Evidence for the retraining of sensation after stroke: a systematic review  
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CRD summary
The review concluded that there was moderate evidence to support the use of passive sensory training to improve sensation and motor function following stroke. Evidence for active sensory training was limited. Higher quality research is required. These conclusions should be viewed with caution, given problems such as variation between the studies, questionable study quality and very small sample sizes.

Authors' objectives
To determine the effect of passive or active sensory training on impairment-specific and functional outcomes following stroke.

Searching
Databases including MEDLINE, AMED, CINAHL, Academic Search Elite, Scopus and the Cochrane Library were searched. Search terms were reported. Google was searched for unpublished studies and the reference lists of relevant articles were checked. The search was limited to full-text articles in English.

Study selection
Experimental studies of passive or active sensory training as the sole intervention following stroke were eligible for inclusion. Stroke could be of any type (infarct/haemorrhage), location or stage (acute, semi-acute or chronic). Active sensory training was defined as an intervention to retrain sensory function only. Passive sensory training was defined as an afferent stimulation protocol not producing muscle contraction, applied via surface electrodes to stimulate somatosensory regions only: studies using other forms of electrical stimulation were excluded. Studies were required to report outcomes on local sensory or motor impairments and/or upper or lower limb function.

The mean age of participant groups in the included studies ranged from 40 to 67 years, where reported. Most strokes were ischaemic (in the few studies that reported this). For most lesions, location was divided almost equally between left and right hemisphere. Strokes had occurred between 19 days to 16 years previously.

Passive sensory training used electrical stimulation at various frequencies and intensities, ranging from just below perceptual threshold to bearable pain, for durations ranging from a one-off session to an eight-week course. Control groups received stimulation just below perceptual threshold or sham stimulation. Active sensory training protocols included a combination of localisation, sensory recognition, proprioception and perceptual learning exercises, administered for 30 to 50 minutes over six to 30 sessions, in some cases as an adjunct to standard care. Control groups received standard physiotherapy or relaxation exercises. Passive training studies reported mostly functional outcomes, while active training studies focused on outcomes at the impairment level. A wide variety of assessment scales and tests was used. Adverse effects were also reported (very briefly) in the review.

The authors did not state how the papers were selected for the review or how many reviewers performed the selection.

Assessment of study quality
A modification of a published appraisal tool (Law 1998) was used to assess the following criteria: study justification and design, sampling, outcomes, methods (e.g. randomisation, controls, allocation concealment, selection criteria, reporting of baseline characteristics and blinding), analysis and conclusions. Points were allocated for quality, with a maximum score of 20.

The assessment was conducted independently by two assessors, with disagreements resolved by a third.

Data extraction
For dichotomous data, risk ratios (RRs) were calculated from the numbers of events in the control and intervention groups of each study, with 95% confidence intervals (CIs). For continuous data, mean differences between the groups in change from baseline were extracted, with standard deviations. Reported p values were also extracted. Authors were contacted for missing data if necessary.

The authors did not state how many reviewers performed the data extraction.

Methods of synthesis
Studies were combined to calculate pooled risk ratios or standardised mean differences (SMDs) with 95% confidence intervals, using a random-effects model. Data considered unsuitable for pooling, due to significant heterogeneity, were reported in a narrative summary, with p values.

Results of the review
Fourteen studies were included in the review (n=296 patients, range 3 to 30). There were five studies with level II evidence (well designed RCT), five with level III evidence (pseudo-randomised or other controlled design), and four with level IV evidence (case-series). The mean quality score was 13.7 points out of 20 (range 11 to 18.5).

**Passive sensory training** (eight studies including seven controlled studies): Seven studies reported on functional outcomes. The sensory training intervention significantly improved scores on the Jebsen-Taylor Hand Function Test (SMD 1.08, 95% CI 0.52 to 1.64; n=29 patients, three studies), with acceptable heterogeneity. The effect size was moderate. A fourth study reported that Brunnstrom Stages scores significantly favoured the intervention group (SMD 0.67, 95% CI 0.25 to 1.09). Of the other three studies, two reported statistically significant benefit from the intervention (effect size not calculable, p<0.05) and one reported no significant benefit. A single study of muscle strength reported no significant benefit from the intervention; findings for spasticity were mixed (two studies).

**Active sensory training** (six studies including two controlled studies): Data were unsuitable for pooling and none of the individual effect estimates reported in the review were statistically significant. However, significant benefit associated with the sensory training intervention was reported by two of three studies of functional outcomes, three of five studies of sensation and two of five studies of proprioception (effect sizes not calculable, all p<0.05).

No study reported any adverse effects associated with the sensory training intervention.

Authors’ conclusions
There was moderate evidence to support the use of passive sensory training to improve sensation and motor function following stroke. Evidence for active sensory training was limited. Higher quality research is required.

CRD commentary
The objectives and inclusion criteria of the review were clear and relevant sources were searched for studies. However, the language restriction meant that some studies may have been missed. Efforts were made to retrieve unpublished studies, but publication bias was not assessed. Steps were taken to reduce the risk of reviewer bias and error by having more than one reviewer independently assess study validity, but it was unclear whether similar precautions applied to study selection or data extraction.

Relevant criteria were used to assess study validity, although high quality studies were given little prominence in the interpretation of findings. There were some reporting discrepancies, with respect to sample numbers (i.e. no indication of control group sizes for some studies) and findings. Appropriate statistical techniques were used to combine studies where data were suitable for pooling; other data were reported descriptively. It appeared that statistical heterogeneity was assessed but no details were provided on methods used. The authors acknowledged that the review was limited by heterogeneity between the studies and quality issues, such as small samples and unreliable outcomes measures. It was difficult to determine the clinical significance of some of the review findings, given the large number of reported outcomes and the lack of precision in most measures of effect.

The authors’ conclusions should be viewed with caution, given problems such as variation between the studies, questionable study quality and very small sample sizes.
Implications of the review for practice and research

**Practice:** The authors stated that passive sensory training may improve hand function and dexterity after stroke and could be useful and feasible as an adjunct to a standard rehabilitation programme. The sensory training could comprise low frequency electrical sufficient to evoke strong paraesthesia.

**Research:** The authors stated that high quality studies with adequate statistical power and meaningful outcome measures are needed to compare passive and active sensory training. The most effective training durations and intervention parameters also need to be established.

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