fall of the ghosts and also by the pressure on the WBB.

All games have a setup screen where therapist can select important parameters such as: interval of time between virtual targets, number of minutes per session, volume, number of games, time between games, and Audio Feedback. These parameters are very important to establish the level of difficulty in sessions and to obtain a high motivation.

The interaction of movements in virtual environments is made by weight transferences according to a previous calibration stage. In this phase, patients interact with the “calibration” virtual environment, ABAR system shows a panel with a dial, and the different pressures of feet and buttocks are stored for the active session. This information will be used to obtain the center of pressure (COP) and to customize the different sessions of the balance rehabilitation process (through internal algorithms that obtain the arithmetic mean of the different weight transferences). Other parameters that ABAR stores are: response time (the time necessary for the first response) and completion time (the needed time to accomplish the goal).

2.2 Participants

At the moment, we are working on the selection of PD patients in a hospital of a small town. We have generated two groups of patients: the control group, composed of PD patients that will make traditional balance rehabilitation and the virtual group, that will use the ABAR system. The inclusion criteria are: subjects needs to obtain a score in the Mini Mental State Examination greater than 23 (>23), in order to ensure the correct participation; patients should be between 50 and 75 years old, patients should have gait and balance impairment, with a high risk of falls and stable medication use. The exclusion criteria are: patients with lower limb problems, clinical instability, patients with a history of falls and patient refusal.

2.3 Training programme

To interact in ABAR system, PD patients will play in different levels of difficulty according to the stage in the rehabilitation process. The program consists of 30 minutes of virtual rehabilitation and afterwards, 30
minutes of traditional rehabilitation, on a 3-5 days per week basis (20 total sessions). Each session is based on virtual games in sitting or standing position. Patients will be evaluated at the beginning and at the end of the clinical study. Clinical tests include: Anterior Reach Test (ART), the Time “Up and Go” Test, the Stepping Test (ST), the 30-second Sit-to Stand Test (30SST) and functional reach test (FRT).

3. CONCLUSIONS

The study presents ABAR system, a new tool designed specifically to reinforce and to improve the balance rehabilitation process in PD patients. To obtain this purpose, ABAR system has: 1) low cost devices such as WBB, a bluetooth dongle, and loudspeakers; 2) custom and motivational games for PD patients to make suitable weight transferences. At the moment, we are working in the testing stage, where patients are being recruited, and therapist/PD patients are providing changes to increase the functionality of ABAR system. We consider that the upcoming results will be promising because PD patients will be able to increase static and dynamic balance.

Acknowledgements: The authors would like to thank the clinical team from San José Hospital for their suggestions and collaborations. This contribution was funded partially by Generalitat Valenciana ("Ajudes per a la realització de projectes d'I+D per a grups d'investigació emergents", projecte GV/2012/069).

4. REFERENCES

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