Exploration of rehabilitation through the use of virtual reality interventions for patients with hand conditions: A scoping review.

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Dear Editor,

The use of virtual reality to aid the rehabilitation of hand and upper-limb conditions has been an emerging field over the past decade. The majority of research in this field has been focused on neurological conditions for example post-stroke, with major advances being made to improve hand function through various robotic and digital techniques. In spite of the technological advancements in virtual reality rehabilitation, it is not readily used in current practice for hand or upper-limb conditions. The recent crisis of COVID-19, and the requirements and/or preferences of some people to receive rehabilitation at home have highlighted the importance of developing this technology so that it could become part of standard practice. This scoping review was conducted to explore research addressing immersive virtual reality in *hand* rehabilitation. The objectives were to identify the strengths and weaknesses of current technology and highlight any gaps in knowledge which could inform future research.

The scoping review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses for Scoping Reviews (PRISMA-ScR) guidelines. The

protocol for this scoping review was specified in advance and is publicly available from protocols.io (Andrew et al., 2021).

A comprehensive search of the following databases was undertaken in November 2020 and 2021: CINAHL, Medline, EMBASE, Scopus, Web of Science, PsychInfo and Epistemonikos for all relevant studies between 2010 – 2020. The study included papers addressing the following:

- *'Immersive virtual reality'*: as close to 'fully immersive' as possible
- *'Hand'*: studies focusing on the hand (including fingers/thumb and wrist)
- *'Rehabilitation'*: including exercise and therapy to restore physical function

Studies not relevant in the field of hand surgery or hand trauma research were excluded: paediatrics, prosthetics, brain studies e.g. using electromyography/electroencephalogram or brain-computer interface/deep brain stimulation, neurological conditions e.g. Parkinson's disease, virtual reality that only addressed cognitive rehabilitation, telemedicine, robotics (used alone, without virtual reality) and/or exoskeletons. Data was extracted and the studies underwent quality appraisal and a descriptive analysis.

Just five studies were identified which looked at virtual reality in hand rehabilitation outside of the exclusion criteria applied. All used virtual reality however none were 'fully-immersive'. The five studies included in the review ranged across the time frame of 2011 to 2019, taking place in five different countries: Romania, Netherlands, United States, Spain and India. The studies consisted of one case report, and the rest were interventional group

design/case-control including a randomised pilot trial and a prototype testing design. The sample sizes were small. The age of the participants across the studies ranged between 25-85 years. Three studies recruited stroke patients and the other two recruited trauma and healthy participants.

The quality of the studies included in this review was evaluated using the Downs and Black, 1998 quality checklist and quality rating scale (Downs and Black, 1998).). Two of the studies had a quality rating of 'fair', and the other two were considered 'poor' (the case study was excluded from ratings).

Of the five studies included in this review, all used either non-immersive or semi-immersive virtual reality alongside an external device, ranging from hand-held devices to robotic-gloves. None of the studies used a fully immersive virtual reality simulation, for example through the use of a virtual reality head set. All the papers included appear to be viability studies, evaluating concept designs. There was no standardised outcome measure used to evaluate hand function. There were a few common measures used across the studies, e.g. the Jebsen-Taylor Hand Function test and the Nine-Hole Peg Test, but the variety was vast. It was therefore difficult to compare the outcomes across the studies. Nica et al. (2013) showed statistically significant improvements in hand function of the patients using the technology. However, the intervention group received an extra hour per day of therapy in comparison to the control. This increase in time could alone have impacted the results and caused beneficial effects with or without the use of technology. The technology however does seem promising and one of the few papers looking at trauma rather than stroke patients.

In general, the graphics used were dated and the devices seemed cumbersome. Using a glove to pick up small objects had *worse* scores than without the glove in one of the studies. This highlights a key weakness in the technology used, perhaps the lack of haptic feedback may have contributed to this. In addition, the gloves were reported as being difficult to put on and seemed bulky which resulted in non-compliance with the intervention. On the other hand, the devices used in the studies did appear as though they could be transported and used in the home setting. The games used were also targeted to the patients' usual daily activities or profession which then allows for the therapy to be individualised which could impact on patient motivation and adherence to therapy.

Overall this scoping review identified a very limited number of studies looking at virtual reality in the field of hand specific rehabilitation which could be relevant in hand surgery and hand trauma. This thereby identifies a lack of evidence in this area and a key area for future research. Developing a virtual reality therapy intervention that could be used at home could prove an invaluable tool to improve outcomes within the field of hand rehabilitation within orthopaedics.

Following this scoping review the authors have made the following recommendations which outlines their future programme of research:

- This technology needs further development and validation, including assessment, measurement and evaluation for use in home therapy

- Exploration of fully immersive virtual reality for hand rehabilitation following hand surgery and hand trauma
- The development of a unified outcome tool for assessment of hand rehabilitation following the use of virtual reality
- A randomised controlled trial to evaluate the difference between hand therapy alone versus augmentation with virtual reality

References

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