Virtual reality in stroke rehabilitation: a systematic review of its effectiveness for upper limb motor recovery
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CRD summary
The authors concluded that there was limited but encouraging evidence that virtual reality is effective in post-stroke rehabilitation of the upper limb. The evidence of effectiveness was based on six small studies of differing design and was therefore limited. Potential language bias, lack of detail about the included studies and the potential for selective reporting of the results undermine the reliability of this review.

Authors' objectives
To evaluate immersive and non-immersive virtual reality (VR) for the rehabilitation of the upper limb in patients with post-stroke hemiplegia.

Searching
MEDLINE, EMBASE, CINAHL, PEDro, OTseeker, PsycINFO, the Cochrane Library and the Evidence-Based Review of Stroke Rehabilitation-Upper Limb Interventions were searched for studies published in English; the search terms were reported. The searches were generally conducted from database inception to December 2005 or January 2006. In addition, reports by major authors in the field were tracked through Web of Science and reference lists of retrieved studies were screened.

Study selection
Experimental studies were eligible for inclusion in the review. These included randomised controlled trials (RCTs), single-subject studies and pre-test post-test studies.

Specific interventions included in the review
Studies that evaluated immersive or non-immersive VR rehabilitation programmes of the upper limb that incorporated retraining of arm movements were eligible for inclusion. Studies of hand movements alone and studies in non-virtual environments were excluded. The included studies compared VR with no therapy or conventional therapy. The duration of the interventions ranged from 4 to 13 weeks and involved between 16 and 35 sessions.

Participants included in the review
Studies of patients with acute (less than 1 month post-stroke), sub-acute (1 to 6 months post-stroke) or chronic (more than 6 months post-stroke) hemiparesis following an ischaemic or haemorrhagic stroke were eligible for inclusion in the review.

Outcomes assessed in the review
Inclusion criteria were not specified in terms of the interventions. The included studies used a variety of different measures to assess function and manual dexterity outcomes.

How were decisions on the relevance of primary studies made?
Three reviewers selected the studies. It was not reported whether this was performed independently or not.

Assessment of study quality
RCTs were assessed and scored using the PEDro rating scale, which covers the following: randomisation; allocation concealment; baseline similarity of the treatment groups; blinding of the patient, therapist and outcome assessors; outcomes measured for more than 85% of those randomised; data analysed on an intention-to-treat basis; statistical comparison between treatments; point measures and variability of the outcome measures reported; and side-effects reported. The maximum possible PEDro score was 10 points. Two reviewers scored the RCTs, and any disagreements were resolved with the aid of a third reviewer where required. The validity of cohort and case-control studies was
assessed using the Newcastle-Ottawa Scale.

Data extraction
The authors did not state how the data were extracted for the review, or how many reviewers performed the data extraction.

Methods of synthesis
How were the studies combined?
The studies were grouped according to the intervention (immersive or non-immersive VR) and comparator (no therapy or conventional therapy), and combined in a narrative. The level of evidence for each comparison of interest was graded using a hierarchy of evidence described by Sackett and adapted to include PEDro ratings.

How were differences between studies investigated?
Differences between the studies were described in the text.

Results of the review
Six studies (n=96) were included: 2 RCTs (n=34), 3 pre-test post-test studies (n=61) and a single-case study (n=1).

Immersive VR versus no therapy: one good-quality RCT (10 chronic stroke patients; PEDro score 8) reported statistically significant improvements for the VR group compared with controls for rehabilitation of the upper limb (motor impairment (Fugl-Meyer Arm Scale, FM) and functional measures (Box and Blocks Test and the Manual Function Test). One single-case study reported improvements post-treatment in manual dexterity, grip force and control of affected limb. Both studies used reliable and valid outcome measures.

Immersive VR versus conventional therapy: no studies were identified.

Non-immersive VR versus no therapy: 3 pre-test post-test studies reported different results. Two studies reported a significant difference post-treatment in change scores for motor impairment: FM and FIM scales in one study of 50 acute stroke patients, and the FM and the Wolf Motor Function Test in the other study of 9 chronic stroke patients. One study of 2 chronic stroke patients reported little or no change post-treatment in the FM and Structured Assessment of Independent Living Skills scores.

Immersive VR versus conventional therapy: one poor-quality RCT (24 acute stroke patients; PEDro score 3) reported no significant difference between patients in the VR and control group for motor impairment (FM and FIM scores).

Authors' conclusions
There was limited but encouraging evidence that VR is effective in post-stroke rehabilitation of the upper limb.

CRD commentary
The review addressed a clear question that was defined in terms of the participants and intervention. Inclusion criteria were broad for the study and not defined for the outcomes; this raises the potential for selective reporting of positive outcome measures. Several relevant sources were searched but only papers published in English were included in the review, so other relevant research might have been missed. Methods were used to minimise reviewer errors and bias in the assessment of validity, but it was unclear whether similar steps were taken in the study selection and data extraction processes. Validity was assessed using specified criteria, although only the composite score was presented for RCTs, this makes it difficult to independently comment on the reliability of the evidence presented.

Given the small number of diverse studies, a narrative synthesis was appropriate and study quality was incorporated into the synthesis. However, individual study results were not reported clearly, meaning it is not possible to verify the results. It was not clear if the included studies assessed outcomes other than those reported; if other outcomes showed different results this could undermine the reliability of the conclusions. Evidence about effectiveness was based on 2 small RCTs, 3 small pre-test post-test studies and a case study, and was therefore extremely limited. The potential language bias, lack of detail about the interventions, participants and results of the included studies, and the potential for selective reporting of the results from included studies undermine the reliability of the review.
Implications of the review for practice and research
Practice: The authors did not state any implications for practice.

Research: The authors stated that further research is needed to evaluate clearly defined VR interventions. Adequately powered RCTs that stratify patients by baseline level of motor and cognitive function and time since stroke are required.

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This is a critical abstract of a systematic review that meets the criteria for inclusion on DARE. Each critical abstract contains a brief summary of the review methods, results and conclusions followed by a detailed critical assessment on the reliability of the review and the conclusions drawn.