Characterizing the Use of Interactive Technologies for Cognitive Rehabilitation in Portuguese Healthcare Institutions

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ABSTRACT

The increasing predominance of cognitive deficits following neurological conditions such as dementia and stroke is a major concern in Portugal. Cognitive rehabilitation has been shown to be fundamental to alleviate some of the deficits, but it is not always customized to the specific profile of each patient. More critically, patients typically do not have rehabilitation while they are in the waiting list or after discharge. One way to address these limitations is using interactive technologies specifically designed for cognitive rehabilitation. Their digital nature allows the customization of parameters enabling personalization and adaptation to each patient's profile, as well as the possibility of quantification of performance. In addition, these tools have the potential to be used at home, allowing patients to continue their rehabilitation and being monitored remotely, alleviating the burden of institutionalization for both patients and healthcare systems. However, before proposing novel technologies, it is imperative to understand current practices, needs, preferences and expectations of health professionals in this domain. For this purpose, we developed an online questionnaire that was distributed among health professionals in Portugal. 116 participants have responded, with 35% reporting having experience in the use of interactive technologies for cognitive rehabilitation. Our results show that health professionals that use these technologies mainly value ease of interaction, diversity of activities, task personalization to the patient's cognitive profile, and adaptation based on performance. These and other insights will be used to inform the development of novel tools for cognitive rehabilitation in clinical and home settings.

Keywords: Cognitive Rehabilitation, Interactive Technologies, Health Professionals, Survey, Human-Centered Design.

1. INTRODUCTION

The biological functional and cognitive decline of the elderly and associated risks (Carneiro et al., 2017) are determinant for dependent functioning in late life (Agüero-Torres et al., 2002). In Portugal, taking into account the expected increase in the ageing ratio, it is expected that the index of functionally dependent elderly will double from 33.9 in 2018 to 67.8 in 2080 for each 100 potentially active (INE, 2019). The aged population is also at a higher risk of suffering a stroke which can have an impact in cognitive function, and consequently on quality of life (Cumming et al., 2013).

Evidence shows that Cognitive Rehabilitation (CR) should target improving everyday functioning and result in meaningful outcomes valuable for the patients and their relatives (Cicerone et al., 2019). CR intervention strategies such as cognitive retraining, functional compensation, assessment, and goal setting and implementation are examples of common practices by Health Professionals (HPs) to achieve this goal (Nowell et al., 2019). However, several traditional CR practices rely on the use of games, puzzles, or paper and pencil activities that not always allow for customization according to each patient's cognitive profile, which is key for the success of rehabilitation (Pariente, 2006). Cognitive training and rehabilitation programs using Interactive Technologies (ITs) such as computer programs and technological devices are considered promising for improving cognitive function

(Ge et al., 2018). ITs have several advantages in comparison to traditional methods, for instance, technologies based on Virtual Environments (VEs) offer the possibility to simulate Activities of Daily Living (ADLs), allowing retraining everyday functioning while promoting enjoyment and adherence to CR (Maggio et al., 2019; Snoswell & Snoswell, 2019). The similarities of VEs to the real world provide the advantage of performing adapted tasks in safe and ecological environments (Ferche et al., 2015). Additionally, the digital nature of ITs allows the customization of parameters enabling personalization and adaptation to each patient profile along with the possibility of quantification of performance (Paravati et al., 2017). Several studies are showing promising results when using these technologies alone or in conjunction with traditional CR (Ge et al., 2018). For example, a recent study compared the effect of applying two types of ITs, a computerized cognitive training programme and a VE rehabilitation system (Baltaduonienė et al., 2019). The results showed that patients who underwent rehabilitation with ITs had their cognitive functions significantly improved compared with the group that only had occupational therapy sessions. Another study compared the performance of stroke patients that underwent adaptive cognitive training in a VE with those doing paper-and-pencil tasks (Faria et al., 2019). The results showed that both groups obtained similar performance, but the VE condition offered a more intensive training, a factor that can be relevant for recovery.

Despite the evidence that supports the effective usage of ITs for CR, not much is known about if and how they are being used in current CR interventions in Portuguese health institutions. For instance, there is not even any record in the Portuguese nomenclature of medical devices list that refers to CR system or software (SNS, 2020). Knowing how and to what extend these technologies are being currently used in daily practice as well as the main barriers for their adoption is crucial to inform the design of new ITs for CR that are more easily adopted and more effectively used. The current practices in CR and HPs' opinions and expectations towards the use of ITs have been studied in other countries such as the Netherlands (de Joode et al., 2012; Wentink et al., 2018), the United States (Wang et al., 2016), and Sweden (Gustavsson et al., 2020). The results from these studies provided useful information and recommendations towards the design and implementation of ITs for CR. For example, ITs for CR should promote the interaction between patients and HPs to share knowledge and experiences because the lack of information on ITs for CR is one of the most reported reasons for not using them (de Joode et al., 2012). Another example is that there should be an effort in creating some systematic delivery of training on how to use these technologies that can be easily accessed by patients and caregivers (Wang et al., 2016). However, these studies focussed on the use of assistive technologies to cognitive aid, and not so much on their use for cognitive training. Here, we investigate the current practices and HP' opinions towards the use of ITs, specifically for CR. For this purpose, we designed an online questionnaire that was disseminated to Portuguese healthcare institutions. Our target was to characterize six main domains: the profile of HPs, the healthcare institutions, the current practices in CR, the use of ITs in CR, rehabilitation at home with ITs, and the collaboration in the design of ITs for CR. Additionally, we also wanted to explore if there are differences in attitude towards using ITs for CR between HPs that are already using them and those who aren't. The results of this study will be used to inform the design of a CR platform for in situ and @home rehabilitation.

2. METHODS

2.1 Experimental Procedure

We developed an online questionnaire using Google forms to be self-administered by HPs currently practicing CR in Portuguese health institutions. The questionnaire was disseminated through different channels to reach the maximum number of HPs practicing CR in health institutions in Portugal. For this, an email was sent to various public and private Portuguese hospitals, rehabilitation centers, and non-profit healthcare institutions. Additionally, the questionnaire was also disseminated through social networks. Before dissemination, we performed an informal pilot with a psychologist experienced in the field, a team member representative of the target audience, to gather feedback on the content, length, and clarity of the questionnaire. After adjustments, the final version consisted of 9 main sections. Some items consisted on statements to be rated on a 6-items Likert scale (LS1-6), ranging from 1 = "I disagree completely" to 6 = "I agree completely". There were also open-ended questions and multiple-choice (MC) answers. At the beginning of the questionnaire, an informed consent was presented, and the participant could only proceed after agreeing. The sections of the questionnaire were grouped in different domains that included the following items:

2.1.1 *The Health Professional*

- *Section 1.* Participant demographics: age; gender; profession; field of specialization; schooling; year of highest degree; years of experience.

2.1.2 *The Healthcare Institution*

- *Section 2.* Health institution information: institution type; district; access to technological resources (LS1-6); amount of people working on Information and Communication Technologies (ICT) (LS1-6).

2.1.3 *Current Practices in CR*

- *Section 3.* Information about current practice in CR: patients' pathologies (MC); patients' age range (MC); session duration; intervention duration; activities performed (MC); usage of ITs in CR (yes/no);

2.1.4 *CR with ITs*

- *Section 4.* CR with ITs: ITs used (MC); context of usage; amount of ITs usage (LS1-6); patient's independence while performing activities through ITs (LS1-6); health professional intervention during the session (LS1-6); essentiality of ITs for CR success (LS1-6).
- *Section 5.* IT task personalization and adaptation: level of automation in terms of personalization (LS1-6); level of automation in terms of difficulty adaptation based on patient performance over time (LS1-6).
- *Section 7.* Level of importance of various characteristics when choosing ITs for CR (LS1-6).
- *Section 9.* Reasons for not using ITs in CR (MC).

2.1.5 *@Home CR with ITs*

- *Section 6.* CR at home with IT: prescription of ITs to be used at home (yes/no); preference for monitoring patients progress; level of independence of patients while performing CR through ITs at home (LS1-6).

2.1.6 *Collaboration in the design process*

- *Section 8.* Collaboration in the design process of ITs for CR: participation in the design process (yes/no/I don't know); preferred types of participation (MC); level of importance of different entities on the design process (LS1-6).

2.2 *Data Analysis*

Data are presented as frequencies and percentages for categorical variables. Median and interquartile range, Mdn (IQR), are used as central tendency and dispersion metrics for ordinal variables. Mean and standard deviation (STD) are used for interval type measures. The Mann-Whitney test was used to test for two-sample between-group differences in ordinal variables. When testing for significance, the threshold was set at 0.05. Data were analysed using IBM SPSS Statistics 26.

3. RESULTS

We have collected data from 116 participants. We organized the results in 6 major domains: profile of HPs, healthcare institutions, current practice in CR, use of ITs in CR, @home CR with ITs, and collaboration in the design of ITs for CR.

3.1 *What is the profile of HPs conducting CR in Portugal?*

The respondents were mostly female (N=93, 80.2%). Most respondents were in the 36-45 (N=48, 41.4%) or in the 26-35 (N=39, 33.6%) age range. 65.5% of the participants had more than 10 years of experience (N=76). 41 were nurses (35.3%), 40 therapists (34.5%), 30 psychologists (25.9%), and 5 clinicians (4.3%). Most reported fields of

specialization were occupational therapy (N=27, 23.5%), generic clinical (N=24, 20.9%), and physical and rehabilitation care (N=22, 19.1%).

3.2 What type of healthcare institutions have been reported?

The most represented institutions were public (N=65, 56%), followed by private (N=29, 25%), non-profit (N=17, 14.7%) and mixed (N=5, 4.3%). Lisbon (N=23) and Porto (N=20) were the districts with higher number of respondents. Concerning the access level to technology of the institution, on the statements "The institution has a high level of access to technological/digital resources" and "The institution has a high level of access to human resources working in ICT", the median ratings were Mdn = 3 (2) and Mdn = 2 (2), respectively.

3.3 What are the current practices in CR?

- *End-users.* Patients with dementia (N=90, 77.6%), stroke (N=72, 62.1%), and Parkinson's disease (N=44, 37.9%), with more than 60 years (N=99, 85.3%) are the main clients of CR (Figure 1).

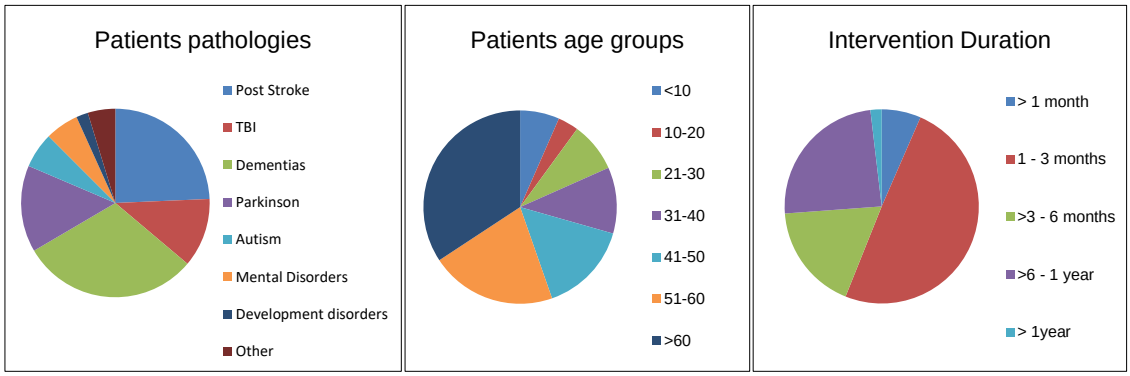

Figure 1. Pie charts of patients' pathologies (left), patients' age groups (middle) and duration of CR interventions (right).

- *Duration.* A CR session lasts in average 38 min (SD = 13). Respondents reported that CR programs typically last 1 to 3 months (N=53, 49.35%) or longer (Figure 1).
- *Activities.* The most common activities currently used are puzzles and games (N=92, 79.3%), paper and pencil tasks (N=89, 76.7%), and training of Activities of Daily Living (ADL) (N= 89, 76.7%) (Figure 2).

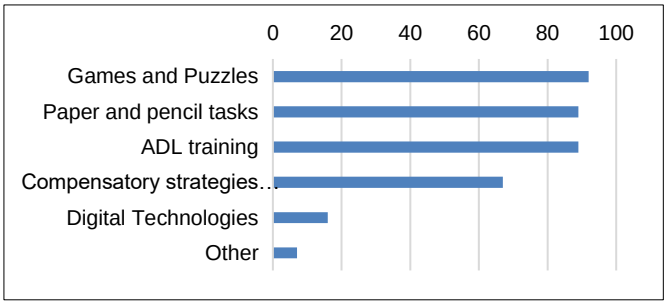

Figure 2. Activities used in current practice in CR.

3.4 How are ITs currently used in CR?

- *Use of ITs in current practices of CR.* 65.5% of the participants never used ITs in CR.
- *HPs' opinions about the use of ITs in CR.* The different statements concerning the use of ITs in CR are presented in Figure 3. (The first four statements were only rated by participants that are currently using ITs in CR)

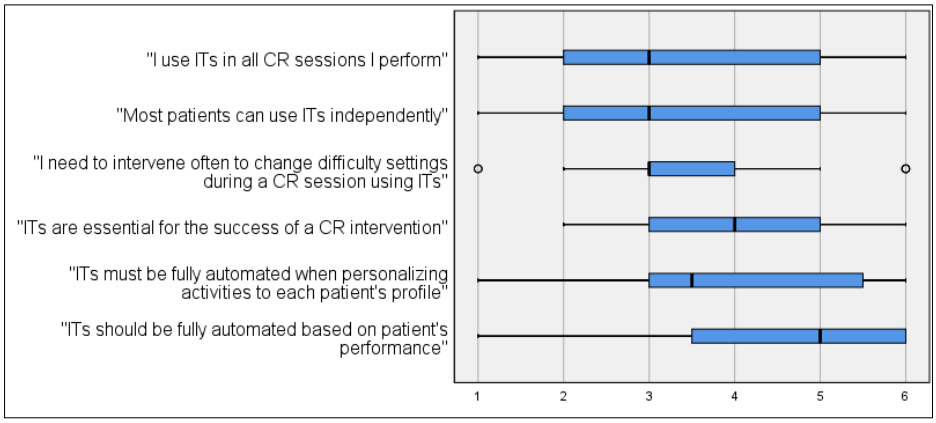

Figure 3. Median ratings on statements concerning the use of Its in CR.

- *ITs' characteristics.* When asked to rate the level of importance of different characteristics of ITs, participants rated high in all of the characteristics (Table 1).

Table 1. Importance of ITs characteristics.

ITs characteristic	***Mdn***	***IQR***
Visual appearance	5	2
Ease of interaction	6	1
Historical data visualization	5	2
Technology costs	6	1
Difficulty personalization to patient's profile	6	1
Difficulty adaptation based on performance	5	1
Content personalization	6	1
Diversity of activities	6	1
Portability	5	2
Data safety and security	6	1
Proof of evidence of efficacy	6	1
Integrated neuropsychological assessment	5	2

- *Reasons for not using ITs in current CR practices.* The inexistence of ITs at the institution was the most mentioned reason (N = 95) (Table 2).

Table 2. Reasons for not using ITs in CR.

Reasons for not using ITs in CR	***HPs without ITs experience (N=76)***	***HPs with ITs experience (N=40)***
Inexistence at the institution	67	28
Inexistence of ICT human resources at the institution	38	19
Lack of information	43	13
Preference for not using ITs	10	8
Institution regulations	9	6
Fear of technical issues	6	5
Lack of evidence of efficacy	6	3
Feeling uncomfortable with technology	8	6
No availability to learn new tools	3	4
Lack of interest for IT	4	3
Patient's inability to use ITs	3	3
Other reasons	2	2

3.4.5 What are the preferences in terms of at-home rehabilitation?

- *Prescription of ITs for CR at home.* 62.1% (N = 72) of the participants never prescribed ITs to be used at home. From those that already prescribed ITs to be used at home (N=44), 43.2% (N = 19) are not using them in current practice (Figure 4).

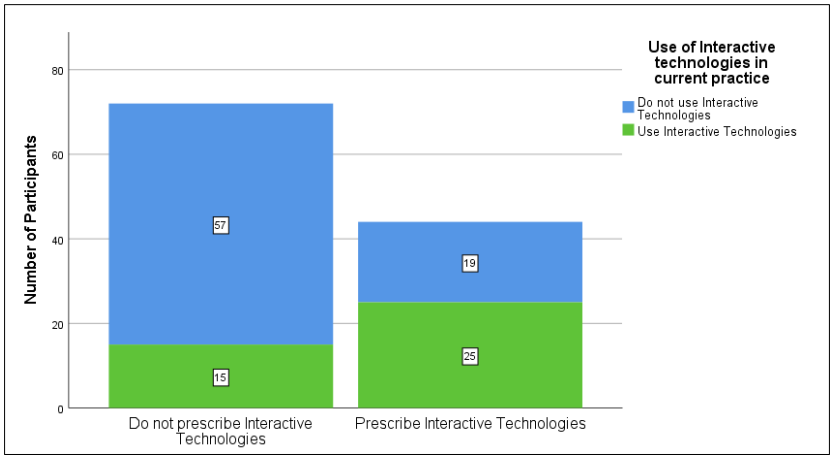

Figure 4. Prescription of ITs to be performed at home.

- *Preferred monitoring type.* 69% (N=80) of the participants answered that they prefer that the patient goes to the institution to be evaluated. 39.7% (N=46) answered that the patient could be monitored at home and only 6.9% (N=8) answered that monitoring could be done remotely through digital means.
- *Patient's independency to use ITs at home.* When comparing participants that already use ITs (Mdn = 3 (2)) and the ones that don't (Mdn = 2 (2)) on the statement: "Most patients are able to perform activities at home through ITs independently without assistance", participants that use ITs gave it a significantly higher rating (U = 1974, p = .006, r = .253).

3.5 What are the preferences of HPs concerning collaboration in the Design of ITs for CR?

88% of the participants (N=102) never collaborated in the design of ITs for CR. If to participate in the design process, the preferred method would be collaborative workshops (N=62, 53.4%). When asked to rate the level of importance of different entities/roles to participate in the design process, psychologists (Mdn = 6 (1)) and therapists (Mdn = 6 (1)) were the ones that obtained higher answers. 37 (31.9%) participants mentioned that they would like to participate in the design of ITs for CR.

4. DISCUSSION AND CONCLUSION

This study investigated the current practices in CR in Portuguese healthcare institutions and the opinions and expectations of HPs towards using ITs for CR. Results assist in characterizing demographically the HPs that are currently practicing CR in Portuguese healthcare institutions. Demographics are very similar to what was found in past studies, most are female occupational therapists aged 30-40 years old (de Joode et al., 2012). Contrary to the same study where only one-third of the participants reported to have treated patients with dementia, in our study, dementia was the most mentioned pathology. However, and aligned with literature (Stringer, 2010), stroke is in the top-three most mentioned, followed by Parkinson's disease.

Results show that ITs are not yet being widely used by HPs in CR sessions. Most participants (65.5%) did not have experience with ITs for CR. This is aligned with previous research where only 27,9% of respondents have reported previous experience with technologies in CR (de Joode et al., 2012). Since this study is from 2012, we would have expected that 8 years later, ITs would have had a higher percentage of use. It is important to highlight that for those reporting previous experience with ITs, these are essential to the rehabilitation success. Similarly, this is aligned with the same previous study where HPs with ITs experience agreed that technologies can be successfully used in CR.

From the participants that are already using ITs in current practice, only a few are prescribing them to patients to be used at home. Interestingly, some of the participants that do not have previous experience with ITs, are prescribing them to their patients to perform activities at home. Participants that have previous experience with ITs are more positive towards the use of ITs at home, and they display higher belief that most participants can perform the activities independently. This is also aligned with previous research where HPs with previous experience were more positive about their potential than those without experience (de Joode et al., 2012).

Among the difficulties and barriers in using ITs for CR, and contrary to previous research where participants responded that the price of technology and the lack of knowledge are the most mentioned reasons, in our study, the inexistence of ITs at the healthcare institution and the lack of human resources in ICT to give support are the major barriers for the use of ITs in CR. However, lack of information is the third most mentioned reason for not using ITs in CR, therefore, researchers should also focus on promoting the dissemination of information directly to health institutions and HPs and not only in scientific publications. Only a very small minority mentioned not having interest in ITs or no availability to learn new tools, therefore, this leads us to conclude that HPs are willing to learn and use ITs in CR if the health institutions make them available. Moreover, the patient's inability to use ITs was not considered a barrier to most of participants. Here we envision the opportunity for researchers, to invest also in finding systematic methods for delivering training for all stakeholders (HPs, caregivers, and patients), as also reported in other studies (Wang et al., 2016).

Finally, this study provided useful information about preferences for collaborative methods for the design of ITs for CR, in this case, a collaborative workshop was the most voted answer. This led us to organize a collaborative workshop with HPs, which results are currently being analysed.

As limitations from this study, our questionnaire did not address two important aspects. First, it would have been important to identify the most common cognitive problems addressed by HPs despite the pathology of the patient. This information would have been useful in finding which activities have more priority in being designed. Second, we didn't ask directly to the participants if they had willingness or interest in using/keep using the ITs for CR, and why. This would have helped in further understanding the reasons behind difficulties and barriers in using ITs.

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5. REFERENCES

Agüero-Torres, H., Thomas, V. S., Winblad, B., & Fratiglioni, L. (2002). The impact of somatic and cognitive disorders on the functional status of the elderly. Journal of Clinical Epidemiology, 55(10), 1007–1012. https://doi.org/10.1016/S0895-4356(02)00461-4

Baltaduonienė, D., Kubilius, R., Berškienė, K., Vitkus, L., & Petruševičienė, D. (2019). Change of cognitive functions after stroke with rehabilitation systems. Translational Neuroscience, 10(1), 118–124. https://doi.org/10.1515/tnsci-2019-0020

Carneiro, J. A., Cardoso, R. R., Durães, M. S., Guedes, M. C. A., Santos, F. L., Costa, F. M. da, & Caldeira, A. P. (2017). Frailty in the elderly: Prevalence and associated factors. Revista Brasileira De Enfermagem, 70(4), 747–752. https://doi.org/10.1590/0034-7167-2016-0633

Cicerone, K. D., Goldin, Y., Ganci, K., Rosenbaum, A., Wethe, J. V., Langenbahn, D. M., Malec, J. F., Bergquist, T. F., Kingsley, K., Nagele, D., Trexler, L., Fraas, M., Bogdanova, Y., & Harley, J. P. (2019). Evidence-Based Cognitive Rehabilitation: Systematic Review of the Literature From 2009 Through 2014. Archives of Physical Medicine and Rehabilitation, 100(8), 1515–1533. https://doi.org/10.1016/j.apmr.2019.02.011

Cumming, T. B., Marshall, R. S., & Lazar, R. M. (2013). Stroke, Cognitive Deficits, and Rehabilitation: Still an Incomplete Picture. International Journal of Stroke, 8(1), 38–45. https://doi.org/10.1111/j.1747-4949.2012.00972.x

de Joode, E. A., van Boxtel, M. P. J., Verhey, F. R., & van Heugten, C. M. (2012). Use of assistive technology in cognitive rehabilitation: Exploratory studies of the opinions and expectations of healthcare professionals and potential users. Brain Injury, 26(10), 1257–1266. https://doi.org/10.3109/02699052.2012.667590

Faria, A. L., Paulino, T., & Badia, S. B. i. (2019). Comparing adaptive cognitive training in virtual reality and paper-pencil in a sample of stroke patients. 2019 International Conference on Virtual Rehabilitation (ICVR), 1–7. https://doi.org/10.1109/ICVR46560.2019.8994746

Ferche, O.-M., Moldoveanu, A., Moldoveanu, F., Voinea, A., & Asavei, V. (2015). Challenges and issues for successfully applying virtual reality in medical rehabilitation. Conference Proceedings of »eLearning and Software for Education« (ELSE), 01, 494–501. https://doi.org/10.12753/2066-026X-15-073

Ge, S., Zhu, Z., Wu, B., & McConnell, E. S. (2018). Technology-based cognitive training and rehabilitation interventions for individuals with mild cognitive impairment: A systematic review. BMC Geriatrics, 18(1), 213. https://doi.org/10.1186/s12877-018-0893-1

Gustavsson, M., Ytterberg, C., & Guidetti, S. (2020). Exploring future possibilities of using information and communication technology in multidisciplinary rehabilitation after stroke – a grounded theory study. Scandinavian Journal of Occupational Therapy, 27(3), 223–230. https://doi.org/10.1080/11038128.2019.1666918

INE. (2019). Estatísticas Demográficas 2018. https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_publicacoes&PUBLICACOESpub_boui=404539341&PUBLICACOESmodo=2&xlang=pt

Maggio, M. G., Latella, D., Maresca, G., Sciarrone, F., Manuli, A., Naro, A., De Luca, R., & Calabrò, R. S. (2019). Virtual Reality and Cognitive Rehabilitation in People with Stroke: An Overview. The Journal of Neuroscience Nursing: Journal of the American Association of Neuroscience Nurses. https://doi.org/10.1097/JNN.0000000000000423

Morris, J., Jones, M., Thompson, N., Wallace, T., & DeRuyter, F. (2019). Clinician Perspectives on mRehab Interventions and Technologies for People with Disabilities in the United States: A National Survey. International Journal of Environmental Research and Public Health, 16(21). https://doi.org/10.3390/ijerph16214220

Nowell, C., Downing, M., Bragge, P., & Ponsford, J. (2019). Current practice of cognitive rehabilitation following traumatic brain injury: An international survey. Neuropsychological Rehabilitation, 0(0), 1–20. https://doi.org/10.1080/09602011.2019.1623823

Paravati, G., Spataro, V. M., Lamberti, F., Sanna, A., & Demartini, C. G. (2017). A Customizable Virtual Reality Framework for the Rehabilitation of Cognitive Functions. In A. L. Brooks, S. Brahnam, B. Kapralos, & L. C. Jain (Eds.), Recent Advances in Technologies for Inclusive Well-Being: From Worn to Off-body Sensing, Virtual Worlds, and Games for Serious Applications (pp. 61–85). Springer International Publishing. https://doi.org/10.1007/978-3-319-49879-9_4

Pariente, J. (2006). Effectiveness of rehabilitation for cognitive deficits. Journal of Neurology, Neurosurgery, and Psychiatry, 77(9), 1102. https://doi.org/10.1136/jnnp.2005.083477

Snoswell, A. J., & Snoswell, C. L. (2019). Immersive Virtual Reality in Health Care: Systematic Review of Technology and Disease States. JMIR Biomedical Engineering, 4(1), e15025. https://doi.org/10.2196/15025

SNS. (2020). Dispositivos Médicos por Nomenclatura Portuguesa do Dispositivo Médico. https://transparencia.sns.gov.pt/explore/dataset/dispositivos-medicos-por-nomenclatura-portuguesa-do-dispositivo-medico/

Stringer, A. Y. (2010). Cognitive Rehabilitation Practice Patterns: A Survey of American Hospital Association. The Clinical Neuropsychologist. https://doi.org/10.1076/clin.17.1.34.15625

Wang, J., Ding, D., Teodorski, E. E., Mahajan, H. P., & Cooper, R. A. (2016). Use of Assistive Technology for Cognition Among People With Traumatic Brain Injury: A Survey Study. Military Medicine, 181(6), 560–566. https://doi.org/10.7205/MILMED-D-14-00704

Wentink, M. M., VAN Bodegom-Vos, L., Brouns, B., Arwert, H. J., Vlieland, T. P. M. V., DE Kloet, A. J., & Meesters, J. J. L. (2018). What is Important in E-health Interventions for Stroke Rehabilitation? A Survey Study among Patients, Informal Caregivers and Health Professionals. International Journal of Telerehabilitation, 10(1), 15–28. https://doi.org/10.5195/ijt.2018.6247