DOI: S1885-527X2020000200004

USE OF VIRTUAL REALITY IN OCCUPATIONAL THERAPY: A CROSS-SECTIONAL STUDY IN NEURO-REHABILITATION CENTERS IN ALICANTE

USO DE LA REALIDAD VIRTUAL EN TERAPIA OCUPACIONAL: ESTUDIO TRANSVERSAL EN CENTROS DE NEURORREHABILITACIÓN DE ALICANTE

Paula Peral-Gómez
PhD, Psicología de la Salud.
Grupo de Investigación en Terapia Ocupacional (InTeO). Departamento de Patología y cirugía. Universidad Miguel Hernández, San Juan de Alicante, España. ORCID 0000-0002-0390-0894

Desirée Valera-Gran*
PhD, Salud Pública.
Grupo de Investigación en Terapia Ocupacional (InTeO). Departamento de Patología y cirugía. Universidad Miguel Hernández, San Juan de Alicante, España. ORCID 0000-0001-6388-127X

E-mail de contacto dvalera@umh.es

*autora para correspondencia

Lilibeth Obregón-Carabalí
Graduada en Terapia Ocupacional.
Clínica Neural, Castellón, España. ORCID 0000-0002-6810-4530

Cristina Espinosa-Sempere
Diplomada en Terapia Ocupacional.
Grupo de Investigación en Terapia Ocupacional (InTeO). Departamento de Patología y cirugía. Universidad Miguel Hernández, San Juan de Alicante, España. ORCID 0000-0003-1983-8244

Iris Juárez-Leal
Diplomada en Terapia Ocupacional.
Grupo de Investigación en Terapia Ocupacional (InTeO). Departamento de Patología y cirugía. Universidad Miguel Hernández, San Juan de Alicante, España. ORCID 0000-0001-5526-6218

Alicia Sánchez-Pérez
PhD, Psicología de la Salud.
Grupo de Investigación en Terapia Ocupacional (InTeO). Departamento de Patología y cirugía. Universidad Miguel Hernández, San Juan de Alicante, España. ORCID 0000-0001-9444-8516

Objective: We aimed to analyze the use of virtual reality among occupational therapists working with neurological patients. **Methods.** A descriptive cross-sectional study was conducted on occupational therapists working in neurorehabilitation centers in the Alicante province between February and May 2017. The information was collected using an online questionnaire made up of 36 questions.**Results.** Of the 23 participants, the majority of them were women (82.6%) with an average age of 31.4 years (SD: 4.1). Approximately half of them (52.2%) used virtual reality as a treatment tool, mainly with adults aged 46-65 (75.0%) affected by acquired brain damage (75.0%) and with cognitive alterations (91.7%). The intervention areas targeted were: attention (83.3%), vision (75.0%), upper limb mobility (75.0%), verbal communication (66.7%), eating (50.0%), shopping (41.7%), and social participation with friends (41.7%). The most used virtual reality systems in occupational therapy treatments were the NeuronUp platform (50.0%) and Xbox Kinect ® / Nintendo Wii ® (33.3%) used with a computer or a tablet. **Conclusions.** Only half of the occupational therapists in the study used virtual reality as a complementary tool for conventional treatment. Further studies exploring the use of these techniques in occupational therapy with people affected by neurological conditions are required.

Objetivos: el uso de la realidad virtual representa un enfoque metodológico prometedor como intervención terapéutica en neurorrehabilitación. En este estudio se analizó el uso de la RV en terapia ocupacional con pacientes neurológicos. **Métodos:** se llevó a cabo un estudio descriptivo transversal con terapeutas ocupacionales de centros de neurorrehabilitación de la provincia de Alicante, entre febrero y mayo de 2017. La información se recogió online con un cuestionario de 36 preguntas. **Resultados.** De 23 participantes, la mayoría eran mujeres (82.6%) y con edad media de 31.4 (DE: 4.1) años. La mitad (52.2%) usaba la realidad virtual como herramienta de tratamiento, principalmente con personas de 46-65 años (75.0%), con daño cerebral adquirido (75.0%) y alteraciones cognitivas (91.7%). Las áreas principales de intervención fueron: atención (83.3%), visión (75.0%), miembro superior (75.0%), comunicación verbal (66.7%), alimentación (50.0%), compras (41.7%) y participación social con amigos (41.7%). Los sistemas de RV más utilizados fueron la plataforma NeuronUp (50.0%) y el ordenador y/o tableta junto con los dispositivos Kinect y Wii (33.3%). **Conclusiones.** Sólo la mitad de lo/as terapeutas ocupacionales usaban la realidad virtual como complemento al tratamiento convencional. Son necesarios más estudios sobre el uso de estas técnicas en terapia ocupacional con personas con afecciones neurológicas.

MeSH Learning; Nervous System Diseases; Virtual reality; Neurological Rehabilitation; Occupational therapy; Video games.

DeCS Aprendizaje; Enfermedades del sistema nervioso; Realidad virtual; Rehabilitación Neurológica; Terapia ocupacional; Videojuegos.

Received text: 16/07/2020 Accepted text: 18/10/2020 Published text: 30/11/2020

INTRODUCTIÓN

Neurological disorders have become the most important health problems worldwide, primarily due to demographic growth and population ageing[1]. In fact, the last report on the global disease burden (GBD 2016) estimated that neurological diseases are the primary cause of disability and the second cause of death[2]. Moreover, these rates are expected to worsen in the future[2].

Neurological diseases encompass a wide variety of diseases that affect the diverse structures of the central and peripheral nervous system, causing alterations in cognitive, sensory and neuro-musculoskeletal functions[3]. Many of these diseases negatively affect – to a lesser or greater extent – the executive abilities of those affected, and influence how they carry out their daily activities and restrict participation in occupational roles[1]. In this sense, there is a continually increasing need for the design and application of effective treatments in proper rehabilitation interventions. This calls for the design of new measures with a better approach to these grave conditions through the combined work of researchers and clinical professionals in neurology. Given that neurology is one of primary focus areas of occupational therapy (OT)[4], proposing new initiatives based on occupational treatment can play an essential role in improving rehabilitation techniques for neurology patients.

In recent years, the application of new technologies for neuro-rehabilitation has opened an important line of study about different approaches to neurology patients. From this perspective, and in order to propose more effective interventions that help to improve both functioning and quality of life of these patients, the use of virtual reality (VR) has gained recent interest. This technology has been used as a type of alternative therapeutic intervention that is complementary to conventional treatment[5-8]. To date, there is evidence that supports the use of this technology as a part of a neuro-rehabilitation program in stroke patients[5,6,9,10], traumatic brain injury[9,11], cerebral palsy[5,6,12,13], spinal cord injuries[5,8], Parkinson Disease[6,9], and multiple sclerosis[6-8,14], among others. These interventions with VR have been related to improvements in motor, cognitive and psychological functions, and with greater participation in the community[5,15].
Virtual reality consists of the generation of a simulated environment by a computer system, either real or imaginary, in which the user can interact through different devices such as a keyboard, mouse or other more complex haptic devices[9]. A VR system is characterized by interaction and immersion[12]. The level of presence or the sensation of physically being in the environment experienced by the user depends on the level of interaction and immersion in the virtual environment[12]. In this respect, there are different VR systems characterized by different levels of immersion offered between the user and the system: non-immersive VR, semi-immersive VR and totally-immersive VR[6,13,15].

Virtual reality provides multiple advantages in neuro-rehabilitation and can be of great utility to occupational therapists who aim for the patient to achieve greater levels of autonomy and functional recovery. This technology allows for carrying out different activities, with different levels of intensity and/or difficulty. It also allows for establishment of real-time objectives[15–17] and is a useful tool to analyze the quality and quantity of progress achieved by the person[18]. Its use in neuro-rehabilitation is supported by the principles of motor learning given that it permits high-intensity training of the patient, maintains his/her motivation with tasks oriented towards objectives and facilitates multi-sensorial feedback[7,9,12,14,17]. Furthermore, the use of VR in the clinical environment has been supported by the appearance of movement sensors of low-cost video games, which are more accessible than rehabilitation technologies, such as the Kinect system for the Microsoft Xbox® console, the Nintendo Wii® and Sony PlayStationMove®[10,19-21].

Objetive

Up until now, there are no prior studies that analyze the use of VR by occupational therapists in treating neurology patients. Therefore, in this study we carried out an exploratory analysis of the clinical use of VR in the treatment of OT with neurology patients in neuro-rehabilitation centers in the province of Alicante, Spain.

METHODS

Study design and population

A cross-sectional study was carried out between February and May of 2017. Participants were occupational therapists selected by intentional sampling based on a search of centers dedicated to neuro-rehabilitation in the province of Alicante and that provided OT services. We excluded those rehabilitation centers dedicated to

serving those with Alzheimer Disease and other types of dementia and/or those with intellectual disability due to the heterogeneity of these types of pathologies and the complexities of treatment. Initially, 27 centers were found to be potentially eligible, and a total of 41 occupational therapists were found, though one occupational therapist was included who was self-employed and specialized in this field.

For recruitment, email was used to contact occupational therapists or the person in charge of neuro-rehabilitation and/or the director of the center. This email provided information about the study and requested the voluntary participation of the occupational therapist via an online questionnaire. A second contact was carried out after 15 days in order to increase participation of those who did not reply to the initial questionnaire. A total of 42 emails were sent. Twelve responses were received after the first email, sent February 14, 2017. Sixteen responses were received from the second email, sent March 1, 2017. Due to the low response rate, contact also took place via telephone. For this analysis, a total of 23 participants were included that completed the online questionnaire, and these individuals made up the final sample.

Study variables

An online questionnaire was designed with 36 yes/no response questions in order to collect information on the use of VR in OT rehabilitation. The questionnaire was divided into different question blocks: general characteristics of the use of VR in clinical practice; profile of the neurology patient; objectives of use of VR; characteristics of VR platforms and devices. Also, a specific battery of questions was included in the questionnaire on the sociodemographic characteristics of the participants.

Ethical considerations

Participation in the study was voluntary and informed. Treatment, communication and release of personal data on all of the subjects who participated conforms to the requirements of Organic Law 15/99 of December 13 on the Protection of Personal Information Data. Data were treated in an anonymous and confidential way.
The study was approved by the Project Evaluation Unit of Miguel Hernandez University in Elche (DPC.PPG.01.17), and it abides by the official norms of the Helsinki Declaration.

RESULTS

Table 1 presents the general characteristics of the occupational therapists that participated in the study. Of the 23 therapists who participated, the majority were women (82.6%) with an average age of 31.4 years (SD: 4.1). Around 78.2% finished their OT training prior to 2011 and a little over a third (39.0%) had some sort of complementary training. In terms of the type of center or institution, 78.3% worked in private centers. Approximately half of the participants used VR as a treatment tool (52.2%), but only one of them also used VR as an evaluation tool.

Figure 1 shows the principal results on the use of VR in clinical interventions by study participants. Of the 12 occupational therapists that used VR, most had used it at the work center (66.7%), 25% had used it both at work and in the home environment of the patient, and 8.3% had used it only in the home environment. Half reported having carried out OT sessions of around 45 minutes, 33.3% had sessions lasting around 60 minutes, and 16.7% had sessions of 30 minutes. Regarding the proportion of use of VR, the majority of the participants (83.3%) indicated that they used VR for around 25% of the treatment session. Moreover, many of the occupational therapists (83.3%) combined the use

Table 1. Characteristics of the Study Participants (n=23)

	n (%)
Age, average (SD)	31,4 (4.1)
Sex	
woman	19 (82.6)
man	4 (17.3)
Year completed studies	
≤2005	9 (39.1)
2006-2010	9 (39.1)
≥2011	5 (21.7)
Complementary training	
no complementary training	14 (61.0)
2nd cycle training	5 (21.7)
university master's degree	3 (13.0)
physiotherapy	1 (4.3)
Type of center/institution	
private	18 (78.3)
public	2 (8.7)
charter	3 (13.0)
Use of VR	
no use	11 (47.8)
treatment	11 (47.8)
evaluation and treatment	1 (4.4)

SD, standard deviation; VR, virtual reality.

Table 2. Profile of Neurology Patients that Receive VR as a Part of Therapy

	n (%)
Age	
≤15 years	3 (25.0)
16-45 years	4 (33.3)
46-65 years	9 (75.0)

of VR with other supports, although 8.3% indicated that also used robotics and augmented reality.

Table 2 displays the general characteristics of patients with neurological pathologies treated with VR by occupational therapists. In general, the most prevalent type of patient were adults between 46-65 years old (75.0%), with a basic level of education (75.5), who had suffered acquired brain damage (75.0%) and primarily presented cognitive alterations (91.7%).

The principal objectives of the use of VR for the treatment of neurological functions and for training in occupational areas are shown in Figure 2 and in Figure 3, respectively. In terms of mental functions, VR was used primarily for attention training (83.3%), perception (83.3%), memory (75.0%) and superior cognitive functions (66.7%). Vision (75.0%), vestibular functions (50.0%) and proprioceptive functions (50.0%) were the most treated sensory functions. In terms of neuro-musculoskeletal functions, voluntary movement (75.0%) and involuntarily reactions and articulation mobility (58.3%, respectively) stand out. Regarding motor control, rehabilitation of the upper limb (75%) was the aspect that was most treated. Communication abilities that were treated with VR were those related to verbal communication (66.7%). To a lesser extent, the basic and instrumental activities of daily living in which VR was used were self-feeding (50.5%), dressing (41.7%), functional mobility (41.7%) and shopping (41.7%), respectively. Regarding social participation, VR was primarily used to support participation with friends and colleagues (41.7%).

Table 3 shows the description of electronic devices and software for the use of VR employed by occupational therapists. Participants reported that the technological devices they most used to carry out their VR sessions were the computer and tablet along with Kinect and Wii consoles (33.3%). The most employed accessories were the Wii Plus remote control (50.0%) and movement sensors (41.7%). With respect to video games and applications, the Wii Sport was the video game that was most used in the VR sessions (50.0%).

>65 years	3 (25.0)
Education level	
no studies	1 (8.3)
basic studies	9 (75.0)
secondary studies	6 (50.0)
superior studies	3 (25.0)
Neurological pathology	
acquired brain damage	9 (75.0)
neurodegenerative disease	5 (41.7)
cerebral palsy	3 (25.0)
Autism spectrum disorder	1 (8.3)
Types of symptoms/problems	
communication symptoms	3 (25.0)
cognitive symptoms	11 (91.7)
conduct problems	3 (25.0)
motor problems	7 (58.3)
occupational problems	5 (41.7)
sensory problems	6 (50.0)
social problems	4 (33.3)

VR, virtual reality

Tabla 3. Dispositivos tecnológicos, accesorios, juegos, aplicaciones informáticas y plataformas de neurorrehabilitación utilizados en sesiones de terapia ocupacional con RV

	n (%)
Dispositivos tecnológicos	
Kinect + ordenador/tableta	3 (25.0)
Wii + ordenador /tableta	2 (16.7)
Kinect + Wii + ordenador/tableta	4 (33.3)
Tableta	1 (8.3)
Otros	2 (16.7)
Accesorios	
mando Wii Plus	6 (50.0)
sensores de movimiento	5 (41.7)
Wii Balance Board	4 (33.3)
gafas de RV	3 (25.0)
JoyStick	2 (16.7)
cascos de sonido envolvente	2 (16.7)
Wii Zapper	1 (8.3)
Wii Wheel	1 (8.3)
Leap motion	1 (8.3)
Juegos y aplicaciones	
Wii Sport	6 (50.0)
WiiFit plus	3 (25.0)
Kinect sports	2 (16.7)
Pictogram Room para ordenador	2 (16.7)
Wii Sport Resort	1 (8.3)
Rehacom para ordenador	1 (8.3)
Plataformas de neurorrehabilitación	
NeuronUp	6 (50)
NeuroatHome	2 (16.7)
AVANT	1 (8.3)
BIOTRACK	1 (8.3)

RV, realidad virtual; AVANT, Advance therapeutics.

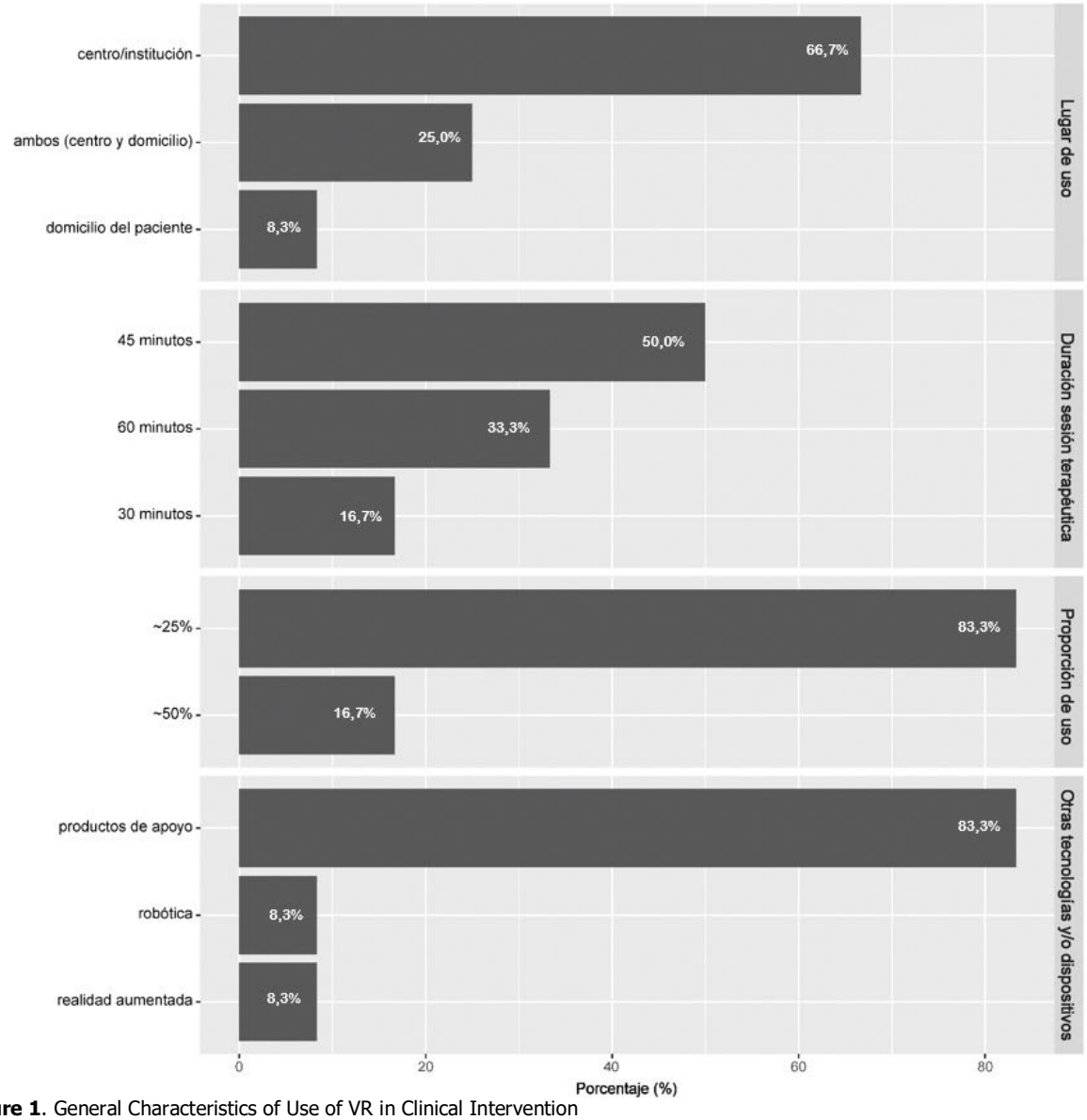

Figure 1. General Characteristics of Use of VR in Clinical Intervention

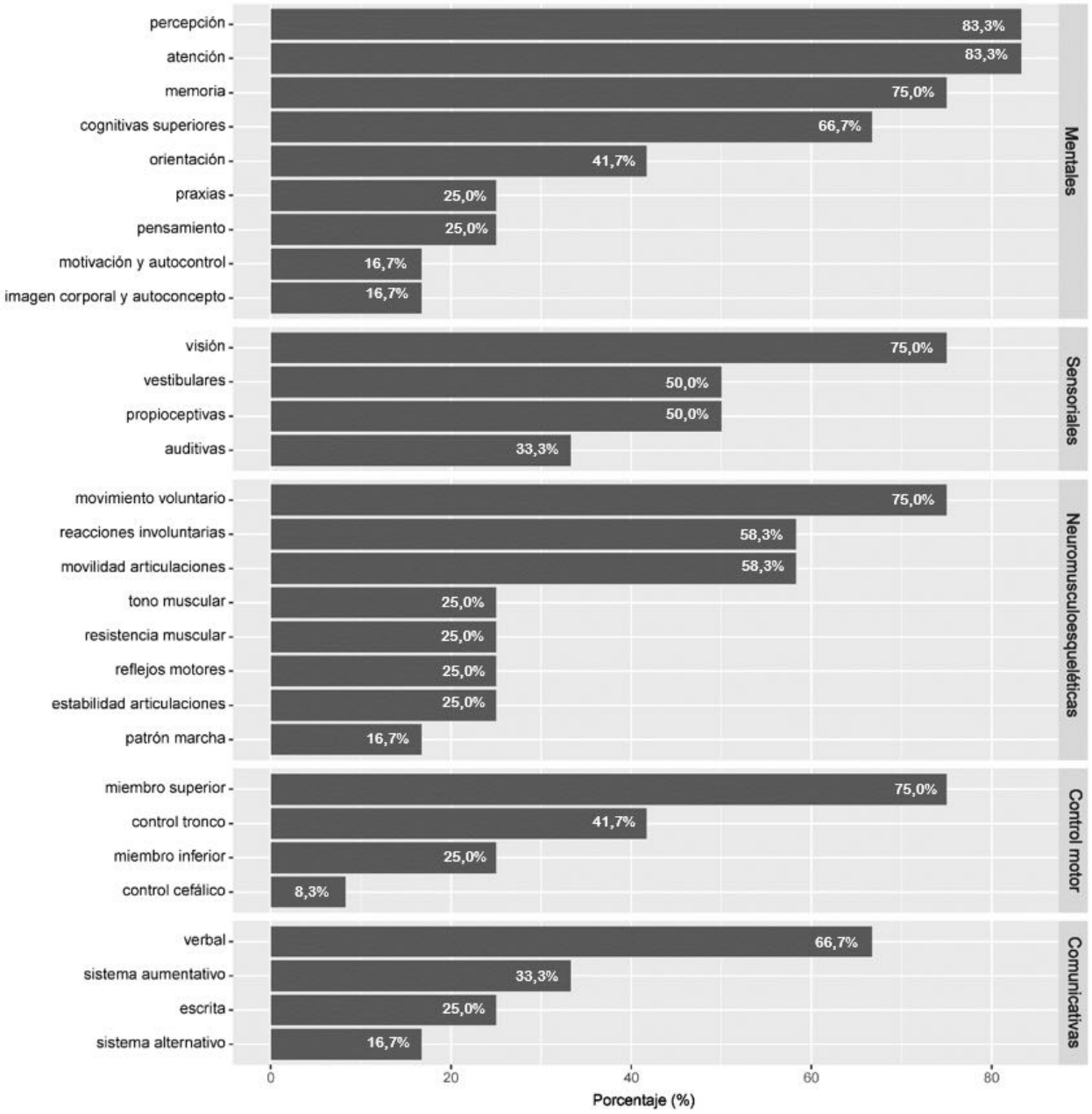

Figure 2. Objectives for the Use of VR for Training of Neurological Functions and Abilities

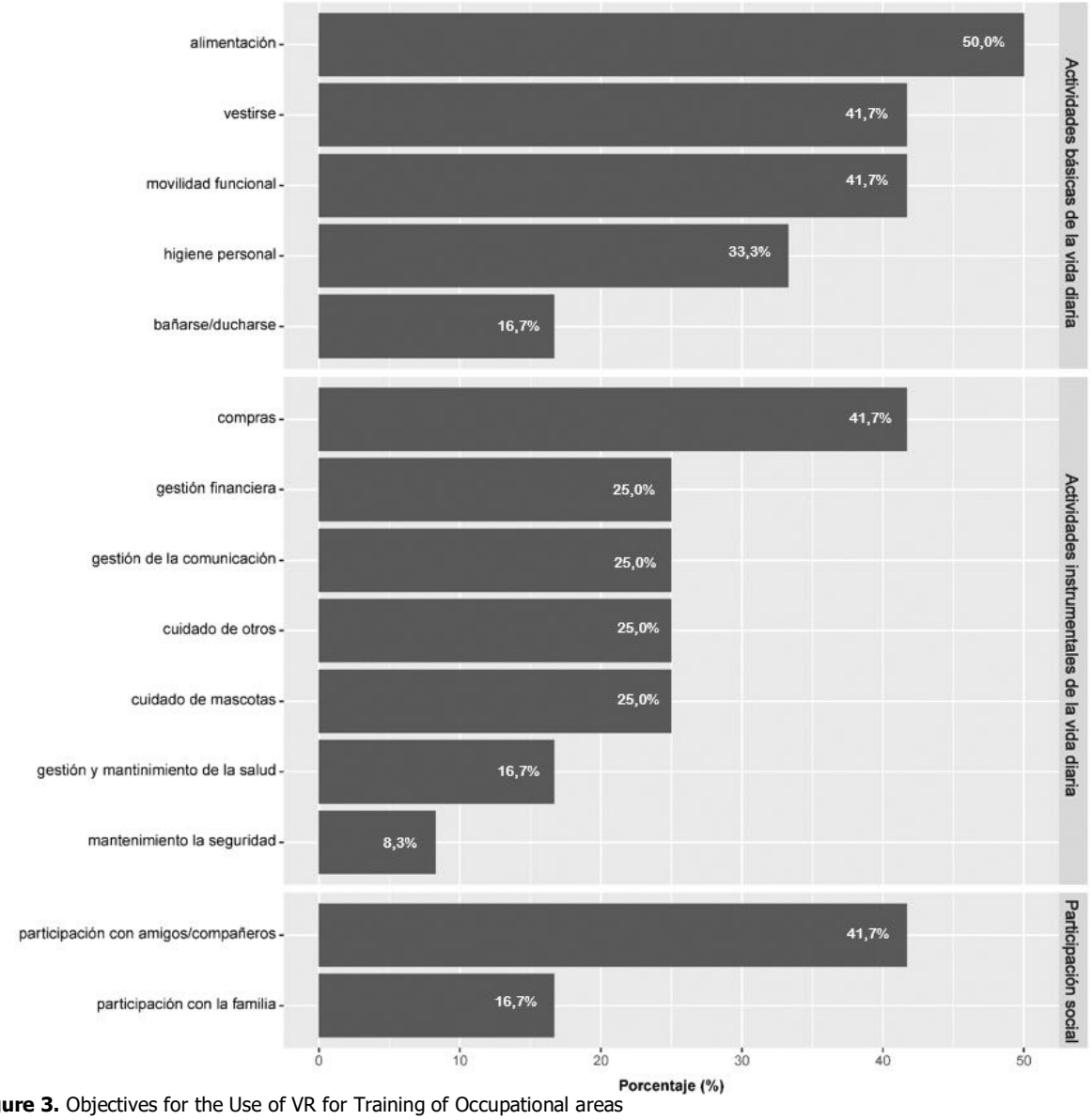

Figure 3. Objectives for the Use of VR for Training of Occupational areas

DISCUSIÓN

This study offers a first approach to the clinical use of VR as a tool for neuro-rehabilitation by occupational therapists. Application of VR within the therapy session was relatively low, the type of system used was non-immersive and semi-immersive, and it was usually used along with support products. The types of patients with whom VR was most used were those who were middle-aged adults with acquired brain damage in whom there was a predominance of symptoms related to cognitive alterations. The use of VR for treating neurological functions was principally directed towards perception, attention, memory and superior cognitive functions (mental functions); vision (sensory functions); voluntary movement (neuro-musculoskeletal functions); rehabilitation of the upper limb (motor control); and verbal communication (communication abilities). For occupational treatment, although used less frequently than in a global sense, VR was principally applied for daily activities related to self-feeding, shopping and to support social participation with friends. The computer and tablet along with the Wii and Kinect system consoles were the devices most frequently used, although the NeuroUp platform for cognitive stimulation was the VR system most used.

In our study, we observed that approximately half of the occupational therapists that participated did not use VR as a work tool in their clinical practice. The main reason they reported was that they did not have access to this technology in their work center. This could be related in part to the extended conviction that technological resources and innovations require a large economic investment. However, although the technologies related to rehabilitation can be costly there are currently low-cost alternatives, originally developed as video games, that have been used in the field of neuro-rehabilitation with positive results[10,19-21]. This increasingly favors their use

is more extended among health professionals. In fact, the occupational therapists in this study that used VR indicated that they normally use the computer and tablet together with this type of low-cost device as a VR system. However, the NeuronUp web platform for neuro-rehabilitation (https://www.neuronup.com/es/) was the treatment option most employed. This platform is also an economical option that offers therapists a group of activities specifically designed for neuropsychological rehabilitation and OT, which allows for creation of individualized intervention programs. This would explain why it is the system with the greatest percentage of use compared with other platforms or devices that therapists reported having used in this study. Moreover, the most common patient profile treated in this study could also be one of the reasons for the greater use of this platform, as it would determine the area or areas of intervention addressed by the occupational therapist. The participants in this study reported that they primarily treated patients with acquired brain damage and with cognitive alterations. Thus, it would be expected that mental functions would be among the areas of intervention addressed most frequently. In addition to being a platform aimed at treatment of occupational dysfunction, and therefore more susceptible to use by occupational therapists, the NeuronUp platform is primarily directed at cognitive stimulation. This would explain its greater use. In any case, the results of this study also show that occupational therapists frequently work with other sensory and neuro-musculoskeletal functions, motor control and communication abilities. The training of these functions was frequently carried out with the computer, tablet or other devices such as the Nintendo Wii and its accessories or the Kinect system. In this sense, there is evidence that the use of VR with these types of devices constitutes an effective neuro-rehabilitation treatment, especially for the recuperation of motor functions[5,6,9,10,19–21].

Despite the fact that the intervention was carried out by occupational therapists, the areas of intervention that were least addressed with VR by the study participants were those related to activities of daily living and social participation. This could be related primarily to the fact that there are more video games, applications and platforms designed to address specific neurological functions and abilities than there are dedicated to simulation of activities of daily living. In fact, evidence on the application of VR for occupational training is practically non-existent. This would also explain the fact that the occupational therapists who used VR reported that they had dedicated a relatively low percent of their time to the use of this technique in their therapy sessions (≈25%). Moreover, they also indicated that they almost always used it along with support products and as a complement to conventional therapy, never as a principal rehabilitation treatment.

Limitaciones y futuras líneas de la investigación

It is important to mention the different limitations of this study. The sample size was low, and the sample came from a specific geographic area which could potentially not be representative of the current situation of other occupational therapists that work in other parts of Spain. In any case, this work is a first exploration of the use of novel techniques such as VR in OT for the treatment of neurology patients, and it aims to serve as a point of departure for future research.

CONCLUSIÓN

Despite advances in the use of new technologies in the field of rehabilitation in neurology patients, only half of the occupational therapists in neuro-rehabilitation centers in the province of Alicante that participated in this study used VR. They primarily used the non-immersive or semi-immersive type, and they used it as a complement to conventional treatment. Considering the VR interventions have been related to improvements in motor, cognitive and psychological function and improvements in participation in the community[5,15], we believe that their use by occupational therapists that work in the area of neuro-rehabilitation will increase considerably in the years to come. Therefore, it is recommended to carry out monitoring and follow-up of these techniques in order to provide more knowledge and evidence to contribute to a better approach to treatment of neurology patients.

AGRADECIMIENTOS

The authors would like to thank all occupational therapists who participated in the study. Moreover, we must recognize the work carried out by all the researchers who make up the InTeO group (Research in Occupational Therapy) of the Miguel Hernández University: Eva-María Navarrete-Muñoz, Alicia Sánchez-Pérez, Miriam Hurtado-Pomares, Paula Peral-Gómez, Cristina Espinosa-Sempere, Iris Juárez-Leal and Desirée Valera-Gran. Finally, we would like to thank Emily Felt for providing assistance with the translation and revision of the English version of this article; she received compensation.

FINANCIACIÓN

This study did not receive funding from any source.

DECLARACIÓN DE AUTORÍA

P. Peral-Gómez and D. Valera-Gran have participated in the design of the study and in the conception and writing of the article. P. Peral-Gómez and L. Obregón-Carabalí carried out the study and collected data information. P. Peral-Gómez and D. Valera-Gran have contributed to the analysis and interpretation of results. All the authors have participated in the critical review and have accepted the final version.

REFERENCIAS BIBLIOGRÁFICAS

1. Neurological Disorders: Public Health Challenges. World Health Organization. Switzerland. WHO Press; 2007. Disponible en: https://www.who.int/mental_health/neurology/neurodiso/en/
2. GBD 2016 Neurology Collaborators. Global, regional, and national burden of neurological disorders, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet Neurol 2019; 18:459-480.
3. Martínez E. Investigación de enfermedades neurológicas en España. Documento de consenso sobre estrategias y prioridades. Madrid. Sociedad Española de Neurología; 2010. Disponible en: http://www.sen.es/noticias/91-articulos/542-libro-blanco
4. Pérez de Heredia-Torres M, Cuadrado-Pérez ML. Terapia ocupacional en Neurología. Rev Neurol. 2002;35(4):366-72.
5. Massetti T, da Silva TD, Crocetta TB, Guarnieri R, de Freitas BL, Bianchi Lopes P, et al. The clinical utility of virtual reality in neurorehabilitaction: a systematic rewiew. J Cent Nerv Syst Dis. 2018;10:1179573518813541.
6. Rose T, Nam CS, Chen KB. Immersion of virtual reality for rehabilitation - Review. Appl Ergon. 2018;69:153-161.
7. Moreno-Verdu M, Ferreira-Sanchez MR, Cano-de-la-Cuerda R, Jimenez-Antona C. Eficacia de la realidad virtual sobre el equilibrio y la marcha en esclerosis múltiple. Revisión sistemática de ensayos controlados aleatorizados. Rev Neurol. 2019;68(9):357-368.
8. Laffont I, Bakhti K, Coroian F, van Dokkum L, Mottet D, Schweighofer N, et al. Innovative technologies applied to sensorimotor rehabilitation after stroke. Ann Phys Rehabil Med. 2014;57(8):543-551.
9. Peñasco-Martín B, de los Reyes-Guzmán A, Gil-Agudo Á, Bernal-Sahún A, Pérez-Aguilar B, de la Peña-González AI. Aplicación de la realidad virtual en los aspectos motores de la neurorrehabilitación. Rev Neurol. 2010;51(8):481-8.
10. Aramaki AL, Sampaio RF, Reis ACS, Cavalcanti A, Dutra FCMSE. Virtual reality in the rehabilitation of patients with stroke: an integrative review. Arq Neuropsiquiatr. 2019;77(4):268-278.
11. Alashram AR, Annino G, Padua E, Romagnoli C, Mercuri NB. Cognitive rehabilitation post traumatic brain injury: A systematic review for emerging use of virtual reality technology. J Clin Neurosci. 2019. pii: S0967-5868(19)30560-0
12. Monge E, Molina F, Alguacil IM, Cano R, de Mauro A, Miangolarra JC. Empleo de sistemas de realidad virtual como método de propiocepción en parálisis cerebral: guía de práctica clínica. Neurología. 2014; 29(9):550-559.
13. Viñas-Diz S, Sobrido-Prieto M. Realidad virtual con fines terapéuticos en pacientes con ictus: revisión sistemática. Neurología. 2016; 31(4): 255-277.
14. Casuso-Holgado MJ, Martín-Valero R, Carazo A, Medrano-Sánchez E, Cortés-Vega MD, Montero-Bancalero FJ. Effectiveness of virtual reality training for balance and gait rehabilitation in people with multiple sclerosis: a systematic review and meta-analysis. Clin Rehabil. 2018;32(9):1220-1234.
15. Saposnik G, Levin M; Outcome Research Canada (SORCan) Working Group. Virtual reality for stroke rehabilitation: a meta-analysis and implications for clinicians. Stroke. 2011;42(5):1380-6.
16. Morales-Gomez S, Elizagaray-Garcia I, Yepes-Rojas O, de la Puente-Ranea L, Gil-Martinez A. Efectividad de los programas de inmersión virtual en los pacientes con enfermedad de Parkinson. Revisión sistemática. Rev Neurol. 2018;66(3):69-80.
17. Cano Porras D, Siemonsma P, Inzelberg R, Zeilig G, Plotnik M. Advantages of virtual reality in the rehabilitation of balance and gait: Systematic review. Neurology. 2018;90(22):1017-1025.
18. Guerrero G, García A. Plataformas de rehabilitación neuropsicológica: estado actual y líneas de trabajo. Neurología. 2015; 30(6): 359-366.
19. Mouawad MR, Doust CG, Max MD, McNulty PA. Wii-based movement therapy to promote improved upper extremity function post-stroke: A pilot study. J Rehabil Med. 2011;43(6):527-33.
20. Tsekleves E, Warland A, Kilbride C, Paraskevopoulos I, Skordoulis D. The Use of the Nintendo Wii in Motor Rehabilitation for Virtual Reality Interventions: A Literature Review. En: Ma M, Jain L, Anderson P, editors. Virtual, Augmented Reality and Serious Games for Healthcare 1. Intelligent Systems Reference Library, vol 68. Berlin: Springer; 2014. 321-344. Disponible en: https://link.springer.com/chapter/10.1007/978-3-642-54816-1_17
21. Saposnik G, Teasell R, Mamdani M, Hall J, McIlroy W, Cheung D, et al. Effectiveness of Virtual Reality Using Wii Gaming Technology in Stroke Rehabilitation. Stroke. 2010; 41(7): 1477-1484.