Effects of robot-assisted therapy on stroke rehabilitation in upper limbs: systematic review and meta-analysis of the literature
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CRD summary
This well-conducted review concluded that, in stroke patients, robot-assisted therapy was not different to intensive conventional therapy for upper limb motor recovery, strength, motor control and activities of daily living, but additional robot-assisted therapy promoted better upper limb motor recovery compared with standard conventional therapy. Given limited data available for each outcome, the reliability of the authors’ conclusions is uncertain.

Authors’ objectives
To compare the effectiveness of robot-assisted therapy with conventional therapy on motor recovery and functional ability in upper limbs of patients with stroke.

Searching
Eleven databases (including DARE, MEDLINE, EMBASE, and The Cochrane Library) were searched up to July 2010; search terms were reported. Related reviews and publications were handsearched.

Study selection
Randomised controlled trials (RCTs) published in a peer reviewed journal that compared robot-assisted therapy with conventional therapy (either standard or intensive), in adult patients with stroke, were eligible for inclusion. The robot-assisted therapy had to be aimed at motor recovery, function or control of the upper limbs. Outcomes of interest were functional or motor recovery of the upper limbs. Trials that compared two types of robotic techniques or devices and those where therapy was not used as a therapeutic tool were excluded.

In the included trials, the mean age of included patients ranged from 54 to 80 years; most were men. Patients had either subacute, acute or chronic stroke at the time of admission to the trials. The robotic devices used included MIT-MANUS, MIME, ARM-Guide, T-WREX, and NeReBot.

Two reviewers independently selected studies for the review, with disagreements resolved by a third reviewer.

Assessment of study quality
Included trials were assessed for quality using the PEDro scale. Criteria included eligibility criteria, random allocation, allocation concealment, baseline comparability, blinding of subjects, therapists and assessors, drop-out rate, intention-to-treat analysis, between-group comparisons and point estimates and variability. The maximum possible score for a trial was 9 points; trials with an overall score of 5 or above were considered high quality.

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

Data extraction
If available, data were extracted on the change from baseline in scores on the outcome scales and used to calculate mean differences, with 95% confidence intervals. If these data were not available, they were estimated from the included trials.

The authors did not state how many reviewers extracted data for the review.

Methods of synthesis
The results of the studies were pooled in meta-analyses. Summary effect standardised mean differences, with 95% confidence intervals, were calculated using the random-effects model. Heterogeneity was assessed with the $\chi^2$ test and quantified using $I^2$.

Subgroup analyses were undertaken on the duration and intensity of therapy, and the stage of stroke recovery. Duration and intensity therapy subgroups were distinguished as either robot-assisted therapy versus intensive conventional therapy.
therapy, or the addition of robot-assisted therapy to standard conventional therapy versus standard conventional therapy alone. Stage of stroke recovery subgroups were defined as acute/subacute or chronic. Separate analyses were undertaken according to the specific outcomes measured: motor recovery (measured by the Fugl-Meyer Upper Limb Motor score), activities of daily living (measured by the Functional Independence Measure), strength (measured by the Motor Power Scale), and motor control (measured by the Motor Status Scale). An additional analysis of motor recovery was undertaken at longer follow up (at the end of trial).

Results of the review
Eleven RCTs were included in the review. All trials were rated as high quality, except for one with a PEDro score of 2 which was excluded from further analysis.

Conventional therapy versus conventional therapy plus robot-assisted therapy: Robot-assisted therapy given in addition to conventional therapy was associated with significantly better motor recovery of the upper limbs (SMD 0.46, 95% CI 0.14 to 0.78; I²=0%; four RCTs) and at six to eight months follow-up (SMD 0.86, 95% CI 0.10 to 1.61; one RCT) compared with conventional therapy alone. Robot-assisted therapy given as an additional therapy was also associated with significantly improved motor strength (SMD 2.31, 95% CI 1.53 to 3.09; I²=0%; two RCTs) and significantly improved proximal motor control (SMD 5.20, 95% CI 1.71 to 8.70; I²=65%; two RCTs) compared with conventional therapy alone. There was no evidence of a difference in activities of daily living between conventional therapy or conventional therapy plus robot-assisted therapy, although a non-significant trend favoured the addition of robot-assisted therapy.

Conventional therapy versus robot-assisted therapy of the same duration and intensity: There was no evidence of a statistically significant difference in motor recovery between conventional and robot-assisted therapy of the same duration and intensity (six RCTs) or at six to eight months follow-up (four RCTs). There was no evidence of a difference in activities of daily living (three RCTs), motor strength (three RCTs), and proximal motor control (one RCT) between the two therapies for the same duration and intensity.

Authors’ conclusions
Robot-assisted therapy was not different to intensive conventional therapy for motor recovery, activities of daily living, strength and motor control, but additional sessions of robot-assisted therapy promoted better motor recovery in the upper limbs of stroke patients when compared with standard conventional therapy.

CRD commentary
The review addressed a clear research question, supported by clearly defined inclusion and exclusion criteria. A wide range of relevant sources were searched to find published studies, but no specific attempts were made to find unpublished studies, so publication bias could not be ruled out. Appropriate methods to reduce reviewer error and bias were used to select studies, but similar methods were not reported for the quality assessment or data extraction stages of the review.

A comprehensive tool was used for quality assessment. All but one of the included trials was considered of high quality; only high quality trials were included in the analysis, although this was not prespecified. An appropriate metric was selected for analysis, given the clinical variation between trials. Synthesis of trials and assessment of heterogeneity were appropriate. Overall synthesis was not undertaken; analyses were performed only in subgroups because of trial variation. Although a small number of trials contributed data to each separate analysis, results were consistent across the different outcomes assessed.

The review was generally well conducted. Given limited data available for each outcome, the reliability of the authors' conclusions is uncertain.

Implications of the review for practice and research
Practice: The authors stated that the findings of the review were applicable only to proximal upper limbs. They also suggested that the use of robot-assisted therapy can provide the opportunity for more intensive practice with minimal supervision by the therapist.

Research: The authors stated that further RCTs are required to investigate effects of robot-assisted therapy on function
and prehension.

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