

VIRTUAL REALITY IN REHABILITATION: WII™ AS AN OCCUPATIONAL THERAPY TOOL IN PATIENTS WITH SPINAL CORD INJURIES

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Abstract: The use of virtual reality has gained importance in the rehabilitation sector over the last few years. The Wii™ console complements traditional treatment by exercising the motor skills in a motivating context, which is important in long-term interventions, such as spinal cord injury.

Objectives: to describe our work with the Wii™ console and the different support products used in occupational therapy at the Fundación del Lesionado Medular, and to discuss advantages and disadvantages.

Method: 63 patients with spinal cord injury (of whom 46 with quadriplegia and 17 with paraplegia), treated over the period of one year in weekly 30-minute sessions.

Results: motor-skill improvements, more involvement of the patients in the treatment.

Conclusion: the features of the console and the support products created by our department make the Wii™ accessible to patients, increase their motivation and enrich the treatment.

Keywords: Spinal cord injury, Nintendo Wii™, rehabilitation, Occupational Therapy.

Introduction

Recently there has been a rising interest in the use of virtual reality to the rehabilitation process (Holden, 2005). The Wii™ console, together with other new technologies, provides a complement to conventional treatment in the form of activities which are accessible and motivating to patients, while enabling the practice of functional movements (Gil- Gómez, Lloréns, Alacañiz, & Colomer, 2011; Cameirao, Bermúdez, & Verschure, 2008).

The Nintendo Wii™ is a console that detects three-dimensional movements of the user by means of an infrared remote control and a sensor bar. This makes for intuitive and easy use, as it is with this control that the desired movements are executed.

The Occupational Therapy Department of the *Fundación del Lesionado Medular* has developed a skill-training program by means of the aforementioned games console. This new tool makes possible the work on different motor skills in a highly motivating context, which is important in cases of spinal cord injury as they involve long periods of rehabilitation and physical maintenance which can be arduous.

The advantages of using the Wii™ in rehabilitation include:

- Ease of use
- Accessibility
- High motivation
- Visual and auditory feedback
- Low cost
- Great variety of games
- Economy of space

Although the obtained results with this training program do not constitute scientific evidence in a strict sense, there are several studies on the application of the Wii™ as a therapeutic tool. Research by Laver, George, Thomas, Deutsch and Crotty (2011) states that virtual reality and interactive video games can be

more effective in improving upper-extremity function and daily life activities, compared to conventional therapy. Different researches (Saposnik et al, 2010; Mouawad, Doust, Max & McNulty, 2011; Celinder, Peoples, 2012; Hurkmans, Ribbers; Streur-Kranenburg, Stam, & Van den Berg-Emons, 2011) mention the potential benefits in the rehabilitation of stroke patients and also the increased motivation resulting from introducing WiiSports® in occupational therapy treatment programs. Other studies (Hurkmans, Ribbers, Steur-Kranenburg, Stam, & Van den Berg-Emons, 2011; Hsu et al, 2011) conclude that tennis and boxing games of WiiSports® can be useful in increasing activity levels and promoting healthy lifestyles in patients with neurological damage. In addition, other studies about the Wii™ console mention the benefits of these games on elderly people in terms of strength, cardiovascular capacity, balance and coordination (Baker, Atlantis, & Fiatarone Singh, 2007).

As regards the support products, there is also evidence of more effective correction of the head position in severely disabled patients by using the Wii control (Shih, Shih, & Shih, 2011).

Objectives

- To describe how the Wii™ was employed as a working tool in the Occupational Therapy Department of the *Fundación del Lesionado Medular*.
- To describe objectives and administration of console-based treatment in cases of spinal cord injury.
- To present different ways of adaptation in order to facilitate its use.
- To discuss advantages and disadvantages of interventions with Wii™.

Methodology

Wii™ training has been used in our occupational therapy department for a year. It was used on 63 patients with the following diagnoses:

- 46 patients with quadriplegia; their injury levels ranging from C4 to C7 (ASIA A, B, C and D)
- 17 patients with paraplegia; their injury levels ranging from D2 to L2 (ASIA A, B, C and D).

All the patients were evaluated on daily life activities, using a version of the SCIM (Spinal Cord Injury Measure) scale; in addition, those with upper-extremity impairment underwent testing of key muscles, upper-extremity goniometric measurement and functional grip strength evaluation. Based on this, certain objectives were established which would constitute the basis for the training program, if they coincided with the skills that can be trained with the console.

The contraindications are just relative, since, according to the manufacturer's instructions, there is no health hazard in using the console. However, several considered factors resulted in patients being excluded from the console-based treatment:

- Cardiorespiratory impairment, which may prevent normal participation in the game, as it may be the cause of dizziness, inability to speak during the activity, etc.
- Low tolerance to frustration.
- Acute musculoskeletal injury: tendinitis, fracture, etc.
- Cognitive or behavioral disorders which may cause the patient to fall.

The objectives that can be targeted with the Wii™ are: range of movement in the upper limbs, coordination, dexterity, speed of movement, exercise tolerance, balance, posture control, visual-motor integration and weight transfer.

In order to reach these objectives, the following games were chosen: *Wii Sports*®, *Wii Sports Resort*®, *Zumba*® and *Just Dance 2*®. In addition, a level of difficulty was selected and a specific type of work was chosen from the following: adaptations and support products to make it accessible, a change in the patient position (sitting or standing), unstable bases, additional weights, etc...

The sessions are held weekly and last for 30 minutes; they can be done individually or in pairs. Games based on dancing and training can be done in groups, with only one or two people obtaining scores. The training program is always carried out with the assistance of at least one occupational therapist that makes sure the activity is being developed on an appropriate way.

In addition, a questionnaire was held in order to know the opinion of the participants about what physical abilities they consider were working on with this Wii training program. They were asked to mark the most appropriate of them in relation to their rehabilitation routine with the Wii console. Balance, mobility of arms, mobility of trunk were considered to be the principal physical abilities trained by the participants.

Table 1. Physical abilities worked on with Wii console according to the participants.

PHYSICAL ABILITY	BALANCE	STRESS RESISTANCE	MOBILITY OF ARMS	MOBILITY OF NECK	MOBILITY OF TRUNK	STRENGTH	OTHER
Nº PARTICIPANTS (TOTAL OF 53)	40	22	41	16	34	14	10

Development

Characteristics of the Wii™ console

The Wii™ is a console with multiple possible uses, given that besides its own characteristics, there are several ways it can be used with patients. It works by means of a sensor bar that detects the movements of the control through infrared rays.

- Control: the main control, known as *Wii Remote*, has certain characteristics that adapts to the skills of a patient with upper extremity impairment -it is wireless, it is held by gripping with the palm, does not require constant manipulation of buttons or a joystick and has a non-slip

sleeve. In addition, its vibration during play functions as a proprioceptive stimulus.

- It has an in-built sensor that measures movement in any direction and at any speed (Cameirao, Bermúdez, & Verchure, 2008).
- There are other control accessories for specific games, such as the *Nunchuck* or the *Balance Board*.
- *Mii* character: an avatar can be created for each user, with a wide range of physical features to choose from. Thus, each patient has their own character, which accumulates the score of each game. This gets them more involved during the activity.

Wii™ Console games

Our Occupational Therapy Department has been working with *Wii Sports*®, *Wii Sports Resort*®, *Zumba*® and *Just Dance2*®, in order to train different skills, as shown in Table 1.

The games *Wii Sports*® and *Wii Sports Resort*® are simulations of different sports: bowling, tennis, golf, baseball, boxing, swordplay, wakeboarding, frisbee, archery, table tennis, power cruising, canoeing, cycling and air sports. There are different levels of difficulty, the level for each game depending on the player's choice or on the accumulated score. The patient must perform the movements just as he/she would do in real life and the *Mii* character moves with the player's movements, so there is immediate feedback. With most of the games, it is possible for two or more players to compete. The games are not very long (maximum 5 minutes) and a break can be taken at any point in the game.

The games *Zumba*® and *Just Dance 2*® consist in performing choreographies by imitating the movements of the character on the screen. In *Zumba*®, information is recorded about the rhythm and energy expenditure: an energy sensor checks in real time if the person should move "more energetically". If the character looks red, the rhythm is not right, while green means "correct rhythm". Besides, it is possible to compete with other patients, in which case a score is obtained at the end of the choreography. There is also the option to select a single song, lasting

about five minutes, or a series of them with increasing and decreasing intensities, lasting twenty minutes.

In *Just Dance 2*[®], it is possible to check the accumulated score on the screen as the choreography goes on. Feedback is given on how correctly the movements were performed. Each song lasts about four minutes.

Table 2. Skills that are exercised in Wii™ games training.

SKILL	Range of movement	Posture control	Exercise tolerance	Speed of movement	Coordination	Motor control	Visual-motor integration	Weight transfer while standing. bimanual activity.
Bowling	X	X			X	X		
Golf		X			X	X		X
Boxing		X	X	X		X	X	X
Tennis	X	X	X	X	X	X	X	
Baseball	X			X	X	X	X	
Frisbee	X	X				X		
Table Tennis	X	X	X	X	X	X	X	
Air sports	X	X				X		
Wakeboarding	X	X			X	X		
Canoeing	X	X	X	X		X		
Cycling	X	X	X	X		X		X
Basketball	X				X	X		
Power Cruising	X	X				X		
Swordplay	X	X	X	X		X	X	X
Zumba	X	X	X	X	X	X	X	X
Just Dance 2	X	X	X	X	X	X	X	X

Working Method

Each treatment is personalized. Working position, length of training program and level of difficulty are established after considering individual's characteristics, evaluation and initial objectives.

- Sitting position: the patient can stay in his/her wheelchair if he/she has insufficient trunk control, or if the only purpose is to work on the upper extremities or the neck. However, activity can be done in the long sitting position, especially when working on posture control and trunk balance. This can be done on a mat, on a stretcher without armrests, on a chair or in a more unstable type of sitting position, using objects such as a ball or a proprioceptive cushion.
- Standing position: certain games, such as golf, frisbee or dancing are interesting when it is necessary to work on lower-extremity weight transfer, righting reactions and posture and movement control.

Adaptations

Accessibility of the Wii™ is relative, since several adaptations can be done in order that as many users as possible can benefit from the treatment activities. Here is a discussion of different ways to make video console training more accessible to patients.

- Glove or bandage: recommended for those who cannot sustain their grip. It consists in bandaging or tying the control to the patient's hand, so that he/she does not need to apply strength to the grip.
- Helmet: it is used on people with severely impaired upper extremities, when the purpose is to work on their neck -or even trunk- mobility. The control is placed on the helmet, which allows the patient to participate in games such as Wakeboarding or Air Sports.
- *WiiWheel*: By means of the steering wheel, a Wii™ accessory, it is possible to work on pronosupination with patients who have no grip strength whatsoever and hardly any shoulder mobility. The steering wheel is placed on a surface (preferably made of non-slippery

material), so that the patient only needs to keep it perpendicular to his/her body, thus performing the required pronosupination movements. This type of movement is not exclusive to the driving games; it can be performed, for example, as an adaptation in the Wakeboarding game.

- Blocking of buttons: in certain games, the patient has to press a button to perform a particular action, which can be a problem. In some cases, adhesive elastic can be used to hold down the button.

Results

The results obtained at our Occupational Therapy Department suggest that there are benefits in using the Wii™ as part of the rehabilitation process:

- Increased motivation towards the activity. As the objective is pursued through games, the activity is more entertaining. Besides, the fact that patients can compete with each other can result in greater tolerance to frustration.
- Greater adherence to treatment. Seeing results in the form of scores and moving on to higher levels of difficulty, the patient receives positive feedback and learns new self-improvement strategies.
- Physical benefits: As the patients work with functional movements and obtain immediate feedback, the activities are more intuitive and easier to integrate into normal movement.
 - Speed of movement. In games such as Table Tennis, the rival keeps the pace that corresponds to the level, forcing the patient to keep up with it in his/her movements.
 - Range of movement and muscular strength in upper extremities. As can be seen on tables 2 and 3, with the games used in the training program, several upper-limb movements are worked on, with the additional advantage that the movements include all planes of space, which is more functional.

- Visual/motor integration. Games such as Table Tennis, Bowling, Baseball or Swordplay require movements performed at a specific time determined by a visual stimulus.
- Exercise tolerance. Because of the variety of games and their short duration, resistance can be adapted to each patient, who can do a single game or a series of games/choreographies.
- Posture control: working in different positions allows the patient to work on his/her balance. He/she continually needs to adjust his/her righting reactions.
- Motor control. The patterns of movement used in the console are functional.
- Suggesting daily life activities for leisure. As a result of the intervention, and the creation of specific adaptations and support products for the console, a new possibility is offered for patients' leisure activities, even for those with very high levels of injury.

Table 3. Main movements worked on with the Wii games.

MOVEMENT	Abdominal flexion and shoulder	Flexion/Extension of the elbow	Pronosupination	Flexion/Extension of the wrist	Trunk rotations	Neck
Bowling	X	X				
Tennis	X					
Table Tennis			X	X		
Golf	X				X	
Wakeboarding			X	X	X	X
Zumba, Just Dance 2	X	X			X	
Cycling		X				
Swordplay	X	X				

The main advantage of this type of virtual reality technology is that it offers a new form of rehabilitation and exercise for functional movement, in a product that is accessible and affordable to the majority of the population.

Furthermore, the satisfaction questionnaire filled by all participants show that motivation is one of the most important reasons for which they got involved in the program.

Although participants consider that their attendance has not increased since this Wii training program started, the majority of them think that it is a useful tool to be used in rehabilitation. It seems to be that motivation is the real challenge of this program as participants express that they consider that physical abilities are working same with Wii training than with other occupational therapy treatments as shown in table 4.

Table 4. Questionnaire analysis. Wii training

Questions	ALMOST NOTHING	LESS	SAME	MORE	A LOT MORE
Are you more motivated to come to your occupational therapy treatment since the beginning of your Wii training?	0	0	14	22	17
Do you think that you are working better on these physical abilities with your Wii training than with other occupational therapy treatments?	1	1	19	19	13
Do you think your attendance to your treatment has improved since the beginning of your Wii training?	1	0	37	11	4
Do you think the Wii training is a useful tool for rehabilitation?	1	0	5	20	27

Discussion

As the Wii™ console was designed for leisure and it was not anticipated that it would be used by people with physical disabilities, we encountered several problems during the rehabilitation process. First, it is not possible to obtain other objective measurements apart from the score. It would be interesting if more detailed data could be collected about each patient; since this would show the progress they made and would make it possible to compare data. Furthermore, it is not always possible to grade difficulty. Ideally, it should be possible to adapt games to each type of injury, so the level of difficulty can be adapted to the patient's skills. The same problem exists with the pace of the games. If both the pace and difficulty were adaptable, the games would be adapted according to the established objectives for each individual patient.

Another problem is that, when some patients see their scores going down, or compare themselves to other player's performance their feedback can be negative.

As regards adaptations, it would be useful if there were some games in which only one joint could be used, as opposed to a combination of several of them. It would also be useful if there were more games that do not require pressing buttons; since such requirement has limited the number of people that could do the proposed Wii™ activities.

In addition, the sample size for this type of research should be greater. Thus, more studies are needed to confirm both the benefits in terms of motor skills and the increased motivation and adherence to treatment.

Conclusion

Wii™ is a useful tool for the intervention process in the rehabilitation of patients with neurological impairment, such as survivors of spinal cord injury. Its characteristics, in combination with the adaptations created by occupational therapists, make it accessible to patients with severe

impairment to the upper extremity. The value that the Wii™ has as a working tool in rehabilitation is given by the professional, who knows the most appropriate way to approach the game so that the desired objectives are achieved for each patient. This results in greater adherence to the treatment on the patient's part and opens the road to a new line of research on this technology.

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Appendices

Appendix 1. Questionnaire filled in by participants in Wii training program at Fundación del Lesionado Medular

ISSUE	QUESTIONS	ALMOST NOTHING	LESS	SAME	MORE	A LOT MORE
1	Are you more motivated to come to your occupational therapy treatment since the beginning of your Wii training?					
2	Do you think that you are working better on these physical abilities with your Wii training than with other occupational therapy treatments?					
3	Do you think your attendance to your treatment has improved since the beginning of your Wii training?					
4	Do you think the Wii training is a useful tool for rehabilitation?					

ISSUE	QUESTIONS	BALANCE	STRESS RESISTANCE	MOBILITY OF ARMS	MOBILITY OF NECK	MOBILITY OF TRUNK	STRENGTH	OTHER
5	Which physical abilities, from your point of view, are you working on with your Wii training?							

1. Could you explain the usefulness of this treatment from your point of view?

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