Effect of virtual reality on upper extremity function in children with cerebral palsy: a meta-analysis
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CRD summary
This review concluded that virtual reality seemed to be a viable tool to improve upper extremity function in children with cerebral palsy, but that more rigorous research was needed to confirm this. Limitations in the review methods/reporting and the evidence base mean that these conclusions may not be reliable.

Authors’ objectives
To evaluate the effect of virtual reality on upper extremity function in children with cerebral palsy.

Searching
PubMed, CINAHL, The Cochrane Library and PsycINFO were searched up to June 2013 for articles written in English. Search terms and the PubMed search strategy were reported. Relevant reviews were manually searched to locate further studies.

Study selection
Eligible studies evaluated the effects of interventions with virtual reality technology that focused on upper extremity function in children with cerebral palsy. Outcomes of interest included upper extremity movements (such as reaching, grasping), or upper extremity function measured using a general fine motor assessment scale. Studies containing children with mixed diagnoses were excluded.

In included studies, mean age of children ranged from six to 14 years (where reported). Cerebral palsy types and measures of upper extremity motor function varied across the studies. Interventions included virtual reality systems ranging from commercially available systems (such as PlayStation) to engineer-built systems (such as IREX and NJIT-RAVR). Most interventions were evaluated in clinics or laboratories. Most studies reported a weekly dose of shorter than 120 minutes; the frequency of sessions ranged from one day a week to as many sessions as the child wanted. Total intervention length ranged from three weeks to 14 months.

The authors did not state how many reviewers selected the studies for inclusion.

Assessment of study quality
The quality of randomised controlled trials (RCTs) was assessed using a 16-item scoring system, which assessed randomisation, matching, blinding, drop-outs, intention-to-treat analysis, characteristics of measurement tools, control of co-interventions, comparability of groups, and control for dose of therapy. A similar 11-item system was used to assess the quality of the other study designs.

Study quality was assessed by one reviewer and checked by a second; any discrepancies were resolved by discussion.

Data extraction
Data on outcomes (means, standard deviations and sample sizes) were extracted to calculate Cohen’s d effect sizes and 95% confidence intervals. For RCTs, these effect sizes represented differences between virtual reality groups and conventional therapy groups. For other study designs, they represented differences between pre-intervention and immediate post-intervention scores. An average effect size was used where multiple effect sizes were reported.

Data were extracted by one reviewer and checked by a second; any discrepancies were resolved by discussion.

Methods of synthesis
Cohen’s d effect sizes and 95% confidence intervals were pooled using random-effects meta-analysis. Summary effect sizes were interpreted as small (0.2), medium (0.5), or large (0.8). Statistical heterogeneity was assessed using $I^2$.

Subgroup and meta-regression analyses were performed to assess the influence of children’s age, cerebral palsy type.
intervention characteristics (such as duration, virtual reality system), research design, and use of kinematics as the outcome measure.

Results of the review
Fourteen studies were included in the review and meta-analysis (including 122 children, ranging from two to 31 children per study): three RCTs (57 children); two cohort studies (20 children); seven case series (37 children); and two studies described as single-subject designs (eight children).

For RCTs, total quality scores ranged from 5 to 11 (out of 16). For other study designs, quality scores ranged from 1 to 9 (out of 11).

For the three RCTs, no statistically significant difference in post-intervention upper extremity function was found between virtual reality groups and conventional therapy groups (d=1.97, 95% CI -0.26 to 4.20). In comparisons between virtual reality pre-intervention versus post-intervention group scores for this outcome, effect sizes were greater post-intervention and were either small (d=0.30) or large (d=1.31, d=5.09) (no other details reported).

When the results of all 14 studies were meta-analysed, upper extremity function showed statistically significant greater improvements post-intervention in virtual reality groups (d=1.00, 95% CI 0.45 to 1.56; I²=56%) compared with pre-intervention scores. Similar results were shown in studies that measured this outcome through participation (d=1.92, 95% CI 1.19 to 2.66) or body structure and function (d=0.70, 95% CI 0.10 to 1.30).

The strongest effects of virtual reality were shown with younger children, home or laboratory settings, engineer-built virtual reality systems, and among studies with RCT or case series designs.

Further results were reported in the review.

Authors' conclusions
Virtual reality seemed to be a viable tool to improve upper extremity function in children with cerebral palsy. More rigorous research designs were needed to confirm this.

CRD commentary
The review question and inclusion criteria were clearly defined. Although relevant data sources were accessed, the restricted inclusion of studies written in English and the absence of searches for unpublished and grey literature mean that studies may have been missed. Efforts were made to minimise reviewer error and/or bias during data extraction and quality assessment, although it was unclear whether this was also performed during study selection.

The quality assessment criteria seemed suitable; the authors reported that the quality of the studies was generally poor to fair. Reporting of the study designs and the results of individual studies or pooled analyses was sometimes limited, or was presented with discrepancies in different parts of the text. Given the clinical and methodological differences across the studies, the statistical methods of synthesis may not have been appropriate. Also, the extremely small sample sizes of the included studies suggested that the statistical power in these analyses was insufficient to detect an effect.

Limitations in the review methods/reporting and the evidence base mean that these conclusions may not be reliable.

Implications of the review for practice and research
Practice: The authors did not state any implications for clinical practice.

Research: The authors stated that a large-scale randomised controlled trial was needed to evaluate the effect of a home-based virtual reality intervention (using an engineer-built system) on upper extremity function in younger children with cerebral palsy. They also recommended that this trial should include participants of similar age and diagnosis.

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