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Application of Virtual Reality in Rehabilitation of Disabilities: A Mini Review

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Abstract: Introduction: Information and communication technology has provided new opportunities for countries' health care systems. Improving the outcome of health treatments in different groups of disabled and disabled patients is one of the benefits of using this tool. Virtual reality has emerged as a powerful backup tool in the field of rehabilitation of the disabled in life and treatment. The purpose of this study is to review the published research on the application of virtual reality in the rehabilitation of the disabled. **Method**: In order to conduct a review research, PubMed, Scopus database was searched with the keywords "virtual reality, virtual reality and disability, virtual reality and electronic health" and its equivalent. The documents retrieved from the search were sent to Endnote software and evaluated according to the set criteria. **Results**: 70 articles that met the inclusion criteria constituted the research sample. The results showed a significant effect of using virtual reality in the rehabilitation of the disabled and improving patient care in the health system of countries. **Conclusion**: Virtual reality can be used in the health system for the rehabilitation of the disabled due to the effectiveness of routine methods of medical rehabilitation interventions. According to the results of the study, the use of virtual reality in mobile health, especially in educating patients and the disabled to self-care and reduce fear and anxiety, will be very effective.

Key words: Virtual Reality, Information and Communication Technology, Disability, Rehabilitation.

1. Introduction

Disability refers to the inability to perform all or part of the activities of individual or social life due to a congenital or acquired defect in physical or mental strength [1, 2].

Nowadays society is facing a process where life expectancy is gradually but constantly increasing. As a result, the group of elderly people is growing to become one of the most significant in the entire population This also means that the prevalence of physical and cognitive impairments is increasing in proportion.In this context, providing the elderly and people with disabilities (E&D) with accessible systems and services that could improve their level of independence and thus enhance their quality of life has become a must for ICT –Information and Communication Technologies – developers such as usability engineers and interaction designers [3].

The World Health Organization points out that a person with a disability is not only a person with a physical problem, but also any person in a social relationship.

According to the organization, the global increase in chronic health problems such as diabetes, cardiovascular disease, stroke, cancer and mental disorders are reasons for the increase the number of people with disabilities in the world (Chronic diseases are considered as disabilities) [4, 5].

According to UNESCO (United Nations Educational, Scientific and Cultural Organization) decisions, the agenda of the 2030 program will Reduce disability (2030 program is a global road map strategically with a clear framework to reduce the risk of natural disasters, the vital importance of capacity, skills and human knowledge to adapt and meet the challenges and opportunities. The present and the future refer to the fundamental contribution of quality,

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inclusive education at all levels and the importance of lifelong learning opportunities for all, etc.) [6].

Disability is not just a health problem; it is a complex phenomenon, and overcoming these problems requires interventions to remove environmental and social barriers. One way to promote the equal presence of persons with disabilities in the transport, communications and information society through the development of information and communication technologies (ICT), development and promotion of technologies, is through the digital divide [7-9].

Virtual reality (VR) is one of the most widely used technologies in this field [10]. Due to the progress of information technology and the reduction of cost in the past ten years, the application of virtual reality (VR) in the field of health care has been increasing [11].

In recent years, virtual reality (VR) technologies have begun to be used as an assessment and an intervention tool in rehabilitation. Due to the increased ability of people with disabilities the life expectancy of people with disabilities has increased significantly over the last century, but yet the life expectancy of these people is lower than the life expectancy of other people in society [12]. Therefore, they need more health and social support than other people in the community to enjoy a more comfortable life [13]. Virtual reality (VR) has recently emerged as a potentially effective way to provide public and special health care services in different communities [14]. The use of information and communication technologies is one of the best ways to involve them in all cultural, social, political and economic affairs. In other words, ICT is the most effective way to empower people with disabilities to learn more about this source text and the complementary translated information needed by other sectors of the information society. They can bridge the information and digital divide between healthy people and people with disabilities and contribute to social justice [15, 16]. One of the most widely used technologies in this field is virtual reality (VR) [17-20]. Which is effective with auxiliary applications to use the largest number of human senses (sight, touch, hearing) [21-23].

This technology is a virtual world parallel to the real world in beneficial interaction with each other to help with medical education, help improve mental disorders, rehabilitate strokes, multiple sclerosis (MS), trauma, make autistic patients independent, treat fear (fear of heights, fear of disaster), illustrates for surgery, creates medical simulations, uses other VR applications in teaching medical surgeries such as eye surgery, orthopedics, laparoscopy, uses in the treatment of physiological diseases, helps with analgesic and anxiety techniques, and helps with nursing care [24-30].

In many cases, virtual reality has been helpful in increasing the rehabilitation of people with disabilities. For example, one of the applications of virtual reality in helping the disabled is to create a graphical simulation environment to solve Disability has been a disability and has made the person use the acquired skills to ease the effect of reducing disability restrictions in personal life [31]. Many programs have been created to help increase the ability of people with disabilities, including cognitive assessment, physical assessment, training, driving, shopping, cross-street without fear, clear hearing, experience of many senses without engaging with the real environment. High-risk (mountaineering, etc.) help these people [32].

In fact, virtual reality is the basic skills that healthy people normally have (sitting, walking, listening to driving, mountaineering...), and in Everyday life plays a key role for them to enable people with disabilities to experience it through the use of those senses in a safe environment [33-35].

This technology in many ways, including the creation of desktop systems equipped with audio software, virtual worlds and games and Systems that create complete immersion in the virtual environment manage the types of fears and anxieties of patients,

disease status management, as well as computer games based on virtual reality interacting with the 3D environment, an effective solution by facilitating specific clinical exercises and Encourages people to do them in rehabilitation treatment [36-40].

In addition to the application of this technology in industry, banking and agriculture, the ultimate goal of this technology is to improve the ability of education, manage the lives of the disabled, increase their independence, and enhance their self-confidence and self-esteem. By minimizing the impact of disability on their lives, ultimately improve their quality of life. A person can enter the society through real experience in a safe environment, so as to feel valuable [41]. The purpose of this study is to review the research on the impact of virtual reality on the rehabilitation of people with physical, psychological and psychological disabilities.

2. Materials and Methods

We Search in PubMed and Scopus databases (2010-2020) using the keywords “VR”, “VR in e-health”, “VR in disability” and “VR mobile Health”. During this time, more than 180 documents were reviewed and related items were extracted according to the following criteria. First of all, from the perspective of topic relevance, the search engine found the title was checked, the research results are divided into two groups, one group is the article, the other group is the book. In the selection criteria following the topic relationship, select items that are more complete than the other items for reference. For books, the selection criteria are subject relevance and usability. After reviewing the titles, we will evaluate the articles in the next step in terms of the relationship between the abstract and the intended purpose. Documents retrieved from the search will be sent to the EndNote software and questions answered according to the criteria set (based on the time frame of the article’s publication. e.g.What disabilities can be treated using virtual reality? Has virtual reality been effective in treatment?) in the review of the title of the article for disability affecting virtual reality (mental, psychological, and physical) and the review of abstractions and results. The selected cases were thoroughly studied and finalized.

3. Review of Recent Research Work to respond to two questions

Disability often occurs both physically and mentally. One application of virtual reality technology is to help stroke victims. As a result of the stroke, people suffer from mobility problems, unable to perform everyday activities such as driving and writing. Virtual reality with IVG has been able to create 3D games and animations to create new methods of treatment and rehabilitation for these people. Studies have shown that disabled people treated with VR and IVG in hospitals gain better skills in daily activities compared to traditional therapies [42].

Studies evaluating the effect of virtual reality system design on the rehabilitation of stroke patients have shown that the use of virtual reality technology is effective in the rehabilitation of stroke patients and in reducing functional errors [43]. This technique has a significant impact on improving gait and balance in these patients [44]. In addition, studies have shown that the use of VR can improve motor function, enhance patients' enthusiasm for community participation, and improve patients’ psychological performance [45].

This technology in order to intervene in the training of wheelchair use skills of people with disabilities in various studies shows that in most virtual reality interventions in this regard, it has had effective effects on improving wheelchair use skills by people with disabilities [46]. The effect of virtual reality in patients with cognitive problems and dementia shows that the use of virtual reality to help cognitive problems and people with dementia has been effective [47]. In cases of amputation and when a person is

waiting to receive a hand or foot prosthesis, practicing with virtual reality before receiving an artificial limb helps the patient to be motivated and to prevent muscle wasting and reduced mobility [48]. Expressed in MS patients with driving problems and accidents of these people and the use of simulation of VR technology (VR) in reducing accidents and traffic violations, the results show that comprehensive assessments of driving, before a serious traffic accident or accident using It is effective in reducing the amount of injuries from the driving simulator [49].

VR by improving the response to individual needs, training, and promote life skills (fearless bystreet, shopping, meet the demand of education, virtual wheelchair training [50, 51], orthopaedics disease (children) skills, to improve the disabled children life skills, etc.) and tips on how to use sound and touch, for blind children and motivation), social participation (simulated streets, cars and pedestrians virtual driving, learn to take public transportation), by minimizing the effects of disability in life to improve the quality of life, create the safe motion perception environment, through the development of behavior problem children's social skills, improve social relations [52]. The results of VR in the treatment of mental disorders and anxiety disorders show that VR is an effective treatment that, according to existing treatment methods, has a lasting effect and can be extended to the real world [53, 54]. VR can also improve the accuracy of functional diagnosis and improve the improvement and efficacy of schizophrenia in neurological and social evaluations of these patients.

Using VR environment to analyze psychological association and predict psychological symptoms can improve the understanding of this disease and provide more effective treatment methods [55-57]. In order to promote the provision of medical services to patients and make them aware of the results of surgery, this undoubtedly brings pressure to patients, which is worrisome. The use of VR platform on smart phones can reduce this anxiety and provide guidance for use. Drugs and methods. Postoperative therapy is very cumbersome and forgetful for patients to listen to the suggestions of nurses and doctors on smart phones, which may be helpful [57, 58]. In order to alleviate the pain and anxiety of patients, virtual reality is used in mobile healthcare applications, because in addition to making patients addicted to VR programs to distract their attention, the National Institutes of health no longer accepts the use of morphine. Victims using bandages and dressings (as non drug analgesics) [59, 60].

4. Discussion

Although a number of researchers believe that most studies on VR require a full understanding of the effects on patients' brains, a large number of studies have shown that it is beneficial and has positive effects on the treatment and rehabilitation of people with disabilities.

A study by J. H. Crosbie and colleagues in 2009 on the impact of virtual reality on stroke rehabilitation suggests that VR is a potentially exciting and safe tool for stroke rehabilitation, but design documentation and the possibility of definitively assessing its value are limited. Thus, while the findings of this study are generally positive, the level of evidence in terms of research quality is still poor to moderate. Further study in the form of carefully controlled studies will ensure that the positive impact of virtual reality is seen. People with learning disabilities such as autism can use VR to enhance learning, self-confidence, job skills, community independence, and personal work.

V. Bernard Opitz [61-64] in his study stated that children with autism are more interested in computer systems than toys and can interact better. In addition, using simulation, a real experience in the virtual world uses VR to help more people with epilepsy and other conditions such as Alzheimer's have a better and more comfortable life. For people with certain visual impairments [65-67], including Stargart's disease (reduced vision of central vision), It is possible to see

images more clearly using VR. The use of virtual reality in helping people with mental disabilities has been shown to have many characteristics that, as an intervention and an assessment, can rehabilitate them [68].

This is done by creating a safe environment to gain experience and skills in the field, which may pose many real-world risks to them. The virtual world can be manipulated in a way that the real world cannot and can convey concepts without the use of language or other symbolic systems. Improving independent living skills, strengthening cognitive function and improving social skills are the results of using virtual technology. This technology needs training, but it is still not possible to create VR in real time with very realistic images. If people with disabilities find VR products unrealistic, unresponsive, or frustrating to use, the benefits of VR over traditional therapies are lost [69].

Moreover, any useful technology must be usable. If people with disabilities are not able to use the new VR technology in their homes and in the rehabilitation centers where they live, they will not be able to receive benefits. While VR offers a lower cost advantage than many real-world simulators, the new technology remains a challenge (technology, acceptance, and cost).With the development of new products, VR systems are becoming more and more cost-effective.

However, maintaining a virtual reality system can be very expensive. Joint distribution of online products and prototypes could close the gap between research and application in one day. There are some problems with the use of HMDS, including low resolution, limited vision, and a tendency to limit movement due to size, weight, and accessories. However, with the expansion of the scope of research based on virtual reality, its shortcomings have been reduced, improving the work efficiency for the disabled.

5. Conclusions

Virtual reality as a new technology in addition to being useful in educational fields can help people with disabilities. The main recognized benefits of VR for people with disabilities are that they can safely engage in an activity they were previously unable to do in a safe simulated environment free of the constraints that result from their disability. (At least experience the feeling of doing it in a virtual environment with a real sense of excitement). However, a number of studies have discussed current technological limitations and ethical concerns about disability.

References

[1] Mansour M. 2009. “Employers’ Attitudes and Concerns about the Employment of Disabled People.” International Review of Business Research Papers 5 (4): 209-18.

[2] https://www.disabled-world.com/disability/types/mobility/

[3] Stendal, K. 2012. “How do People with Disability Use and Experience Virtual Worlds and ICT: A Literature Review.” *Journal for Virtual Worlds Research* 5 (1).

[4] https://www.who.int/disabilities/infographic/en/

[5] World report on disability 2011.

[6] https://en.unesco.org/sustainabledevelopmentgoals

[7] https://www.aimu.us/2017/02/25/disabilities-causes-diagnosis-and-management/

[8] www.telecentre.org

[9] Ullmann, H., Jones, F., Williams, R. C., Williams, D. Information and communications technologies for the inclusion and empowerment of persons with disabilities in Latin America and the Caribbean. 2018.

[10] Hossain, M. K., editor ICT for persons with disabilities: bridging the digital divide in Bangladesh. International Conference on Computers for Handicapped Persons; 2010: Springer.

[11] Riva, G. 2002. “Virtual Reality for Health Care: The Status of Research.” *Cyber Psychology & Behavior* 5 (3): 219-25.

[12] Heller, T., Sorensen, A. 2013. “Promoting Healthy Aging in Adults with Developmental Disabilities.” *Developmental Disabilities Research Reviews* 18 (1): 22-30.

[13] Riva, G. 2005. “Virtual Reality in Psychotherapy: Review.” *Cyberpsychol Behav* 8 (3): 220-30.

[14] Groah, S. L. et al. 2012. “Spinal Cord Injury and Aging: Challenges and Recommendations for Future Research.” *Am J Phys Med Rehabil* 91 (1): 80-93.

[15] Kang, S., Kang, S. 2019. “The study on the application of virtual reality in adapted physical education.” *Cluster*

Computing 22 (1): 2351-5.

[16] Quintero, J., Baldiris Navarro, S. M., Rubira, R., Cerón, J., Velez, G. 2019. "Augmented Reality in Educational Inclusion. A Systematic Review on the Last Decade." *Frontiers in Psychology* https://doi.org/10.3389/fpsyg.2019.01835.

[17] Sarraf-Razavi, M., Tabatabaei, S. M., Talaei, A., Bordbar M. R. F. 2019. "Application of Virtual Reality for Helping People with Psychiatric Disorders: A Mini Review." *Landscape* 109 (3): 395-417.

[18] Massetti, T. et al. 2018. "The Clinical Utility of Virtual Reality in Neurorehabilitation: A Systematic Review." *J Cent Nerv Syst Dis* doi: 10.1177/1179573518813541.

[19] da Cunha, R. D., Neiva, F. W., da Silva, R. L. de S. 2018. "Virtual Reality as a Support Tool for the Treatment of People with Intellectual and Multiple Disabilities: A Systematic Literature Review." *Revista de Informática Teórica e Aplicada* 25 (1): 67-81.

[20] Gomez, J. et al. 2017. "The Use of Virtual Reality Facilitates Dialectical Behavior Therapy® "Observing Sounds and Visuals" Mindfulness Skills Training Exercises for a Latino Patient with Severe Burns: A Case Study." *Frontiers in Psychology* doi: 10.3389/fpsyg.2017.01611.

[21] Fang, H., Zhang, J., Sensoy, M., Thalmann, N. M. 2011. "Design of a Reputation Mechanism for Virtual Reality: A case for E-Commerce." TRUST IN AGENT SOCIETIES (TRUST-2011) pp. 53-67.

[22] Wang MJ-C. Contextual Processing of Objects: Using Virtual Reality to Improve Abstraction and Cognitive Flexibility in Children with Autism: University of Toronto; 2010.

[23] Alsofy, S. Z. et al. 2020. "Comparison of Stand-Alone Cage and Cage-with-Plate for Monosegmental Cervical Fusion and Impact of Virtual Reality in Evaluating Surgical Results." *Clinical Neurology and Neurosurgery* doi: 10.1016/j.clineuro.2020.105685.

[24] Söderström, S. 2009. "The Significance of ICT in Disabled Youth's Identity Negotiations." *Scandinavian Journal of Disability Research* 11 (2): 131-44.

[25] Cho, S. et al. 2014. "Development of Virtual Reality Proprioceptive Rehabilitation System for Stroke Patients." C*omput Methods Programs Biomed* 113 (1): 258-65.

[26] Eichenberg, C., Wolters, C. 2012. "Virtual Realities in the Treatment of Mental Disorders: A Review of the Current State of Research." doi: 10.5772/50094.

[27] Wilson, P. N., Foreman, N., Stanton, D. 1997. "Virtual Reality, Disability and Rehabilitation." *Disabil Rehabil* 19 (6): 213-20.

[28] Wendy E. Mackay. 1998. "Augmented Reality: Linking real and virtual worlds. A new paradigm for interacting with computers" Proceedings of the working conference on advanced visual interfaces.

[29] Tabatabaei, S. M., Talaei, A. 2019. "Virtual Reality as a Friend of the Elderly: A Mini-Review." *Biomedical Journal of Scientific & Technical Research* 22 (2): 16517-16519.

[30] Bassas. M, Maurer. W, Safar. M: Virtual Reality in Industry Illinois Institute of Technology, 2018.

[31] Lee, S., Shin, S. 2013. "Effectiveness of Virtual Reality Using Video Gaming Technology in Elderly Adults with Diabetes Mellitus." *Diabetes Technology & Therapeutics* 15 (6): 489-96.

[32] McComas, J., Pivik, P., Laflamme, M. 1998. "Current Uses of Virtual Reality for Children with Disabilities." *Virtual Environments in Clinical Psychology and Neuroscience*.

[33] Tarrant, J., Viczko, J., Cope, H. 2018. "Virtual Reality for Anxiety Reduction Demonstrated by Quantitative EEG: A Pilot Study." *Front Psychol* 9: 1280.

[34] Chowdhury, T. I., Ferdous, S. M. S., Quarles, J. 2017. "Information recall in a virtual reality disability simulation." Proceedings of the 23rd ACM symposium on virtual reality software and technology.

[35] Mondellini, M., Pizzagalli, S., Greci, L., Sacco, M. 2019. "Assessment of an Immersive Virtual Supermarket to Train Post-stroke Patients: A Pilot Study on Healthy People." AVR 2019: Augmented Reality, Virtual Reality, and Computer Graphics. pp. 313-329.

[36] Arfaoui, A., Edwards, G., Morales, E., Fougeyrollas, P. 2020. "Designing Interactive and Immersive Multimodal Installations for People with Disability." doi: 10.5772/intechopen.90678.

[37] Masmoudi, M., Djekoune, O., Zenati, N., Benrachou, D. E. 2019. "Design and Development of 3D Environment and Virtual Reality Interaction: Application to Functional Rehabilitation."

[38] Negrini, S., Pollet, J., Piovanelli, B. 2019. "Cochrane Rehabilitation: Prove Scientifiche sull'uso della tecnologia e robotica in riabilitazione." *Giornale italiano di Medicina Riabilitativa* 4-6.

[39] Mountain, A. D., Kirby, R. L., Smith, C., Eskes, G., Thompson, K. 2014. "Powered Wheelchair Skills Training for Persons with Stroke: A Randomized Controlled Trial." *Am J Phys Med Rehabil* 93 (12): 1031-43.

[40] Heirani, A., Aghdasi, M. T., Jahangiri, M. 2016. "Effect of Virtual Motor Rehabilitation on Balance and Mobility among Patients with Acquired Brain Injury." *MEJDS*.

[41] Jack, D. et al. 2000. "A virtual reality-based exercise program for stroke rehabilitation." Proceedings of the fourth international ACM conference on Assistive technologies.

[42] Jeffs, T. L. 2009. "Virtual Reality and Special Needs." Themes in science and technology education. 2 (1-2): 253-68.

[43] Wu, H., Ashmead, D. H., Adams, H., Bodenheimer, B. 2018. "Using virtual reality to assess the street crossing behavior of pedestrians with simulated macular degeneration at a roundabout." *Frontiers in ICT* 5: 27.

[44] Yalon-Chamovitz, S., Weiss, P. L. T. 2008. "Virtual Reality as a Leisure Activity for Young Adults with Physical and Intellectual Disabilities." *Research in Developmental Disabilities* 29 (3): 273-87.

[45] Zahid. et al. 2013. "Information Communication Technology (ICT) for Disabled Persons in Bangladesh: Preliminary Study of Impact/Outcome." https://hal.inria.fr/hal-01468147.

[46] Park, M. J., Kim, D. J., Lee, U., Na, E. J., Jeon, H. J. 2019. "A Literature Overview of Virtual Reality (VR) in Treatment of Psychiatric Disorders: Recent Advances and Limitations." *Front Psychiatry* 10: 505.

[47] Pascual, A., Ribera, M., Granollers, T., Coiduras, J. L. 2014. "Impact of Accessibility Barriers on the Mood of Blind, Low-Vision and Sighted Users." *Procedia Computer Science* 27: 431-40.

[48] Pivik, J., McComas, J., MaCfarlane, I., Laflamme, M. 2002. "Using virtual reality to teach disability awareness." *Journal of Educational Computing Research* 26 (2): 203-18.

[49] Fang, H., Zhang, J., Sensoy, M., Thalmann, N. M. 2011. "A Reputation Mechanism for Virtual Reality-Five-Sense Oriented Feedback Provision and Subjectivity Alignment." doi: 10.1109/TrustCom.2011.42.

[50] Palanica. A., Docktor, M., Yan Fossat. A. 2019. "Using Mobile Virtual Reality to Enhance Medical Comprehension and Satisfaction in Patients and Their Families." *Perspect Med Educ* 8 (2): 123-127.

[51] Alex, M., Wünsche, B. C., Lottridge, D. 2021. "Virtual Reality Art-Making for Stroke Rehabilitation: Field Study and Technology Probe." *International Journal of Human-Computer Studies* https://doi.org/10.1016/j.ijhcs.2020.102481.

[52] Wiederhold. B. K. et al. 2018. "Using Virtual Reality to Mobilize Health Care: Mobile Virtual Reality Technology for Attenuation of Anxiety and Pain." https://ieeexplore.ieee.org/document/8197481.

[53] Hassan A. Aziz. 2018. "Virtual Reality Programs Applications in Healthcare." *Journal of Health & Medical Informatics* 9: 1. doi: 10.4172/2157-7420.1000305.

[54] Hosseinnia, F., Khaleghi, A., Mahmoudi, K. 2020. "Using Gamification Based on Virtual Reality Mobile Platform for Treatment of Adults with Amblyopia." In book: Internet of Things, Infrastructures and Mobile Applications, Proceedings of the 13th IMCL Conference (pp.836-843). doi: 10.1007/978-3-030-49932-7_78.

[55] Li, H. et al. 2020. "Application Research of Virtual Reality and Augmented Reality." MMIA 2020: Application of Intelligent Systems in Multi-modal Information Analytics. pp. 494-499.

[56] Zainal, N. et al. 2020. "Predicting MIRA Patients' Performance Using Virtual Rehabilitation Programmed by Decision Tree Modelling." Part of the Studies in Systems, Decision and Control book series (SSDC, volume 295), pp. 451-462.

[57] Silva, T. D. D, et al. 2020. "Effect of Combined Therapy of Virtual Reality and Transcranial Direct Current Stimulation in Children and Adolescents With Cerebral Palsy: A Study Protocol for a Triple-Blinded Randomized Controlled Crossover Trial." *Frontiers in Neurology* https://doi.org/10.3389/fneur.2020.00953.

[58] Ahern, M. et al. 2020. "The Effectiveness of Virtual Reality in Patients with Spinal Pain: A Systematic Review and Meta-Analysis." *Pain Practice* 20 (6): 656-675.

[59] Lam, A. K. N. et al. 2020. "Use of Virtual Reality Simulation to Identify Vision-Related Disability in Patients with Glaucoma." *JAMA Ophthalmol* 138 (5): 490-498.

[60] Gerling, K. et al. 2020. "Virtual Reality Games for People Using Wheelchairs." In: 2020 CHI Conference on Human Factors in Computing Systems. https://doi.org/10.1145/3313831.3376265.

[61] Raphail, A. A-M. et al. 2020. "The Relationship between Multiple Sclerosis Symptom Severity Measures and Performance on Driving Variability Metrics in a Virtual Reality Simulator." *Am J Phys Med Rehabil* 99 (4): 278-84.

[62] Gianola, S. et al. 2020. "Effects of early virtual reality-based rehabilitation in patients with total knee arthroplasty: A randomized controlled trial." *Medicine* (Baltimore) 99 (7): e19136.

[63] Lee, J. H. et al. 2003. "A Virtual Reality System for the Assessment and Rehabilitation of the Activities of Daily Living." *Cyberpsychol Behav* 6 (4): 383-8.

[64] Bu, L. et al. 2021. "A User-Centric Design Approach for Smart Product-Service Systems Using Virtual Reality: A Case Study." *Journal of Cleaner Production* https://doi.org/10.1016/j.jclepro.2020.124413.

[65] Wiederhold, B. K. et al. 2014. "How Can Virtual Reality Interventions Help Reduce Prescription Opioid Drug Misuse?" *Cyberpsychol Behav Soc Netw* 17 (6): 331-2.

[66] Wiederhold, B. K. et al. 2014. "Virtual Reality as a Distraction Technique in Chronic Pain Patients." *Cyberpsychol Behav Soc Netw* 17 (6): 346-52.

[67] Saposnik, G., Levin, M. 2011. "Virtual Reality in Stroke

Rehabilitation: A Meta-Analysis and Implications for Clinicians." *Stroke* 42 (5): 1380-6.

[68] Slater, M., Sanchez-Vives, M. V. 2016. "Enhancing Our Lives with Immersive Virtual Reality." *Front. Robot. AI* https://doi.org/10.3389/frobt.2016.00074.

[69] Mao, Y., Chen, P., Li, L., Huang, D. F. 2014. "Virtual Reality Training Improves Balance Function." *Neural Regen Res* 9 (17): 1628-34.