Multi-disciplinary rehabilitation for acquired brain injury in adults of working age (Review)

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TABLE OF CONTENTS

[Intervention Review]

Multi-disciplinary rehabilitation for acquired brain injury in adults of working age

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ABSTRACT

Background

Evidence from systematic reviews demonstrates that multi-disciplinary rehabilitation is effective in the stroke population where older adults predominate. However, the evidence base for the effectiveness of rehabilitation following acquired brain injury (ABI) in younger adults is not yet established, perhaps because there are different methodological challenges.

Objectives

To assess the effects of multi-disciplinary rehabilitation following ABI in adults aged 16 to 65 years. To explore approaches that are effective in different settings and the outcomes that are affected.

Search methods

We searched CENTRAL (The Cochrane Library 2008, Issue 2), MEDLINE (Ovid SP), EMBASE (Ovid SP), ISI Web of Science: Science Citation Index Expanded (SCI-EXPANDED), ISI Web of Science: Conference Proceedings Citation Index-Science (CPCI-S), and Internet-based trials registers: ClinicalTrials.gov, Current Controlled Trials, and RehabTrials.org. We also checked reference lists of relevant papers and contacted study authors in an effort to identify published, unpublished, and ongoing trials. Searches were last updated in April 2008.

Selection criteria

Randomised controlled trials (RCTs) comparing multi-disciplinary rehabilitation with either routinely available local services or lower levels of intervention; or trials comparing an intervention in different settings or at different levels of intensity. Quasi-randomised and quasi-experimental designs were also included provided that they met pre-defined methodological criteria.

Data collection and analysis

Two authors independently selected trials and rated their methodological quality. A third review author arbitrated when disagreements could not be resolved by discussion. We performed a 'best evidence' synthesis by attributing levels of evidence based on methodological quality. We subdivided trials in terms of severity of brain injury, the setting, and type of rehabilitation offered.

Main results

We identified 11 trials of good methodological quality and five of lower quality. Within the subgroup of predominantly mild brain injury, 'strong evidence' suggested that most patients made a good recovery with provision of appropriate information, without additional specific intervention. For moderate to severe injury, there was 'strong evidence' of benefit from formal intervention. For patients with moderate to severe ABI already in rehabilitation, there was strong evidence that more intensive programmes are associated with earlier functional gains, and 'moderate evidence' that continued outpatient therapy could help to sustain gains made in early post-acute rehabilitation. There was 'limited evidence' that specialist in-patient rehabilitation and specialist multi-disciplinary community rehabilitation may provide additional functional gains, but the studies serve to highlight the particular practical and ethical restraints on randomisation of severely affected individuals for whom there are no realistic alternatives to specialist intervention.

Authors' conclusions

Problems following ABI vary. Consequently, different interventions and combinations of interventions are required to suit the needs of patients with different problems. Patients presenting acutely to hospital with moderate to severe brain injury should be routinely followed up to assess their needs for rehabilitation. Intensive intervention appears to lead to earlier gains. The balance between intensity and cost-effectiveness has yet to be determined. Patients discharged from in-patient rehabilitation should have access to out-patient or community-based services appropriate to their needs. Those with milder brain injury benefit from follow up and appropriate information and advice. Not all questions in rehabilitation can be addressed by randomised controlled trials or other experimental approaches. Some questions include which treatments work best for which patients over the long term, and which models of service represent value for money in the context of life-long care. In future, such questions will need to be set alongside practice-based evidence gathered from large systematic, longitudinal cohort studies conducted in the context of routine clinical practice.

PLAIN LANGUAGE SUMMARY

Multi-disciplinary rehabilitation for brain injury in working-age adults

Studies show that multi-disciplinary (MD) rehabilitation is beneficial to patients with brain damage from stroke. Some MD programs are also targeted to working-age adults who have brain injuries through trauma or other causes. These patients are younger than most stroke patients and may have different goals, such as returning to work or parenting. Brain-injured people can have a variety of difficulties, including problems with physical functions, communication, thought processes, behaviour, or emotions. The severity of the problems can vary from mild to severe. MD rehabilitation addresses one or more of the above areas instead of focusing on a single aspect such as physical (motor) function.

The authors of this Cochrane review looked for evidence on the effectiveness of MD rehabilitation in adults, aged 16 to 65 years, with acquired brain injury (ABI) from any cause. They looked for controlled trials in which one group of people received a treatment (such as MD rehabilitation) and was compared with a similar group that received a different treatment. They found 16 studies. As a whole, the studies suggested that patients with moderate to severe brain injury who received more intensive rehabilitation had earlier improvements. For mild brain injury, information and advice was usually more appropriate than intensive rehabilitation. There was not much evidence related to other aspects of MD rehabilitation, so the review authors recommend that more research be done. Rehabilitation for brain injury is such an individualised and long-term process that it can be difficult to draw general conclusions from research studies.

BACKGROUND

Brain injury rehabilitation services are increasingly defined by the needs of patients, rather than by the underlying pathology (that is the disease or diagnosis). Specialist multi-disciplinary rehabilitation services in the UK have been developed to serve the needs of younger (16 to 65 years of age) or working age adults. This separation from services for 'older adults' is not simply ageist but also arises because younger individuals often have different goals for rehabilitation (such as returning to work or parenting) that

may be less relevant in an older, predominantly retired population. Moreover, younger adults may be able to continue learning and adapting over a longer period of time. Because they and society may have to live with the consequences of disability for many years, there may well be both an opportunity to gain further recovery of independence following longer or more intensive rehabilitation, or both, and this may be economically worthwhile (Jackson 1999). There is also some evidence that younger patients respond better in different environments than older populations (Gladman 1993; Kalra 1994). The Royal College of Physicians' National Clinical Guidelines for Stroke make the following recommendations. "Younger adults who have had a stroke should be managed within specialist medical and rehabilitation services that a) recognise and manage the particular physical, psychological and social needs of younger patients with stroke (eg. vocational rehabilitation, child care activities) and b) are provided in an environment suited to their specific social needs (RCP 2008)."

The principal causes of acquired brain injury (ABI) in this younger adult group include:

- traumatic brain injury (TBI) – injury resulting from trauma to the head and its direct consequences including hypoxia, hypotension, intracranial haemorrhage, and raised intracranial pressure;
- diffuse acquired brain injury – diffuse damage arising from trauma due to the above or a range of other acute incidents including hypoxia (e.g. due to drowning, electrocution, anaesthetic accident), hypoglycaemia, viral encephalitis;
- cerebrovascular accident (stroke) – which may be ischaemic or haemorrhagic but includes a higher proportion of subarachnoid haemorrhage (from aneurysms or arterio-venous malformations) than strokes in the older population;
- other causes – such as neurosurgical operations (e.g. removal of a meningioma), radiotherapy, cerebral abscess, bacterial meningitis, and gunshot wounds.

It is pertinent, therefore, to consider the evidence on the effectiveness of rehabilitation separately for the younger group of working-age adults; and to use a broad definition of 'acquired brain injury (ABI)' that encompasses all of the above conditions and represents the group of patients which typically presents for rehabilitation following a single-incident neurological insult. This approach is in keeping with the UK National Service Framework (NSF) for Long-term Conditions, which focuses on common features of neurological conditions categorised by their pattern of progression (acute single insult, unpredictable variation, inevitable progression) rather than specific pathological diagnoses. The present review has contributed to the evidence base to underpin the UK National Clinical Guidelines for Rehabilitation following Acquired Brain Injury (RCP/BSRM 2003) and the UK NSF for Long-term Conditions (DoH 2005), which also highlighted the particular needs of the working-age adult.

Patients with ABI experience a wide range of different deficits, depending on the nature and location of their injury. They may present to rehabilitation with various combinations of physical, communicative, cognitive, behavioural, psychosocial, and environmental problems. In terms of the vocabulary used in the expanded World Health Organization's International Classification of Functioning (WHO ICF) (Wade 2000; Wade 2003; Wade and Halligan 2004) they demonstrate heterogeneity at each of the different levels, in that they:

- suffer a variety of different pathologies;
- experience a great variety of different impairments with each patient having a unique combination in terms of severity and nature of impairment;
- also experience very varied limitations in, or restrictions on, activities (disabilities) and participation (previously known as handicap);
- approach rehabilitation from a variety of different contexts – personal, social, and physical.

This means that each individual has a unique set of needs. Different individuals need different programmes of rehabilitation and, moreover, the same individual will need different programmes of rehabilitation at different stages in their recovery. For example:

- following the initial stages of recovery from acute injury, some patients will need to undergo a period of intensive in-patient rehabilitation to return to functional independence and to make the transition from hospital back into the community; outcomes from these post-acute programmes tend to focus on reduction of impairment and disability;
- once back in the community, attention turns more towards social integration, with return to work and financial independence if possible; community-based rehabilitation programmes supporting these activities correctly focus on outcome measures which reflect improved participation and psychosocial adjustment.

This heterogeneity of patients, rehabilitation services, and outcomes poses a challenge to traditional interventional or RCT-based methodologies (Whyte 2002) as well as to the assimilation of findings through meta-analysis. These problems are not unique to rehabilitation but are similarly faced by many medical specialities (Shiel 2008) and have been recognised by the Medical Research Council (MRC) in its approach to evaluation of complex interventions (Craig 2008).

The current review serves to:

- identify the existing trial-based evidence for multi-disciplinary rehabilitation in ABI in adults of working age;

- discuss explicitly the issues for future expansion of the evidence base by traditional research methods;

- identify gaps in knowledge and suggest appropriate methods by which these could be explored in the future.

The methodology described below takes into account advice offered by Greener and Langhorne (Greener 2002) regarding the application of systematic reviews in the field of rehabilitation.

OBJECTIVES

Specific questions that are addressed by this review are:

- does organised multi-disciplinary rehabilitation achieve better outcomes than the absence of such services for this group of patients?

- does a greater intensity (time, expertise, or both) of rehabilitation lead to greater gains?

- which types of programmes are effective and in which setting?

- which specific outcomes are influenced (dependency, social integration, mood, return to work etc.)?

- are there demonstrable cost benefits for multi-disciplinary rehabilitation?

METHODS

Criteria for considering studies for this review

Types of studies

We included all randomised controlled trials (RCTs) which compared multi-disciplinary rehabilitation with either routinely available local services or lower levels of intervention; or trials which compared an intervention in different settings or at different levels of intensity (see types of intervention). We considered quasi-experimental designs provided there was a large element of chance in the availability of a place within a given service versus the possibility of referral elsewhere (see Discussion).

Types of participants

We included trials if the study population was predominantly of working age (that is mean age between 16 and 65 years) and participants had acquired brain injury (ABI) from any cause (including traumatic brain injury (TBI), diffuse brain injury, stroke, subarachnoid haemorrhage, intra-cranial haemorrhage, or mixed ABI populations). We also classified as eligible for inclusion, trials which encompassed all ages but presented a separate subanalysis of the population aged 16 to 65 years so that outcomes for adults within this age group were separately identifiable. We have not yet identified any trials in this category.

Rehabilitation programmes designed principally to meet the needs of older people may include a minority of younger individuals, because of the lack of more appropriate services for them, but in practice they often fail to address their more extended rehabilitation goals (Kersten 2002; Roding 2003). For this reason, we did not contact authors for extracted information on younger adults within predominantly elderly study groups unless there was clear evidence that they were identified and treated as a separate group. Again we have not identified such trials.

The classification of patients who have experienced acquired brain injury is complex because, as noted above, individuals may have one or more of a wide range of impairments, each of differing severity. However, the nature and severity of neurological deficits tends to determine the type of rehabilitation programme offered, as well as the goals for treatment and the outcome measures used. For example, as a very crude generalisation, patients with mild ABI tend to primarily have cognitive losses and goals for rehabilitation tend to focus on enhanced participation, whereas patients in the moderate to severe category are more likely to have goals centred on improvement at the level of impairment and activity (disability). We did not include or exclude studies on the basis of severity, but we subgrouped them on this basis for the purpose of analysis and discussion.

Types of interventions

Rehabilitation is broadly defined as a problem-solving educational process aimed at reducing disability and handicap experienced by someone as a result of disease or injury (Wade 1992). For the purposes of this review, we have defined multi-disciplinary rehabilitation as any intervention delivered by two or more disciplines working in coordinated effort to meet these objectives.

There is no agreed classification of rehabilitation interventions and programmes. Again, broadly speaking, programmes may be described in terms of setting and content.

Rehabilitation settings include:

- in-patient settings – where rehabilitation is delivered in the context of 24-hour care, which may be in a hospital ward or a specialist rehabilitation unit;

- out-patient or day treatment settings – which again may be in a hospital environment, a local community venue (such as a

day centre), or a specialist rehabilitation environment;

- domiciliary or home-based – focused around the patient's own home and local community.

Current terms found in the literature regarding programme content include:

- physical rehabilitation;
- cognitive and behavioural therapy;
- vocational and recreational therapy;
- psychosocial and counselling input.

However, it is probable that the actual content of any two programmes within the same category varied greatly, and also that similar programmes may have been given different labels. Consequently, we included any study that stated or implied that it involved a multi-disciplinary or inter-disciplinary rehabilitation programme, or used any of the labels above, provided it compared the named intervention with some form of control.
For the same reasons, it is equally difficult to describe the control. For this review, we considered the following:

- a lower level or different type of intervention such as routinely available local services, or minimal intervention (such as information only or single session treatment);
- waiting list conditions;
- interventions given in different settings (such as in-patient versus community rehabilitation);
- lower intensity of the treatment programme.

We excluded studies assessing the effects of the following:

- therapy from a single discipline (e.g. physiotherapy) including studies on intensity of treatment within that single discipline;
- a single uni-disciplinary intervention or modality (e.g. physical exercise);
- coma arousal programmes as these are already dealt with in a Cochrane review (Lombardi 2002), except where this formed part of a co-ordinated multi-disciplinary approach.

Types of outcome measures

We were interested in those outcomes which reflect the burden of disabling illness on individuals and their families, and in the services provided for them. We excluded studies which reported only outcomes at the level of impairment.
The measurement of outcome after rehabilitation can be described on two principal axes:

- timing of measurement - from onset of disease or onset of rehabilitation;
- level of measurement within the WHO ICF.

Since many of these studies were undertaken when the previous WHO classification of Impairment, Disability and Handicap was current, we have included these terms in brackets alongside the current terms.

Time

For the purposes of this review:

- short term refers to the time from assessment at admission to discharge from the rehabilitation programme (regardless of its length) and up to six months after;
- long term refers to any time from six months after the end of intervention, usually one year or longer.

Outcomes

Once again, there is no agreed classification of outcome measures for research into rehabilitation after ABI but, for this review, the outcomes have broadly been categorised as follows.
a) Outcome measures which focused on goals at the level of impairment and activities (disability), for example:

- residual symptoms (e.g. post-traumatic amnesia (PTA), post-concussion symptoms);
- functional independence including mobility, cognitive functioning, and ability to perform basic activities of daily living (ADL) (e.g. the Barthel Index, the Functional Independence Measure (FIM) or Functional Assessment Measure (FIM+FAM), Glasgow Outcome Scale (GOS));
- carer burden and stress (e.g. Caregiver Strain Index and Caregiver Burden Scale).

b) Outcome measures that focused on goals at the level of participation (previously known as handicap) and personal context (psychosocial adjustment, quality of life) (Langhorne 1995) for example:

- discharge destination (e.g. home or institution);
- return to work;
- social integration or activities (e.g. Rivermead Head Injury Follow-up Questionnaire (RHFUQ));
- extended activities of daily living (EADL) (e.g. the Community Integration Questionnaire(CIQ));
- health-related quality of life for patient and carer (e.g. the General Health Questionnaire (GHQ), Short-Form-36 (SF-36));
- patient and carer mood (e.g. Hospital Anxiety and Depression Scale (HADS)) and satisfaction with services.

Where given, we also included outcomes which reflected the use of resources. These included: length of stay or treatment, subsequent re-admission to hospital, the need for care including level of care, and extent of support required after discharge.

Search methods for identification of studies

Searches were not restricted by date, language, or publication status.

Electronic searches

The review drew on search strategies developed by the Cochrane Injuries Group and Cochrane Stroke Group. We searched the following electronic databases:

- CENTRAL (*The Cochrane Library* 2008, Issue 2);
- MEDLINE (Ovid SP) (1950 to April (week 2) 2008);
- EMBASE (Ovid SP) (1980 to (week 15) April 2008);
- ISI Web of Science: Science Citation Index Expanded (SCI-EXPANDED) (1970 to April 2008);
- ISI Web of Science: Conference Proceedings Citation Index-Science (CPCI-S) (1990 to April 2008);
- National Research Register 2007;
- ClinicalTrials.gov;
- Current Controlled Trials;
- RehabTrials.org.

CINAHL (1983 to 2004), PsycLIT (1983 to 2004), and AMED (1985 to 2004) were searched as part of the original review; however, they did not yield any eligible trials over and above those identified through the other databases. For this update we did not rerun those searches. The National Research Register was searched up to 2007, but has now been archived. ClinicalTrials.gov, Current Controlled Trials, and RehabTrials.org were searched using a search strategy adapted from the one used in MEDLINE.
Full details of the search strategies can be found in Appendix 1.

Searching other resources

We identified additional trials:

- from reference lists in review articles;
- by consultation with colleagues and trialists.

Data collection and analysis

Because of the broad search strategy, we expected to find a large number of non-relevant articles. We assessed studies using a two-stage process:1) trial selection, 2) assessment of methodological quality.

Trial selection for the initial review

From an initial list of over 3650 articles, we screened abstracts and titles to exclude totally irrelevant articles. This left a shortlist of 291 articles. Two review authors (LTS, AN) independently undertook a preliminary screen of titles and abstracts for these 291, considering type of study, participants, and intervention. This first selection stage resulted in categorisation to exclusion, selection, or indecisive. Disagreements between the two review authors were discussed in consensus meetings. If the first selection was indecisive or disagreement persisted, we obtained the full article for further assessment. We were prepared to seek further information about the method of randomisation or the multi-disciplinary nature of rehabilitation interventions from the trialists, where necessary. However, in practice, it was the earlier published studies (10 to 20 years old) where critical information was missing, and attempts to contact the authors were unsuccessful because they had usually retired or moved on. This process led to the exclusion of 267 articles, leaving 24 for probable inclusion.

Evaluation of methodological quality

For each trial selected for inclusion from stage one, at least two review authors independently assessed methodological quality using Van Tulder's criteria (see below). For the original review, articles were assessed by DTW, LTS, AN; for the update they were assessed by AN, IS, and LTS. Disagreements regarding article quality ratings were resolved by discussion or, if necessary, by arbitration through the third assessor. All authors contributed to the analysis and discussion.

Assessment of methodological quality

The Cochrane Musculoskeletal Group (van Tulder 1997) proposed a checklist which had 19 quality-related criteria (11 criteria for internal validity, six descriptive criteria, and two statistical criteria). Although subsequent lists have tended to focus more on the internal validity criteria (van Tulder 2003), this original checklist has been used for trials in low back pain and is increasingly being explored elsewhere in the context of complex interventions. It has been used in other reviews in rehabilitation for example the UK National Stroke Guideline, 2008 (RCP 2008), including a Cochrane review of occupational therapy for stroke (Steultjens 2002; Steultjens 2003b), and has recently been adapted (Steultjens 2003a) to provide an abbreviated list for assessment of trials employing other trial designs (including patient series and cohort studies).
We considered that this expanded list provided a more sensitive basis for discriminating between better and poorer quality trials in the present context. In this review, therefore, we rated methodological quality using a standardised checklist based on that introduced by (van Tulder 1997) (see Table 1). We would like to draw particular attention to the definitions listed below.

Design

- We identified quasi-randomised allocation where procedures such as alternation; or reference to case record numbers, dates of birth, or day of the week were used.
- We identified quasi-experimental designs where there was no attempt made at randomisation but where there was: (a) a prospective allocation to study groups, and (b) a large element of chance in the allocation. However, unacceptable designs included comparison of two entirely separate services, and

retrospective matching of controls from a separate unrelated database. We excluded studies using these designs.

- Fatal flaws in the study design or execution meant that we determined that the study was inadequate, and excluded it from the analysis. Examples of fatal flaws included: withdrawal of more than 40% of patients, total or nearly total non-adherence to the protocol. or very poor or non-adjusted comparability in the baseline criteria.

Blinding

If consent procedures include a proper description of the trial alternatives (as they should), it is then rarely feasible to blind the individuals properly to their allocated rehabilitation intervention. Even single blinding (through independent, blinded assessment of outcomes) may be difficult in patients with cognitive impairment who not uncommonly volunteer unsolicited information during the course of an interview (Powell 2002).

The authors accepted that blinding of patients and their treating therapists was not feasible, and the best that could be achieved in this context was single blinding. We scored blinding of outcome assessors positive if: (a) the assessors were blinded regarding treatment allocation, and (b) standardised assessment measures or procedures were used to structure the interviews. Otherwise we scored it as negative.

Concealment of treatment allocation

We used the following guide to define adequate procedures for treatment allocation concealment:

- where an independent person, not responsible for determining the eligibility of the patients, generated the assignment;
- any form of centralised randomisation scheme, e.g. a computer system providing allocations in a locked, unreadable file that could be assessed only after inputting the characteristics of an enrolled participant;
- numbered or coded containers; or sequentially numbered, sealed, opaque envelopes.

If the concealment of treatment allocation was described only as random or randomised, we classified it as unclear.

Adverse effects

Rehabilitation can certainly have 'adverse effects', but in clinical practice this has often been considered unlikely and the absence of adverse effects is, therefore, hardly ever specifically recorded. Because adverse effects can and do occur, they should be recorded. We looked for evidence on adverse effects but found no study that explicitly investigated them.

Scoring

We considered RCTs to be of high methodological quality (using van Tulder's list) if the following were scored positively (Steultjens 2003a; Steultjens 2003b):

- at least 6 out of 11 internal validity items, and
- at least 3 out of 6 descriptive items, and
- at least 1 out of two statistical items.

Studies were rated as of low methodological quality if they achieved less than these scores.

Analysis and data synthesis

Meta-analysis can be undertaken only if the study populations, interventions, outcomes, and study designs are agreed to be sufficiently consistent to allow pooling of data. While dichotomous data (for example return to work) might reasonably be pooled, most outcome instruments which are commonly used to assess activity and participation are in the form of 'long ordinal' scales. There are significant concerns about the validity of either treating these as continuous data or reducing them to binary outcomes.

We expected that there would be too much clinical heterogeneity among the studies, particularly with regard to outcome measures (diversity of assessment tools, timing of measurements, presentation of results) to make quantitative analysis possible. Instead, we broadly grouped the selected studies according to the type of intervention and participants, and subjected them to a qualitative descriptive analysis. We performed a 'best evidence' synthesis by attributing levels of evidence based on the assessment of methodological quality described above; categorised into 'strong', 'moderate', 'limited' evidence as described by van Tulder 2003 (see Table 2). We highlighted the strength of trial findings and gaps in current knowledge, and identified future research directions.

RESULTS

Description of studies

See: Characteristics of included studies; Characteristics of excluded studies.

From the 24 articles selected from stage two, we identified 16 trials which met the eligibility criteria for consideration. We identified 14 of these through MEDLINE and EMBASE, and two through AMED. We excluded one trial on the basis of fatal flaws: Relander 1972 had more than 40% attrition at one-year follow up (see methodological assessment below).

Six of the articles were supplementary papers either providing: additional details of programme content (Braverman 1999; Warden 2000 for the trial by Salazar 2000), subgroup or specific analyses (King 1997; Wenden 1998 for the trial by Wade 1997, Kwakkel

2002 for Kwakkel 1999), or follow-up data (Paniak 2000 for Paniak 1998). Two trials (Wade 1997; Wade 1998) reported data from the same programme but in different (sequential) cohorts of patients, so we have treated these two papers as separate trials.

For the four articles selected from the updated search (2004 to 2008), three trials met the eligibility criteria for consideration (Björkdahl 2006; Elgmark 2007; Zhu 2007). The paper by Zhu 2007 presented the findings from the completed study from which Zhu 2001 had presented preliminary findings. The trial by Björkdahl and colleagues was presented in two papers: Björkdahl 2006 reported the main trial findings, and Bjorkdahl 2007 presented a subgroup analysis of carer burden. However, the latter analysis was excluded on the basis of fatal flaws (small numbers with a high chance of type II error and poorly matched groups at baseline). The 16 trials that we considered were:

- eight single-blinded RCTs (Björkdahl 2006; Kwakkel 1999; Paniak 1998; Powell 2002; Slade 2002; Wade 1997; Wade 1998; Zhu 2007);
- four unblinded RCTs (Elgmark 2007; Salazar 2000; Shiel 2001; Smith 1981);
- three quasi-randomised controlled clinical trials (CCTs) (Bowen 2001; Ozdemir 2001; Werner 1996); and
- one quasi-experimental study (Semlyen 1998).

Type of brain injury

Ten of the 16 trials studied patients with traumatic brain injury (TBI); four studied stroke, and one (Slade 2002) studied a mixed population of acquired brain injury (ABI).

Participants

The trials covered a range of different severities of ABI. Two studies (Wade 1997; Wade 1998) recruited people with brain injury of all severities, two (Elgmark 2007; Paniak 1998) recruited only mild TBI, and the remainder recruited patients with moderate to severe ABI. Between them, the trials recruited 2233 patients and 132 carers.

Interventions

The interventions were also varied. However, trials could broadly be divided into the following categories.

- Five trials (Elgmark 2007; Paniak 1998; Salazar 2000; Wade 1997; Wade 1998) enrolled all patients presenting acutely to hospital with TBI, and therefore included populations predominantly in the milder ambulatory category. The emphasis of the intervention was primarily targeted at increasing participation (social integration, return to work etc) and reducing post-concussional symptoms.
- Eleven trials (Björkdahl 2006; Bowen 2001; Kwakkel 1999; Ozdemir 2001; Powell 2002; Semlyen 1998; Shiel 2001; Slade 2002; Smith 1981; Werner 1996; Zhu 2007) enrolled patients (following TBI or stroke) who were already presenting to rehabilitation services. This group, therefore, had greater levels of motor impairment and dependence in personal activities of daily living (ADL) and interventions were targeted at improving function in ADL (reduced disability), although measures of participation (reduced handicap) were sometimes also included.

Within this second group, trials covered a range of different interventions in different settings.

- Two trials assessed the impact of out-patient rehabilitation programmes: one testing programmes of different intensity (Smith 1981), the other testing therapy offered late after treatment (Werner 1996).
- Three trials assessed the benefits of a co-ordinated community-based multi-disciplinary team approach on patients (Powell 2002) and carers (Bowen 2001). Björkdahl 2006 compared a short programme of home-based rehabilitation with out-patient (day clinic) rehabilitation following a period of in-patient stroke rehabilitation.
- Two trials assessed the benefits of a specialist in-patient rehabilitation programme as opposed to local services (Semlyen 1998) or home-based advice (Ozdemir 2001).
- Four trials compared higher intensity programmes with lower (standard) intensity of treatment: two with a view to assessing impact on length of stay (Shiel 2001; Slade 2002), and two (Kwakkel 1999; Zhu 2007) focusing on improving functional outcomes.

Outcomes

Within these groups, studies used differing outcomes that were measured at different time intervals over a varying follow-up period. As anticipated, we found insufficient concordance between outcome measures, time points, and types of intervention to allow pooling of data for meta-analysis.

Risk of bias in included studies

Using the van Tulder scoring system, the maximum achievable score is 19. The results of scoring are shown in Table 3.

We identified 11 RCTs which were of high methodological quality. Wade 1997 noted that only 478 of the originally randomised 1156 participants (41%) could be traced to attend an interview. However, this is not unexpected in the often itinerant group of people who suffer head injuries. A detailed analysis of baseline characteristics was offered and demonstrated no significant differences between the interviewed and non-interviewed groups. One RCT (Björkdahl 2006) was of lower quality as it was small and probably underpowered for comparison of the two groups, as well as lacking in some aspects of methodological detail.

We identified three quasi-randomised RCTs as being of low methodological quality (Bowen 2001; Ozdemir 2001; Werner 1996).

- The Werner 1996 trials started off as a randomised trial, with a weighted 2:1 chance of the patient being allocated to active intervention (by picking a number of 666 or less from a sample of 1 to 1000); but after nine of the initial 16 controls dropped out, trialists added a further five non-randomised control participants. In addition, it did not include measures of variability or point estimates.
- Bowen 2001 and Ozdemir 2001 reported a quasi-randomised unblinded trials with only short-term follow up.

The remaining low-scoring trial had a quasi-experimental design. Semlyen 1998 reported a quasi-experimental study in which patients were either admitted to a specialist multi-disciplinary (MD) rehabilitation programme or passed back to their standard local services (LS), depending on geography and the availability of a vacancy in the specialist programme. Although there was an element of chance in this allocation, those patients with the most severe brain injuries, whose needs could not be met by their local services, in fact had no alternative option and remained on the acute ward for longer periods until a specialist bed became available. The multi-disciplinary rehabilitation group was, therefore, significantly more disabled to start with and participants were in hospital for longer than the group referred on to local services. The study reported in this paper illustrates some of the important practical, methodological issues, which are considered in the discussion.

Effects of interventions

Milder ambulatory patients

The five trials which predominantly addressed the milder ambulatory group (Elgmark 2007; Paniak 1998; Salazar 2000; Wade 1997; Wade 1998) recruited a total of 1258 patients (see Table 4). Four of the trials (Elgmark 2007; Paniak 1998; Wade 1997; Wade 1998) compared a programme of treatment as needed (which was largely community based) to a lesser intervention (Paniak: information only; Wade: standard follow-up arrangements, which usually meant no further input). Salazar 2000 compared an in-patient based cognitive rehabilitation programme with weekly telephone counselling and advice at home. All four trials were rated as good quality RCTs, on all assessment criteria, although the Salazar study was unblinded.

The general conclusion from all these studies was that intervention in a totally unselected group of patients with mild TBI was not effective. Both the treatment group and control intervention made substantial gains in terms of reduced post-concussion symptoms and enhanced participation, including return to work. No significant differences were recorded between groups.

However, in the trial by Wade 1997 a post-hoc subgroup analysis demonstrated that those who were admitted to hospital or had post-traumatic amnesia (PTA) of >1 h (n = 121) did demonstrate significant gains with treatment. These gains were demonstrated in terms of fewer difficulties with everyday activities (increased participation) as measured by the Rivermead head injury follow-up questionnaire (RHFUQ) ($P < 0.03$).

A subsequent trial (Wade 1998) (218 completing participants) was, therefore, undertaken This trial prospectively selected the group admitted to hospital. This second trial again demonstrated improved outcomes for the treatment as needed group, with significantly fewer post-concussive symptoms (Rivermead post-concussion questionnaire (RPQ)) (Mann-Whitney U: $z = -2.27$; $P < 0.02$) and improved participation (RHFUQ) ($z = -2.54$; $P < 0.01$). The impact of proactive intervention appeared to be most marked for patients with PTA <7 days; these patients may be less likely than those who are more severely affected to present to services by themselves.

From the 'best evidence' synthesis of these studies, we concluded that there is 'strong evidence' to suggest that:

- the majority of patients with mild TBI make a good recovery;
- patients with PTA of less then one hour, usually not admitted to hospital, do not need any specific intervention;
- patients with PTA of one hour or more do benefit from routine follow-up contact giving information and advice;
- there is a subgroup of patients with moderate to severe injury who benefit from a higher level of intervention and who may not present themselves unless routine follow up is provided.

Patients with greater limitations on activities, generally more severe brain damage, and generally requiring a greater multi-disciplinary rehabilitation input

The effectiveness of combined out-patient physiotherapy and occupational therapy was investigated by two trials in stroke patients (see Table 5).

- Smith 1981 reported a good quality, unblinded RCT (n = 133) that demonstrated improved functional ability (Northwick Park ADL index) for the groups attending outpatients as compared with a no-treatment control group ($P < 0.01$). A trend towards greater improvement with the more intense of two out-patient programmes was not tested for significance. However, the gains for both the treated groups were maintained at one-year follow up, while the control group deteriorated ($P < 0.05$).

- Werner 1996 reported a single-blind CCT (n = 49) that was of much lower quality (see Table 3). The study assessed the benefits of late out-patient intervention (offered at least one year after a stroke). The treatment group demonstrated significant gains in function (FIM motor score increase of 6.6 compared with 1.5, $P < 0.03$) and socialisation (sickness impact profile -5.2 compared with an increase of 2.6 in the control group, $P < 0.04$) at three months, which were maintained at nine months.

However, no significant change in mood (Beck depression inventory) was observed.

In summary, there is 'moderate evidence' that outpatient therapy improves the outcomes of stroke rehabilitation, with 'limited evidence' that more intensive treatment regimens are associated with better outcomes. There is 'indicative evidence' that this type of intervention may be effective even late (at least one year) after stroke.

Effectiveness of community-based coordinated multi-disciplinary rehabilitation

This was addressed by two trials (see Table 6).

- Powell 2002 reported a good quality, single-blind RCT (n = 110) of a multi-disciplinary community outreach service providing a home-based goal-orientated programme, two to six hours intervention per week, compared with standard treatment. This was a more severely affected group than those studied by Wade 1998 (91% with PTA for seven days as compared with only 7%). Follow up was variable but averaged approximately two years. Gains for the intervention group were reported in reduced disability (35.4% showing improvement in Barthel index as compared with 19.6% in the control group, $P < 0.05$) and increased participation (significant changes in the self-organisation and psychological scales of the BICRO-39, $P < 0.05$); but no gains were observed for the secondary outcomes, which included FIM+FAM and mood (hospital anxiety and depression scales (HADS)). Global disability scales such as the FIM and FIM+FAM were noted to be insensitive since the majority of items did not change. A maximal gain index was therefore also calculated, which selected the subscales with maximal change. Rated in this way, changes in both disability (FIM+FAM) and participation (Bicro-39) reached a greater level of significance ($P < 0.025$).

- Bowen 2001 reported an unblinded CCT of lower quality in which carer outcomes were evaluated following input from a multi-disciplinary head injury specialist rehabilitation team in addition to standard services. An 'early arm' (n = 41) started the intervention before discharge, and a 'late' arm (n = 28) started after discharge. However, despite best intentions, only 23/41(56%) actually received early intervention and 19/28 (67%) received late intervention, with some mixing between the groups and 14 patients receiving neither intervention. Nevertheless, an intention-to-treat analysis revealed that the early intervention group still received significantly earlier treatment (median five days, $P < 0.001$) than the late intervention group (median 40 days) post-injury. At six months, after adjusting for confounding factors there was a clinically plausible, superior outcome for both intervention groups in comparison to controls with regard to emotional status (Wimbledon self-report scale) and knowledge about brain injury. However, this did not reach Bonferroni-adjusted clinical significance ($P < 0.01$). Logistic difficulties with recruitment and service provision led to significant under-powering of this study and may have interfered with the demonstration of a clinically significant effect.

- Björkdahl 2006 reported a small single-blinded RCT (n = 59) comparing a short programme of home-based rehabilitation with out-patient day rehabilitation following a period of in-patient stroke rehabilitation. Although neither group changed significantly in terms of impairment, both were reported to make significant gains in Assessment of Motor and Process skills (AMPS) and mobility over a one-year follow-up period. Whilst there was a trend toward earlier gains in the home-rehabilitation group, there were no significant difference at any time point. Only the day-clinic group changed significantly on functional measures (Functional Independence Measure) but the degree of change was small (5 FIM points over one year). Despite an a priori power calculation the trial was probably under-powered to distinguish between the groups, with a moderately high chance of a type II error. On the basis of this evidence neither programme could be said to be better than the other, although the cost of the home-based programme was noted to be half that of the day clinic.

In summary, for this group there is 'limited evidence' that multi-disciplinary, community-based rehabilitation can improve functional outcome for patients at the level of 'activity ' (disability) on the ICF (especially when targeted towards specific goals).

Specialist in-patient rehabilitation

Two studies addressed the benefit of specialist in-patient rehabilitation in comparison with local services (Semlyen 1998) (n = 51) or a home-based advisory service (Ozdemir 2001) (n = 60) (see Table 7). Both these studies were small and of low methodological quality.

- The methodological problems of Semlyen 1998 (n = 51) have already been highlighted. The multi-disciplinary (MD) rehabilitation group was significantly more disabled at the outset. Thus the significantly greater gains which were evident at each measurement point up to 24 months may have reflected this lower starting point and the fact that many of the other rehabilitation group were already at ceiling levels on some scores. Carer distress was assessed using the General Health Questionnaire. This identified a higher proportion of 'cases' in the MD rehabilitation group at the outset, which fell between six and 12 months. By contrast, the proportion of cases in the other rehabilitation groups started from a lower point but rose progressively throughout the follow-up period. By 12 months, the carers in the other rehabilitation group had significantly higher levels of distress than the MD rehabilitation group.

- Ozdemir 2001 reported an unblinded CCT in 60 stroke patients. The groups were well matched to start with. The

treatment group made a five-fold greater gain in FIM score (mean 59.6 4.8 ± 14.1) versus (mean 12.3 4.8 ± 13.4) (P < 0.001), and a two-fold change in mini-mental state examination (MMSE) (mean 4.8 ± 5.0) versus (mean 2.0 4.8 ± 2.1) (P < 0.025) compared with the control group.

In summary, there is 'limited evidence' at the current time that specialist in-patient rehabilitation services can improve functional outcome in terms of both activity (reduced disability) and carer distress when compared with controls. However, this partly reflects the practical and ethical difficulties associated with allocating patients with severe brain injury no opportunity of co-ordinated multi-disciplinary rehabilitation (see Discussion).

Increased intensity of rehabilitation

Four trials addressed the benefits of increased intensity of rehabilitation (see Table 8).

- Kwakkel 1999 reported a good quality, single-blinded RCT in 101 severely disabled stroke patients comparing: a group with emphasis on arm training (n = 33), a group with emphasis on leg-training (n = 31), and a control group (n = 37) whose arm and leg were immobilised in an inflatable splint. Each treatment was applied for 30 minutes, five days a week for the first 20 weeks after a stroke, which was over and above a consistent basic-level intervention for all groups. Post-hoc analysis by the Kruskal-Wallis test showed that leg training resulted in significantly greater independence (Barthel index) and mobility (functional ambulation categories) than the control group, up to the first 20 weeks, and better dexterity (Action Research arm test) in the arm training group from week 12 onwards. The effects of treatment appeared to be maintained at one year but no significant differences between groups were demonstrated beyond six months.

- Shiel 2001 reported a two-centre RCT (n = 51 completing participants) in patients with moderate to severe traumatic brain injury. At each centre, patients were randomised to receive routine treatment with or without additional input from an additional experienced member of staff acting in a trans-disciplinary capacity to supplement the rehabilitation programme. Those with added intensity of input made more rapid gains in independence (FIM+FAM) in both centres, with no evidence of any ceiling effect of therapeutic intensity beyond which no further response was observed. However, there were marked differences between the two centres in terms of staffing levels and intensity of the routine programme. This led to substantially shorter lengths of stay in one centre, so that no significant reduction in length of stay was observed for the trial as a whole despite the more rapid gains in independence.

- Slade 2002 conducted a good quality, single-blind RCT (n = 131) in a group of mixed ABI, comparing two rehabilitation programmes in the same setting, one more intensive than the other. Records of therapy input demonstrated that patients were able to tolerate the increased input with no adverse effects. Although it was intended for the intensive group to receive 67% more therapy than the control group, they in fact only received 30% more. The intention to demonstrate a reduced length of stay as a result of more intensive therapy was confounded by external delays in discharge. Analysis by a regression model was, therefore, undertaken to account for confounding variables including impairment mix and factors that could not be controlled for in the study design (community delays and missed treatment). This demonstrated a significant reduction in length of stay (14 days, P < 0.001) for the intensive group. Similar Barthel scores between groups at admission and discharge confirmed that this reduced length of stay was not at the expense of a poorer functional outcome.

- Zhu 2007 reported a small but good quality, single-blind RCT in patients with moderate to severe traumatic brain injury (n = 68) that compared different intensities of treatment (two versus four hours per day, for up to six months). Analysis of time utilisation, presented in a preliminary report (Zhu 2001), showed that after the second week the majority of patients could tolerate over two hours of therapy per day. Functional and overall outcome status FIM and the Glasgow outcome scale (GOS) were recorded monthly to six months and then bi-monthly to one year. No significant differences were found between the two treatment groups beyond three months, but significantly more patients in the high intensity group achieved a maximum FIM score at three months (47% versus 19%) and GOS at two months (28% versus 8%) although these early functional gains did not appear to impact significantly on length of stay. The study provides evidence that intensive rehabilitation may speed up recovery rather than changing the final outcome. The authors concluded that early intensive rehabilitation can improve the functional outcome of patients with TBI in the early months post-injury and could (theoretically) increase the chances of their early return to work, although actual return to work and job retention were not recorded as an outcome in this study. As the majority of patients did not remain in the programme beyond 90 days, it is not possible to know whether a more prolonged intervention, or treatment targeted at goals beyond simple activities of daily living, could have capitalised on these earlier gains to produce higher-level gains in participation and social integration.

In summary, there is 'strong evidence' that more intensive rehabilitation programmes are associated with earlier function gains once patients are fit to engage. There was no evidence of a ceiling effect in therapeutic intensity in any of these studies. However, for intensive intervention to be cost-effective, it is necessary to demonstrate that it is associated with potential cost savings further down the line (for example reduction in length of stay, or long-term dependency) which might offset the additional costs of

providing the initial programme. None of the studies undertook a direct analysis of cost-effectiveness and, at the current time, there is only moderate evidence that more intensive rehabilitation leads to reduced length of stay. On the other hand, length of stay is frequently affected by external confounders (such as the lack of a suitable place to discharge the patient to, or lack of community support for a patient otherwise ready for discharge) that may need to be controlled for before this benefit can be demonstrated.

DISCUSSION

This review suggests that multi-disciplinary rehabilitation by expert neurological rehabilitation services does improve outcomes after acute brain injury in adults of working age, and that a greater intensity is likely to lead to a faster and possibly greater level of recovery. It also suggests that people with relatively minor traumatic brain injury who are not admitted to hospital, or who do not have a period of post-traumatic amnesia of over 30 minutes, will recover without routine specialist follow up and rehabilitation. The review highlights the need for further research, both to confirm the general conclusion, to investigate cost-effectiveness, and to investigate which components of the rehabilitation package are of particular importance.

Context

This review needs to be set in the context of other studies and reviews investigating specialist (neurological) rehabilitation. Several other Cochrane reviews have come to similar conclusions concerning other rehabilitation programmes for stroke (Stroke Unit Trialists Collaboration 2007), after hip or knee joint replacement (Khan 2008), for people with multiple sclerosis (Khan 2007), and in chronic obstructive pulmonary disease (Lacasse 2006).

It is therefore no surprise that this review suggests that rehabilitation is an effective intervention.

However it must be stressed that the studies have, primarily, investigated the process of rehabilitation and not any specific intervention (therapy or treatment) or group of interventions. They have shown that being involved in a service that encompasses a multidisciplinary team of people with expertise in neurological rehabilitation and that focuses on reducing disability and increasing social participation through a problem-solving process will generally improve a patient's outcome.

The evidence from stroke rehabilitation, used to formulate the relevant recommendation (3.2.1B) in the third edition of the UK National Clinical Guideline for Stroke (RCP 2008), would suggest that the key features of a successful, specialist rehabilitation service are that it:

- comprises a multi-disciplinary team;
- ensures that all team members have relevant expertise;
- includes educational programmes for staff, patients, and relatives;
- has a specific geographic base or location;
- uses agreed protocols for the management of common problems based on evidence, wherever possible.

We have not systematically studied the characteristics of all the teams involved in these studies but it seems probable that they all had the same characteristics.

Limitations of this review

This review took an inclusive approach to a broad area of clinical practice and a wide-ranging group of conditions under the collective banner of acquired brain injury. This approach posed significant challenges for the assessment and assimilation of the available evidence.

We may have included studies of too low quality to allow useful conclusions on their own. However, the presented synthesis using a 'best evidence' approach, which includes a measure of methodological quality, has facilitated a helpful comparison of the various studies available. It also allows open acknowledgement of the limited evidence that comes from these poorer studies, which is nevertheless the best currently available.

Secondly a more piecemeal approach, undertaking many separate reviews of the various different models of practice, might have been easier to interpret and analyse. However, patients rarely present with a single problem and studies on single solutions are not necessarily useful or usable. They have their own weaknesses, either recruiting very selected patients or having many other variables that affect outcome. Thus, whilst some countries do plan or organise service provision around specific programmes of rehabilitation for specific diagnostic groups, a broader needs-led approach to service provision for more mixed patient groups is probably more appropriate, and this is what we have evaluated. The stroke unit studies are the strongest example of research which has focused on a broad approach, not a piecemeal approach, and they have been both clear in their outcome and influential.

Next, it is obviously difficult to fit studies into categories. Some studies ostensibly focused on a single profession, such as occupational therapy, are nonetheless investigating the process of rehabilitation rather than a single intervention. They were not included. Some studies investigating people of an older age will nonetheless be investigating the rehabilitation process but they were not included.

Lastly, we have focused on acute onset conditions but the process of rehabilitation and the types of problems faced by people with other types of disease are similar.

We chose to limit ourselves in part to fill a gap in the broader set of rehabilitation reviews and in part because service commissioners

(purchasers) perceive adults with acquired brain injury as a specific population needing a specific set of evidence.

In summary, we believe that these limitations should be set in the context of the whole body of research into specialist rehabilitation and that they do not detract from our conclusions.

Implications

The direct findings of this review have some implications for service commissioning and provision, largely supporting the development and use of specialist neurological rehabilitation services for people of working age with significant residual problems soon after acute onset brain injury, however acquired.

However, the other main lessons to be learned relate to the nature of rehabilitation and how research into rehabilitation is undertaken.

Randomised controlled trials are the primary means by which treatment efficacy is demonstrated, mainly because of their ability to control for unknown confounding factors; of which there are many in rehabilitation. They are well suited to single easily identified interventions, such as specific drugs or procedures.

Rehabilitation is a complicated (that is multi-factorial) intervention undertaken in a (mathematically) complex situation; in other words, rehabilitation has many components which are inter-related and inter-dependent, and the relationships being targeted may well be non-linear and unpredictable on an individual basis. This has been increasingly recognised in many other areas of healthcare research.

In the context of research into both the rehabilitation process and more specific rehabilitation interventions (treatments), this review has highlighted a number of challenges:

- patient numbers are relatively small;
- there is marked heterogeneity in clinical characteristics, interventions, settings, and outcomes that are relevant;
- the resources required to randomly assign whole systems of care to different patient groups are far greater than those required to deliver specific medications or procedures;
- the length of time over which rehabilitation may have its effects (always many months and usually several years) is usually longer than any funded research project.

In addition, the expanding body of evidence for effectiveness of multi-disciplinary rehabilitation in other conditions (particularly stroke) makes it increasingly difficult, ethically, practically, and electively, to randomise patients to non-specialist rehabilitation as it is more-or-less certainly less effective. However, the reality is that specialist neurological rehabilitation services are not available to many patients, even in rich countries (such as the UK and USA), so in practice it should still be possible to undertake randomised studies comparing rehabilitation by a specialist multi-disciplinary neurological rehabilitation team with non-specialist, un-co-ordinated piecemeal rehabilitation that is currently received by many people. Indeed, there is probably an ethical imperative to undertake such studies in order to acquire a body of evidence equivalent to that acquired for stroke units, providing the various practical and logistic barriers can be overcome.

The studies identified in this review illustrate some of the practical problems with research in this area that will need to be addressed in future research

1. **Recruitment and retention of participants**

Where fully informed consent is obtained prior to engagement, as it should be, recruitment and retention can be problematic, especially for the control arm. For example Werner 1996 started out as a weighted randomised study. Once recruited, however, many of the control group demonstrated reluctance to attend for evaluations, expressing disappointment at not having been selected for treatment. After more than half the control group defaulted from follow up, the trialists were forced to recruit an additional five controls in a non-randomised fashion.

2. **Differences between centres**

In view of the small number of patients available in any one centre, multi-centre studies will usually be essential. However, the additional heterogeneity introduced may outweigh the benefits of increased numbers in analysis. This problem was well illustrated in the study by Shiel 2001 where the two centres, chosen initially for their similarity of service, turned out to have critical differences in staffing levels and, therefore, the intensity of rehabilitation offered as routine. This led to disparate lengths of stay that were sufficient to confound this critical outcome in statistical analysis.

3. **Outcome measurement**

Common (shared) measures are a necessary pre-requisite for assimilation of data. A number of global outcome assessments, such as the Barthel ADL index and the FIM, have been developed with the aim of creating comparable datasets and are increasingly widely used. Unfortunately, these pose a number of further problems.

- Homogeneity: the measures themselves may be less homogeneous than previously supposed. Analysis indicates that even the most consistently applied instruments behave differently in different cultures and settings (Tennant 2002), and there are several different versions of the Barthel index in current usage (Turner-Stokes 1997).
- Sensitivity to targeted changes: rehabilitation is increasingly targeted towards specific goals set for the individual and their family. These global instruments address a range of different dimensions, many of which are not likely to change in response to such targeted efforts. The overall scores are therefore unlikely to reflect the true benefits of the intervention. The study by Powell 2002 attempted to overcome this problem by recording only the dimensions which demonstrated maximal gain (maximum gain index). This enhanced the statistical differences between the treatment and control arms but might be considered to represent excessive manipulation of the data, especially since these selected dimensions were not identified as the target areas prior to treatment.
- Interpretation: the study by Semlyen 1998 illustrates a dilemma for data interpretation. The participants who received MD rehabilitation were more disabled at the outset but achieved

the same level of function (Barthel index) as those in the other rehabilitation group by 12 months. This may be interpreted as an inverse bias for the treatment arm, who therefore demonstrated significantly greater gains during rehabilitation despite the lower starting point. Alternatively it may be argued that this lower starting point offers a statistical advantage by dint of greater opportunity for change in a scale with recognised ceiling effects.

- Ceiling effects: possible ceiling effects of the FIM, which is commonly used as an outcome measure for brain injury rehabilitation, were seen in the study by Zhu 2007. The same percentage of control and treatment group patients eventually reached the maximum FIM score by one year post-injury. However, the treatment group achieved their high scores more quickly with a significant difference detectable at three months. It is not possible to determine whether the earlier return to full independence allowed patients to extend their horizons beyond basic activities of daily living as the study did not record measures of extended activities of daily living or participation.

These limitations in outcome measurement also underline the need to collect more person-centred measures, such as goal attainment scaling, to record whether the rehabilitation programme achieved the intended goals for that individual; as well as the need for further development of standardised measures that record gains at the various levels of impairment, activity, and participation. As in other complex areas of medical practice, it may, therefore, be necessary to develop the evidence base for effective management through triangulation of a range of different research methodologies. In this review we have included quasi-randomised studies and quasi-experimental designs, providing they met the pre-determined criteria. It is accepted that these research designs are open to a certain level of bias. However, given the problems noted above, the authors accepted that in the real-life context of clinical practice this level of 'randomness' may be the best that can be achieved in the context of severe brain injury. In future, these experimental designs will need to be set alongside practice-based evidence (Horn 2007) gathered from large systematic, longitudinal cohort studies conducted in the context of routine clinical practice to address the questions that cannot be answered by RCT designs, such as which treatments work best for which patients over the long term and which models of service represent value for money in the context of life long care.

AUTHORS' CONCLUSIONS

Implications for practice

The various findings from this review serve to emphasise the varied nature of acquired brain injury and the need for different services to suit the needs of different populations. Implications for practice from this review are as follows.

- Whilst every patient presenting to hospital with ABI should be given information about the nature of the brain injury and who to contact in case of problems, it appears that routine follow up may be reserved for patients identified as having at least significant brain injury on the basis of their presentation or residual deficits. These individuals are most easily defined as those admitted to hospital or, if not, with any documented period of coma or post-traumatic amnesia extending for more that 30 minutes.

- For those patients engaged in rehabilitation, intervention should be offered as intensively as possible, although the balance between intensity and cost-effectiveness has yet to be determined.

- Patients discharged from in-patient rehabilitation settings who have continued rehabilitation needs and goals should have access to follow-up out-patient or community-based services that are appropriate to their needs.

Implications for research

There are important questions still to be answered regarding the effectiveness of rehabilitation interventions in acquired brain injury. Where these cannot be answered by well-designed RCTs, they may still be appropriately addressed by alternative methodologies or by breaking down the research questions. In particular, there is a need to explore:

- the effectiveness of specific interventions within the overall rehabilitation programme, and the characteristics which render patients most likely to gain benefit;

- development of a method to determine an individual's ability to engage in and benefit from intensive rehabilitation, and the most appropriate level of intensity;

- the cost-effectiveness of rehabilitation interventions and their impact on quality of life for both patients and carers;

- development of appropriate outcome measures and better understanding of their behaviour in different cultural settings, as well as in statistical handling;

- improved measurement techniques for assessment of targeted interventions, such as goal attainment, or agreed methodologies for refining global instruments to focus on the areas of particular interest or relevance to the intervention;

- the long-term (over 12 months) effects of rehabilitation, both in terms of patient outcome and in terms of the social costs associated with ABI (care costs and loss of income for the patient and family);

- development of appropriate methods for incorporating other research designs in formal reviews and meta-analyses.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Björkdahl 2006

Methods	Single-blind RCT
Participants	Stroke Randomised (completed) n=61 (59): home group n=30 (29), day clinic group n=29 (29)
Interventions	9 hours of training per week for 3 weeks Home group: OT and PT trained patient at home with family Day clinic group: multi-professional team trained patient in the day clinic
Outcomes	AMPS (Assessment of Motor and Process Skills) Functional Independence Measure (FIM) Instrumental Activity Measure 30-metre walking test National Institutes of Health Stroke scale (NIHSS) Barrow Neurological Institute screening for higher cerebral functions
Notes	Follow up: 3 weeks, 3 months, 1 year

Risk of bias

Item	**Authors' judgement**	**Description**
Allocation concealment?	No	

Bowen 2001

Methods	Unblinded quasi-RCT
Participants	Moderate to severe TBI Carers n=96 randomised Treatment n=69, Control n=27 (All completed)
Interventions	Head injury neurorehabilitation team (HINT) Early = started pre-discharge Late = started after discharge Control = existing services
Outcomes	Carers' perception of how well-informed they are Carers' mood/emotion
Notes	Follow up: 6 mths

Bowen 2001 (*Continued*)

Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Unclear	D - Not used

Elgmark 2007

Methods	Single-blind RCT
Participants	Mild traumatic brain Injury Treatment group n=264, Control n=109
Interventions	Follow up at 2-8 weeks by telephone or letter with advice and referral as required Control = no specific treatment (routine care)
Outcomes	Post-concussion symptom questionnaire (PCSQ), Life Satisfaction questionnaire, Community Integration Questionnaire (CIQ), Short-form health survey (SF-36)
Notes	Patients sent 2 questionnaires, first between 2-8 weeks post-injury, second at 1 year

Kwakkel 1999

Methods	Single-blind RCT
Participants	Middle cerebral artery stroke Randomised (completed) Total n=101 (81) Leg training n=31 (26), Arm training n=33 (29), Control n=37 (34)
Interventions	Intensive arm or leg training by physio/occupational therapists versus immobilisation with inflatable splint
Outcomes	Primary outcomes: ADL ability: Barthel Index Mobility: FAC Dexterity: AR arm test Secondary outcomes: participation: SIP NHP Frenchay Activities Index
Notes	Follow up: 6 mths

Risk of bias		
Item	**Authors' judgement**	**Description**

Kwakkel 1999 (*Continued*)

Allocation concealment?	Unclear	B - Unclear

Ozdemir 2001

Methods	Unblinded quasi-RCT
Participants	Stroke subjects n=60 In-patient n=30, Home n=30 (All completed)
Interventions	In-patient rehabilitation versus home exercise programme
Outcomes	Impairment: Ashworth Scale Brunnstrom stages MMSE Activity: FIM
Notes	Variable measurement before and after rehabilitation (mean 64 days)

Risk of bias

Item	**Authors' judgement**	**Description**
Allocation concealment?	Unclear	D - Not used

Paniak 1998

Methods	Single-blind RCT
Participants	Moderate-severe TBI Randomised (completed) Total 119 (111) Treatment n=53 (59), Control n=58 (60)
Interventions	Treatment as needed with full MD programme versus single session - educational input
Outcomes	Impairment: Problem checklist Participation: CIQ Health status: SF-36 Work status
Notes	Follow up: 3-4 mths

Risk of bias

Paniak 1998 (*Continued*)

Item	Authors' judgement	Description
Allocation concealment?	Unclear	B - Unclear

Powell 2002

Methods	Single-blind RCT
Participants	Moderate-severe TBI Randomised (completed) n=110 (94) Treatment n= 54 (48), Control n= 56 (46)
Interventions	Community-based outreach MD Team Visits x 2 per week. Mean 6 months duration Control - written information only
Outcomes	Activity: Barthel Index FIM+FAM Participation: BICRO 39 scales Mood: HADS Maximum Gain Index (MGI)
Notes	Variable measurement (mean 2 yrs)

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Unclear	B - Unclear

Salazar 2000

Methods	Unblinded RCT
Participants	Defence veterans Moderate-severe TBI Randomised (completed) n=120 (107) In-Pt n=67 (60), Home n=53 (47)
Interventions	In-patient intensive 8-week programme versus Home - weekly telephone contact with counselling and advice from nurse
Outcomes	Work status: Return to work Fitness for military duty

Salazar 2000 (*Continued*)

Notes	Follow up: 1 y	
Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Yes	A - Adequate

Semlyen 1998

Methods	Unblinded quasi-experimental design	
Participants	Moderate-severe TBI subjects n=51 Treatment n=33, Control n=18 (All completed)	
Interventions	Co-ordinated MD rehabilitation in a specialist brain injury rehabilitation unit (HM) versus other rehabilitation (OR) in local district services	
Outcomes	Activity and independence: Barthel index FIM+FAM NIAF Care-giver's health: GHQ-28	
Notes	Follow up: to 2 yrs	
Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Unclear	D - Not used

Shiel 2001

Methods	Unblinded RCT
Participants	Moderate-severe TBI patients n=51 Intensive n=24, Routine n=27 (All completed)
Interventions	Intensive rehabilitation (with additional healthcare professional experienced in BI) versus standard treatment
Outcomes	Disability: FIM+FAM Healthcare: length of stay

Shiel 2001 (*Continued*)

Notes	Admission to discharge	
Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Unclear	D - Not used

Slade 2002

Methods	Single-blind RCT	
Participants	Mixed brain injury (mod-severe) and stroke Randomised (completed) n=161 (131) Intensive n= 80 (75), Standard n=81 (76)	
Interventions	Intensive MD rehabilitation: intensive group received 67% more therapy	
Outcomes	Healthcare: Length of stay: controlled for ADL ability Barthel Index	
Notes	Admission to discharge	
Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Yes	A - Adequate

Smith 1981

Methods	Unblinded RCT
Participants	Stroke patients discharged from hospital, n=133 Intensive n=46, Conventional n=43 (All completed) Control n=44
Interventions	Out-patient physio/OT for up to 6 mths: Intensive = 4 days per week Conventional = 3 half days per week Control = health visitor encourages self exercise
Outcomes	ADL dependency: Northwick Park ADL index
Notes	Follow up: at 3 and 12 mths

Smith 1981 (*Continued*)

Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	Unclear	B - Unclear

Wade 1997

Methods	Single-blind RCT
Participants	TBI - all severities (presenting via A&E) Randomised (completed) n=1156 (478) Treatment n=579 (252), Control n=577 (226)
Interventions	Oxford Head Injury service (OxHIS) Advice and referral as required Control: standard services only
Outcomes	Symptoms: Post concussion RPQ Social disability RHFUQ Post traumatic amnesia
Notes	6 mths

Risk of bias		
Item	**Authors' judgement**	**Description**
Allocation concealment?	No	C - Inadequate

Wade 1998

Methods	Single-blind RCT
Participants	TBI - all severities (but only if admitted to hospital) Randomised (completed) n=321 (218) Treatment n=184 (132), Control n=130 (86)
Interventions	Oxford Head Injury Service (OxHIS) Advice and referral as required Control: standard services only
Outcomes	Symptoms: Post-concussion RPQ Social disability

Wade 1998 (*Continued*)

	RHFUQ (RHFUQ) Post traumatic amnesia
Notes	6 mths

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	Yes	A - Adequate

Werner 1996

Methods	Single-blind quasi-RCT
Participants	Stroke patients - at least 1 y since stroke (mean 2.9 years) Randomised (completed) n=49 (35) Treatment n=33 (28), Control n=16 (7) (5 additional non-randomised controls recruited)
Interventions	Late treatment: Out-patient physio / OT for 3 mths versus no treatment
Outcomes	Activity FIM-motor Limitation of participation: SIP Mood Beck depression inventory
Notes	Follow up: at 3 and 9 mths

Risk of bias

Item	Authors' judgement	Description
Allocation concealment?	No	C - Inadequate

Zhu 2007

Methods	Single blind RCT
Participants	Moderate to severe TBI
Interventions	Multi-disciplinary rehabilitation at two intensities: Intensive**:** 4 hrs/day, 5 days/wk (n=36) Conventional**:** 2 hrs/day, 5 days/wk (n=32)

Zhu 2007 (*Continued*)

Outcomes	Global outcome**:** Glasgow Outcome Scale (GOS) Activity (disability): FIM, Neurobehavioural Cognitive Status Examination (NCSE)
Notes	Assessment points: 0, 1, 2, 3, 4, 5, 8, 10, and 12 months No statistically significant difference in FIM or NSCE between the two groups. However, a significantly greater number of patients achieved maximal FIM and GOS scores within 3 months, although there was no difference at later time points and up to one year. Early intensive rehabilitation can improve the functional outcome of patients with TBI in the early months post-injury and hence may increase the chance of their early return to work. Intensive rehabilitation in this study speeded up recovery rather than changing the final outcome

Risk of bias

Item	**Authors' judgement**	**Description**
Allocation concealment?	Yes	

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Bjorkdahl 2007	Fatally flawed: small numbers with a high chance of type II error and poorly matched groups at baseline
Relander 1972	Fatally flawed: over 40% attrition at one-year follow up. Outcome measured by questionnaire only with no validatory evidence presented
Sonoda 2004	Low methodological quality as per Van Tulder criteria.

DATA AND ANALYSES

This review has no analyses.

ADDITIONAL TABLES

Table 1. Scoring criteria using the method of van Tulder 1997

Criterion	Score positive if:
a) Eligibility criteria specified	A list of inclusion/exclusion criteria was explicitly stated
bi) Method of randomisation	A random (unpredictable) assignment sequence was used.
bii) Treatment allocation concealment	Assignment was concealed from the investigators. Assignment generated by an independent person not responsible for determining the eligibility of the patients. This person has no information about the persons included in the trial and has no influence on the assignment sequence or on the decision about eligibility of the patient
c) Similarity of baseline characteristics	The study groups were comparable at baseline for the important prognostic parameters. In order to receive a "yes," groups have to be similar at baseline regarding demographic factors, duration and severity of complaints, percentage of patients with neurologic symptoms, and value of main outcome measure(s)
d) Treatment and control interventions specifically described	Details are given of the programme, including disciplines involved and treatment duration
e) Care provider blinded to the intervention	Treating team is blinded regarding the intervention (NB rarely possible in this context)
f) Co-interventions avoided or equal	Co-interventions should either be avoided in the trial design or similar between the index and control
g) Compliance	Compliance was measured and satisfactory in all study groups
h) Patient blinded to the intervention	Patient is blinded regarding the intervention (NB: rarely possible in this context if consent procedures are properly applied)
i) Outcome assessor blinded to the intervention	Outcome assessor blinded regarding treatment allocation and standardised assessment measures were used to structure the interviews. Scored negative if only self-reported (questionnaire) outcomes were used and no observer outcomes
j) Outcome measures relevant	Outcome measures reflected disability (activity) or participation as relevant to the intervention
k) Adverse effects described	Any adverse effects of the intervention are described.

Table 1. Scoring criteria using the method of van Tulder 1997 (*Continued*)

l) Withdrawal rate described and acceptable	The number of participants who were included in the study but did not complete the observation period or were not included in the analysis must be described and reasons given. If the percentage of withdrawals and drop-outs does not exceed 20% for immediate and short-term follow ups, 30% for intermediate and long-term follow ups and does not lead to substantial bias a 'yes' is scored
mi) Short-term outcome measurement	Outcomes were measured at the end of treatment (e.g. admission to discharge) or within 6 months of the end of treatment
mii) Long-term outcome measurement	Outcomes were measured at 1 year or more.
n) Timing of outcome assessment in both groups comparable	Timing of outcome assessment should be identical for all intervention groups and for all important outcome assessments
o) Sample size described for each group	Number of participants is stated for each group.
p) Intention-to-treat analysis	All randomised patients were included in the analysis (minus missing values), irrespective of non-compliance and co-interventions. If loss to follow-up was substantial (20% or more), an intention-to-treat analysis as well as an alternative analysis, which accounts for missing values (e.g. a worst-case analysis), should have been performed
q) Point estimates and measures of variability	A mean or median figure was given for each important outcome parameter, together with a measure of variability such as standard deviation, standard error of the mean, or 95% confidence intervals

Table 2. Method for synthesis of 'best evidence'

Category of evidence	Criteria
Strong evidence	Consistent statistically significant findings in outcome measures in at least two high quality RCTs
Moderate evidence	Consistent statistically significant findings in outcome measures in at least one high quality RCT and at least one quasi-RCT or quasi-experimental design
Limited evidence	Consistent statistically significant findings in outcome measures in at least one high quality RCT or Consistent statistically significant findings in outcome measures in at least two quasi-RCT or quasi-experimental design
Indicative findings	Consistent statistically significant findings in process or outcome measures in at least one quasi-RCT or quasi-experimental design
No evidence	Conflicting results between trials or in the case of insufficient data

Table 3. Methodological quality assessed by the van Tulder method

Study ID	Internal Validity	Descriptive Criteria	Statistical Criteria	Total Score	Positive criteria
Kwakkel 1999	9	5	2	16	a,bi,bii,c,d,f,g,i,j,l,mi,mii,n,o,p,q.
Paniak 1998	8	5	2	15	a,bi,c,d,f,g,i,j,l,mi,mii,n,o,p,q.
Zhu 2001	9	4	2	15	a,bi,bii,c,d,f,g,i,j,l,mi,n,o,p,q.
Wade 1997	8	4	2	14	a,bi,bii,c,d,f,g,i,j,l,mi,n,o,q.
Wade 1998	8	4	2	14	a,bi,bii,c,d,f,g,i,j,l,mi,n,o,q.
Powell 2002	8	4	2	14	a,bi,bii,c,d,f,g,i,j,l,mii,n,o,q.
Smith 1982	7	5	2	14	a,bi,c,d,f,g,i,j,l,mi,mii,n,o.
Salazar 2000	7	5	2	14	a,bi,c,d,f,g,j,l,mi,mii,n,o,p,q.
Slade 2002	8	3	2	13	a,bi,bii,c,d,f,g,i,j,l,mi,o,p,q
Shiel 2001	7	3	2	12	a,bi,d,g,h,i,j,l,mi,o,q.
Zhu 2007	6	4	2	12	a.bi,bii,c,d,i,j,l,mi,mii,n,o,p,q
Elgmark 2007	6	4	2	12	a,bi,bii,c,d,i,j,l,mii,n,o,p,q
Bowen 2001	5	4	2	11	a,bi,c,d,f,j,l,mi,n,o,p,q.
Bjorkdahl 2006	5	3	2	10	d,i,j,l,mi,mii,n,o,p,q
Werner 1996	4	4	1	9	a,bi,d,i,j,mi,mii,n,o.
Semlyen 1998	4	4	1	9	a,d,f,g,j,l,mi,mii,n,o.
Ozdemir 2001	3	4	2	9	a,c,d,f,g,j,mi,o,q.
Relander 1972	1	4	0	5	a,c,d,l,mii.
Sonada 2004	2	3	1	5	a,c,d,j,o,q

Table 4. Results from the four studies predominantly addressing the milder ambulatory group

Paniak 1998 and 2000	**Subjects and Group comparison**	Patients with TBI admitted to hospital (all severities). Mean age 33 yrs **Intervention:** 'Treatment as needed' (TAN) (n=58) **Control:** Single session (SS) of education and advice (n=53)			
	Primary outcomes	**Impairment:** Problem Checklist (PCL) **Participation:** Community Integration Questionnaire (CIQ) **Health Status:** Short-Form 36 (SF-36) **Work Status:** Socio-economic status (SES)			
	Assessment points	3-4 months (n=111) and 1 year (n=105)			
	Summary of Results	Participation (CIQ) did not change significantly for either group Impairment (PCL) and health status (SF-36): Repeated measures MANOVA showed significant effects for time in both groups which were maintained at 1 year There was no significant group interaction or time by group for any of the primary outcomes at either time point			
	Vocational status (SES)	**Intervention** Mean (SD)	**Control** Mean (SD)	**Difference in mean**	**P value** (MANOVA)
	Pre-injury	37.2 (18.7)	34.3 (18.5)	2.9	N/S
	Baseline	26.9 (20.7)	23.2 (19.9)	0.8	N/S
	3-4 months	32.5 (20.2)	32.8 (19.7)	0.3	N/S
	1 year	34.8 (19.7)	36.7 (21.0)	1.9	N/S
	Authors' conclusions	Both interventions appear to be equally effective			
Salazaar	**Subjects and Group comparison**	Active duty military personnel with moderate-severe TBI. Mean age 25 yrs **Intervention:** 8-week intensive in-patient cognitive behavioural programme (n=67) **Control:** limited home programme of weekly telephone support from psychiatric nurse (educational material, counselling and suggested home exercises) (n=53)			
	Primary outcomes	**Work status:** Return to work Return to fitness for military duty			
	Assessment points	1 year			

Table 4. Results from the four studies predominantly addressing the milder ambulatory group (*Continued*)

	Summary of Results	No overall difference in outcome between the groups, Post hoc analysis demonstrated a significant group interaction (in favour of the intervention group) for 'fitness for military duty' at 1 year for the more severe subgroup who were unconscious for >1 hr			
	Vocational status at 1 year	**Intervention** % achieved	**Control** % achieved	**Difference**	**P value** (Fisher Exact)
	Return to work	90%	94%	4% (-5,14)	N/S
	Fit for military duty	73%	66%	7% (-10.24)	N/S
	Post hoc analysis of subgroup unconscious for > 1 hr (n=75)				
		(n=35)	**(n=40)**	**Difference**	**P value**
	Fit for military duty	80%	58%	22%	0.05
	Authors' conclusions	Overall benefit of in-patient cognitive rehabilitation programme similar to that of limited home rehabilitation, although institutional therapy may be beneficial for selected patients with severe TBI			
Wade 1997	**Subjects and Group comparison**	All patients presenting to Accident and Emergency following TBI. Age 16-65 yrs **Intervention:** Telephone follow-up at 7-10 days with advice and referral as required (n=252) **Control:** no specific intervention (standard services only) (n=226) (NB: Despite major efforts to trace and contact patients, follow-up interview at 6 months could be achieved in only 478 of the 1156 (41%) of the patients randomised.)			
	Primary outcomes	**Social disability:** (Rivermead head injury Follow-Up Questionnaire RFUQ) **Symptoms:** (Rivermead Post-concussion symptoms Questionnaire -RPQ)			
	Assessment points	6 months			
	Summary of results	No overall difference between the intervention and control groups Post hoc analysis revealed a significant group interaction (in favour of the active intervention group) with respect to social disability in a subgroup of patients with more severe injury (>1 hr PTA)			
	Health Status at 6 months	**Intervention** Mean (SD)	**Control** Mean (SD)		**P-value** (Mann-Whitney)
	RFUQ	3.6 (6.0)	3.3 (6.3)		N/S
	RPQ	7.7 (10.9)	6.8 (10.0)		N/S

Table 4. Results from the four studies predominantly addressing the milder ambulatory group (*Continued*)

	Post hoc analysis of subgroup with PTA > 1 hr (n=121)			
		(n=71)	**N=53)**	
	RFUQ	0.85 (0.89)	1.17 (1.07)	0.003
	RPQ	2.03 (0.85)	2.21 (0.89)	N/S
	Authors' conclusions	Routine follow-up does not appear to be necessary for all patients presenting with head injury, but a sub-group of patients with more severe TBI may benefit from such intervention		
Wade 1998	**Subjects and Group comparison**	All patients admitted to hospital following TBI (i.e. a more severe group than the total group reported in Wade 1997). Age 16-65 yrs **Intervention:** Telephone follow-up at 7-10 days with advice and referral as required (n=132) **Control**: no specific intervention (standard services only) (n=86). (NB: Follow-up data obtained in 218 (69%) of the 314 patients randomised)		
	Primary outcomes	**Social disability:** (Rivermead head injury Follow-Up Questionnaire RFUQ) **Symptoms:** (Rivermead Post-concussion symptoms Questionnaire -RPQ)		
	Assessment points	6 months		
	Summary of results	Significant group interaction (in favour of the active intervention group) with respect to social disability and post-concussion symptoms. Subgroup analysis demonstrated that the main benefit appeared in the group with PTA<7 days		
	Health Status at 6 months	**Intervention Mean (SD)**	**Control Mean (SD)**	**P-value** Mann-Whitney U test
	RFUQ	5.36 (7.81)	8.23 (8.75)	0.01
	RPQ	9.8 (11.7)	13.9 (13.6)	0.02
	Authors' conclusions	Early intervention by a specialist service significantly reduced social morbidity and severity of post-concussion symptoms 6 months after head injury, in the group of patients who required admission to hospital. Possibly most beneficial for the moderate to severe group some of whom may not present without pro-active intervention		
Elgmark 2007	**Subjects and Group comparison**	All patients aged 16-60 with Mild Traumatic brain injury according to the American Congress of Rehabilitation medicine criteria **Intervention:** Follow-up at 2-8 weeks by telephone or letter with advice and referral as required (n=264 - of which 96 received intervention, and 150 declined) 18 lost to		

Table 4. Results from the four studies predominantly addressing the milder ambulatory group (*Continued*)

		follow-up **Control**: no specific intervention (regular care) (n=131).22 lost to follow-up 246 treatment and 109 controls included in intention-to-treat analysis		
	Primary outcomes	**Symptoms:** Change in Post-concussion symptoms - Swedish Post-concussion symptoms Questionnaire (PCSQ) **Social disability:** Community integration questionnaire (CIQ), Life Satisfaction Questionnaire, Short-form Health Survey (SF-36)		
	Assessment points	1 year post injury		
	Summary of results	No statistically significant differences were found between intervention and control groups. Patients who experiences few PCS 2-8 weeks post injury declined rehabilitation and returned to work. Thise who suffered several PCS and accepted rehabilitation did not recover after one year		
	Health Status at 6 months	**Intervention Mean (SD)**	**Control Mean (SD)**	**Significance**
	Total PCSQ	5.2 (5.3)	4.4 (5.3)	N/S
	CIQ	20.3 (4.0)	19.8 (4.0)	0.02
	Authors' conclusions	In this particular study of MTBI, active rehabilitation did not change outcome to a significant degree. Further studies should focus on patients who remain symptomatic during the first 1-3 months and test various types of interventions		

TBI = traumatic brain injury, PTA = post-traumatic amnesia

Table 5. Results from the two studies addressing out-patient rehabilitation

Smith 1981	**Subjects and Group comparison**	Patients suitable for out-patient rehabilitation following discharge from hospital after acute stroke (n=133). Mean age 63 years **Intervention:** Out-patient physiotherapy and occupational therapy for 6 months at two levels of intensity: • Intensive (4 whole days per week) (n=46) or • Conventional (3 half days per week) (n=43) versus **Control:** (no routine rehabilitation, health visitor encourages home exercises as learned in hospital) (n=44)
	Primary outcomes	**Dependency for ADL:** (Northwick Park ADL score)
	Assessment points	3 and 12 months

Table 5. Results from the two studies addressing out-patient rehabilitation (*Continued*)

	Summary of Results	Significantly greater decrease in ADL scores in the intervention groups compared with control at 3 months. The difference is sustained at 1 year follow-up with a greater number of patients deteriorating in the control group (Trend towards better result from intensive rehabilitation compared with conventional regimen not tested statistically)			
	Decrease in ADL score	**Intensive rehabilitation**	**Conventional rehabilitation**	**Control**	**P value**
	Mean change 0-3 m	3.54 (n=41)	2.87 (n=40)	1.50 (n=42)	1v3: p<0.01 1/2v3: p<0.01
	Mean change 0-12m	3.50 (n=36)	2.89 (n=36)	0.60 (n=35)	1v3: p<0.05
	Authors' conclusions	Out-patient rehabilitation following stroke appears to be effective effective. Decreasing intensity of rehabilitation was associated with both an increase in the proportion of patients who deteriorated and the extent to which they deteriorated			
Werner and Kessler	**Subjects and Group comparison**	Patients discharge from in-patient rehabilitation and at least 1 year (mean 2.9 years) after stroke (n=49). Mean age 63 years **Intervention:** Out-patient Physiotherapy and Occupational therapy (2 hours, 4 times per week for 3 months) (n=33) **Control:** no specific intervention (n=16) (NB: 28% (5/33 intervention group and 9/16 controls) did not complete follow-up: 5 non-randomised controls were subsequently recruited to make control numbers up to 12)			
	Primary outcomes	**Activity:** Functional Independence Measure - Motor (FIM-MM) **Limitation of Participation:** Sickness Impact Profile (SIP) **Depression:** Beck Depression Inventory (BDI)			
	Assessment points	3 and 9 months			
	Summary of Results	Significant changes in FIM and SIP at 3 months maintained a 9 months. Trend towards improved mood did not reach significance			
	Mean change in score	**Intervention (n=28)**	**Control (n=12)**	**Difference in mean**	P value (T-tests)
	FIM-MM (0-3 mths)	6.6	1.5	5.1	0.03
	FIM-MM (3-9 mths)	0.7	-1.0	1.7	N/S

Table 5. Results from the two studies addressing out-patient rehabilitation (*Continued*)

	SIP (0-3 mths)	-5.2	2.6	7.8	0.04
	BDI (0-3 mths)	-2.6	0.2	2.8	N/S
	BDI (3-9 mths)	0.7	0.5	0.2	N/S
	Authors' conclusions	Significant gains can still be attained in the post-acute stroke survivor, despite prior in-patient rehabilitation services			

ADL = activities of daily living

Table 6. Results from the three studies addressing community team-based rehabilitation

Powell 2002	**Subjects and Group comparison**	Patients (16-65 yrs) with severe traumatic brain injury 3 mths-20 yrs previously (n=110 allocated: 94 (85%) completed follow-up) **Intervention:** Inter-disciplinary team interventions: 2 sessions per week for mean 27.3 (SD19.1) weeks in community settings (home, work or day centres) (n=48) **Control:** Written information only (n=46)		
	Primary outcomes	**Activity:** Barthel Index (BI) **Participation:** Brain Injury Community Rehabilitation Outcome (BICRO-39)		
	Assessment points	Approximately 2 years (median 23 months (IQR 18-40)		
	Summary of Results	Intervention group made significant more gains on both the BI and BICRO scales. Median changes were small reflecting the diversity of the population, but 40% of intervention group and only 20% of controls made a clinically significant improvement of 2+ points on at least one BICRO subscale		
	Change scores from baseline	**Intervention**	**Control**	**P value**
	BI: % improving Median (IQR) change	35.4% 0 (-5, 5)	19.6% 0 (-5, 4)	<0.05
	BICRO-39: % Median (IQR) change	80% 2.5 (-1.7, 6.2)	70% 0.9 (-4.1, 6.8)	<0.05
	Authors' conclusions	Multi-disciplinary community rehabilitation, even years after injury, can make clinically significant gains which outlive the active treatment period		

Table 6. Results from the three studies addressing community team-based rehabilitation (*Continued*)

Bowen 2001	**Subjects and Group comparison**	Carers of young adult (16-65 yrs) TBI survivors with hospital stay of at least 3 days (n= 96) **Intervention:** Active intervention from Head Injury Neurorehabilitation Team (HINT) • Early intervention - whilst still in hospital (n=41) • Late intervention - after discharge from hospital (n=28) **Control:** No specific intervention - existing services only (n=27) (NB: 20/96 (21%) received service other than that allocated - only 56% allocated to early intervention actually received it)			
	Primary outcomes	**Information received:** Carer perception of how well-informed they are - 7 questions **Emotional state:** Wimbledon Self-report Scale (WSS)			
	Assessment points	6 months post injury			
	Summary of Results	Analyses adjusting for potential confounding factors confirmed a clinically plausible superior outcome for both treatment groups compared to controls, but none of the results reached significance (set at p<0.01)			
	Mean change from baseline	**Early (n=41)**	**Late (n=28)**	**Control (n=27)**	**P value** (T-tests)
	% poorly informed	46-64%	46-81%	63-89%	N/S
	WSS (median (IQR)	3 (0-9)	2 (0-6)	8 (1-15)	N/S
	Authors' conclusions	Hypothesis not confirmed, but absence of effect cannot be proven on these data, which may reflect a type II error in view of mixing of groups. Longer-term follow-up data also required			
Bjorkdahl 2006	**Subjects and Group comparison**	Stroke patients (mane age 53 years)) discharged from an in-patient rehabilitation programme • **Intervention 1:** Short programme (3 weeks) of Home-based rehabilitation programme, individually tailored, focusing on activities within their natural context (n= 30) • **Control:** Similar length programme in 'ordinary' day clinic rehabilitation (n=29)			
	Primary outcomes	**Functional Assessment:** Motor and Process skills (AMPS), Secondary measures: Mobility (30 metres walking test). FIM, Instrumental activity measure **Impairment:** NIH scale.			
	Assessment points	End of intervention (3 weeks post discharge), 3 and 12 months			
	Summary of Results	Both groups improved significantly from discharge to 1 year follow-up. No significant differences between the two groups for any of the four assessments, at any time point, although there was a trend towards earlier gains in the home-rehabilitation group. Only			

Table 6. Results from the three studies addressing community team-based rehabilitation (*Continued*)

		the day clinic group changed 'significantly' on the FIM, but degree of change was small (5 FIM points over 1 year). Costs of home rehabilitation programme were less than half of the day clinic			
	Rasch transformed AMPS data (logits)	**Home (n=30)** Mean (SD)		**Day clinic (n=39)** Mean (SD)	
		Motor	Process	Motor	Process
	Discharge	1.45	1.00	1.42	1.18
	3 weeks	1.71	1.26	1.52	1.37
	3 months	2.02	1.23	1.88	1.54
	1 year	2.18	1.55	2.28	1.59
	Authors' conclusions	Both rehabilitation programmes could be recommended, but further studies are required to define patients who may benefit specifically from home rehabilitation. Costs should also be taken into consideration			

Table 7. Results from the two studies addressing in-patient rehabilitation

Semlyen 1998	**Subjects and Group comparison**	Consecutive patients in hospital with severe TBI and referred for in-patient rehabilitation within 4 weeks of injury. (Age 16-62 yrs) **Intervention:** Multi-disciplinary specialist rehabilitation service - Hunter's Moor (HM) (n=33) **Control:** 'Other rehabilitation' (OR) in local non-specialist services in district hospitals (n=18)
	Primary outcomes	**Activity and independence:** Barthel Index, FIM and Newcastle Independence Assessment form (NIAF) **Care-givers' Health:** GHQ-28
	Assessment points	1,2,3,6,12 and 24 months after injury
	Summary of Results	Only Z values (BI) and t-values (FIM and NIAF) are given. HM intervention group were significantly more disabled at outset (as indicated by the FIM up to 3 months, the BI up to 6 months and the NIAF up to 12 months). By 12 months, therefore the HM group had caught up with the OR group in level of activity The OR group made significant gains only up to 12 weeks on the NIAF and FIM Cognitive scale, but none on the FIM motor or BI (already at ceiling). By contrast the HM continued to make significant gains up to 24 months, as assessed by NIAF and BI Significant improvements in carer distress for the HM group were also sustained at 2 yrs, whereas the OR group showed evidence of deterioration between 6 and 12 months No difference in length of stay between the two groups.

Table 7. Results from the two studies addressing in-patient rehabilitation (*Continued*)

	Authors' conclusions	The results support the efficiency of specialist rehabilitation services in achieving lasting gains for patients with more severe disability over similar lengths of stay		
Ozedemir 2001	**Subjects and Group comparison**	Stroke patients referred for rehabilitation after medical stabilisation. (n=60). Mean age 59.1 (SD 5.9 **Group 1:** In-patient rehabilitation (n=30) - at least 2 hours/day of formal therapy, 5 days per week **Group 2:** Home-based rehabilitation (n=30) - team visited home for 2 hrs/ week and instructed family in home exercises - family provided therapy at least 2 hours/day, 7 days per week Mean duration of rehabilitation 64 days in both groups		
	Primary outcomes	**Impairment:** Brunnstrom score, Ashworth (spasticity) **Activity:** FIM, Mini-mental state examination (MMSE)		
	Assessment points	Before and after rehabilitation		
	Summary of Results	Significant group differences in favour of the in-patient group for change in Brunnstrom, FIM and MMSE scores, but no difference in spasticity		
	Change scores	**Group 1** Mean (SD)	**Group 2** Mean (SD)	P value (T-tests)
	Ashworth UE	0.5 (1.2)	0.2 (0.5)	N/S
	Ashworth LE	0.2 (1.2)	0.1 (0.3)	N/S
	Brunnstrom (UE)	2.0 (1.2)	0.3 (0.6)	<0.001
	Brunnstrom (LE)	2.4 (1.2)	0.8 (0.6)	<0.001
	FIM	59.6 (14.2)	12.3 (13.4)	<0.001
	MMSE	4.8 (5.0)	2.0 (2.1)	<0.001
	Authors' conclusions	Intensive in-patient rehabilitation provided significantly more favourable functional and cognitive outcomes than home based rehabilitation programme		

Table 8. Results from the four studies addressing enhanced intensity of rehabilitation

Kwakkel 1999	**Subjects and group comparison**	Stroke patients within 2 weeks of onset (n=101). All groups received 15 mins arm training plus 15 mins leg training daily, plus 1.5 hours ADL training per week In addition, for 30 mins 5 days/week, groups received: **Group 1:** Intensive arm training (n=33) **Group 2:** Intensive leg training (n=31) **Group 3 (control)** inflatable splint (n=37)			
	Primary outcomes	**ADL ability:** Barthel Index (BI) **Walking ability:** Functional ambulation categories (FAC) **Dexterity:** Action Research Arm Test (AR Arm Test)			
	Assessment points	0, 6, 12, 20, 26, 38, 52 weeks			
	Median (IQR) at 20 weeks	**Arm training**	**Leg training**	**Control**	**P value** (K-W test)
	BI:	17 (14-20)	19 (16-20)	16 (10-19)	<0.05
	FAC:	4 (3-5)	4 (3-5)	3 (1-4)	<0.05
	AR Arm Test:	9 (0-39)	2 (0-56)	0 (0-2)	<0.01
	Authors' conclusions	Greater intensity of leg training improves early functional recovery and whereas greater intensity of arm training improves only dexterity, providing further evidence that therapy primarily induces effects on the abilities at which training is specifically aimed. Functional gains were maintained up to one year			
Zhu 2001	**Subjects and group comparison**	Patients aged 12-65 with moderate to severe TBI up to 6 months post injury (n=68) **Interventions:** Multi-disciplinary rehabilitation of two intensities: • **Intensive:** 4 hrs/day, 5 days/wk (n=36) • **Conventional:** 2 hrs/day, 5 days/wk (n=32)			
	Primary outcomes	**Global outcome:** Glasgow Outcome Scale (GOS) **Activity (disability):** FIM, Neurobehavioural Cognitive Status Examination (NCSE)			
	Assessment points	0, 1, 2, 3, 4, 5, 8, 10 and 12 months			
	Summary of Results	No statistically significant difference in FIM or NSCE between the two groups. However, a significantly greater number of patients achieved maximal FIM and GOS scores within 3 months, although there was no difference at later time points and up to one year			

Table 8. Results from the four studies addressing enhanced intensity of rehabilitation (*Continued*)

	Outcome at 6 months	**Intensive (n=36)**	**Conventional (n=32)**	**P value** (Chi-squared)
	% good GOS: 3 mths 12mths	38%	14%	chi^2 3.9 df 1, p=0.044 p=0.483
	% full FIM: 3 mths 12 mths	47%	19%	chi^2 5.8, df 1, p=0.015 p=0.242
	Authors' conclusions	Early intensive rehabilitation can improve the functional outcome of patients with TBI in the early months post-injury and hence may increase the chance of their early return to work. Intensive rehabilitation in this study speeded up recovery rather than changing the final outcome		
Shiel 2001	**Subjects and group comparison**	Patients with moderate to severe TBI (age 16-70 yrs) admitted for rehabilitation (n=51) . Stratified randomised on age and GCS Intervention groups • **Enhanced intensity:** intervention by an experienced rehabilitation professional (nurse in one centre, Occupational therapist in the other) (N=24) • **Routine**: multidisciplinary rehab (n=27) NB: study conducted across two centres, which had very different structures and processes, one offering significantly more routine therapy than the other. Patients at each centre were randomised to received standard and enhanced therapy according to their practice		
	Primary outcomes	**Activity (Disability):** FIM+FAM		
	Assessment points	Admission and discharge		
	Summary of Results	Despite the procedural differences between centres there were no significant differences in FIM+FAM change scores between centres. Significant differences were observed between the intensive and routine intervention group and were greatest in the domains of self-care, continence, locomotion and psychosocial function. No significant difference in length of stay overall, but possibly skewed by very prolonged LOS for intervention group in one centre		
	Change scores during admission	**Enhanced intensity** Median (IQR)	**Routine** Median (IQR)	**P** (Mann Whitney)
	FIM+FAM Motor	74 (47-95)	21 (2-48)	<0.01

Table 8. Results from the four studies addressing enhanced intensity of rehabilitation (*Continued*)

	FIM+FAM Cognitive	40 (14-45)	12 (5-22)	<0.01
	Authors' conclusions	Increased intensity of rehabilitation is associated with enhanced function recovery		
Slade 2001	**Subjects and group comparison**	Patients with acquired brain injury (stroke, TBI or MS) aged 16-65 admitted for rehabilitation (n=131) **Interventions:** Multi-disciplinary rehabilitation of two intensities: • **Intensive:** allocated 62.5% of total therapy time available (n=75) • **Control:** allocated 37.5% of total therapy time available (n=66) NB: Although in theory the intensive group should have received 67% more therapy than the controls, in reality, they received only 30% more)		
	Primary outcomes	Length of stay (LOS) ADL ability: Modified Barthel Index		
	Assessment points	Admission and discharge		
	Summary of Results	There was no significant difference in discharge Barthel Scores (data not given), but this is expected, since patients are discharged at the point where they are sufficiently independent to manage in the community. This question is then whether more intensive therapy reaches that point earlier The mean LOS for all patients was 84.6 days. Straight forward comparison showed no significant group interaction However, a multiple regression model was applied to take account of confounders which could not be controlled for on experimental design (impairment mix, community delays, missed treatment etc) and this demonstrated a 14 day reduction for the intensive group		
	Authors' conclusions	Intensive rehabilitation has the potential to reduce length of stay, but concurrently, LOS in both groups was increased by 16 days due to external delays in discharge		

APPENDICES

Appendix 1. Search strategy

CENTRAL (*The Cochrane Library 2008, Issue 2)*
#1MeSH descriptor Craniocerebral Trauma explode all trees
#2MeSH descriptor Stroke explode all trees
#3MeSH descriptor Anoxia explode all trees
#4MeSH descriptor Hypoxia, Brain explode all trees
#5(brain or head or intracran* or cerebr* or cerebellar or brainstem or vertebrobasilar) near3 (injur* or infarc* or ischem* or ischaem* or thrombo* or apoplexy or emboli* or hemorrhag* or haemorrhage* or hematoma* or haematoma* or aneurysm* or anoxi* or hypoxi*)
#6encephaliti* or mening*
#7#1 OR #2 OR #3 OR #4 OR #5 or #6
#8MeSH descriptor Rehabilitation explode all trees
#9MeSH descriptor Rehabilitation Centers explode all trees
#10rehabilitat*
#11#8 or #9 or #10
#12MeSH descriptor Comprehensive Health Care explode all trees
#13MeSH descriptor Critical Pathways explode all trees
#14MeSH descriptor Delivery of Health Care explode all trees
#15MeSH descriptor Patient Care Team explode all trees
#16(multi-disciplinary or inter-disciplinary or integrated or multi-modal or multi-professional) near3 (therap* or restor* or care* or team*)
#17(activit* near3 daily living) or ADL or EADL
#18(self or personal or alone or own) near3 (care or manag*)
#19(self or personal or alone or own) near3 (dress* or feed* or eat* or toilet* or bath* or mobil* or driving or drive or (public next transport*))
#20(daily or domestic or house or home) near3 (activit* or task* or skill* or chore*)
#21social near3 (activit* or function* or support* or skill* or adjust* or behavior or behaviour or facilitat*)
#22community near5 (re-integrat* or rehabilit*)
#23#12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22
#24#7 and #11 and #23

MEDLINE (Ovid SP): 1950 to April (week 2) 2008
1. exp Craniocerebral Trauma/
2. exp Stroke/
3. exp Anoxia/
4. exp Hypoxia, Brain/
5. ((brain or head or intracran* or cerebr* or cerebellar or brainstem or vertebrobasilar) adj3 (injur* or infarc* or isch?em* or thrombo* or apoplexy or emboli* or h?emorrhag* or h?ematoma* or aneurysm* or anoxi* or hypoxi*)).ab,ti.
6. (encephaliti* or mening*).ab,ti.
7. 1 or 2 or 3 or 4 or 5 or 6
8. rehabilitation.fs.
9. exp Rehabilitation/
10. exp Rehabilitation Centers/
11. "rehabilitat*".ab,ti.
12. 8 or 9 or 10 or 11
13. 7 and 12
14. exp Comprehensive Health Care/
15. exp Critical Pathways/
16. exp "Delivery of Health Care"/
17. exp Patient Care Team/

18. ((multi?disciplinary or inter?disciplinary or integrated or multi?modal or multi?professional) adj3 (therap* or restor* or care* or team*)).ab,ti.
19. ((activit* adj3 daily living) or ADL or EADL).ab,ti.
20. ((self or personal or alone or own) adj3 (care or manag*)).ab,ti.
21. ((self or personal or alone or own) adj3 (dress* or feed* or eat* or toilet* or bath* or mobil* or driving or drive or (public adj1 transport*))).ab,ti.
22. ((daily or domestic or house or home) adj3 (activit* or task* or skill* or chore*)).ab,ti.
23. (social adj3 (activit* or function* or support* or skill* or adjust* or behavio?r or facilitat*)).ab,ti.
24. (community adj5 (re?integrat* or rehabilit*)).ab,ti.
25. or/14-24
26. 13 and 25
27. clinical trial.pt.
28. randomized.ti,ab.
29. randomised.ti,ab.
30. placebo.ti,ab.
31. drug therapy.fs.
32. randomly.ti,ab.
33. trial.ti,ab.
34. groups.ti,ab.
35. exp animals/
36. exp humans/
37. 35 not (35 and 36)
38. or/27-34
39. 38 not 37
40. 26 and 39
41. (2004* or 2005* or 2006* or 2007* or 2008*).ed.
42. 40 and 41

EMBASE (Ovid SP): 1980 to (week 15) April 2008
1. exp Head Injury/
2. exp CEREBROVASCULAR ACCIDENT/
3. exp ANOXIA/
4. exp STROKE/
5. ((brain or head or intracran* or cerebr* or cerebellar or brainstem or vertebrobasilar) adj3 (injur* or infarc* or isch?em* or thrombo* or apoplexy or emboli* or h?emorrhag* or h?ematoma* or aneurysm* or anoxi* or hypoxi*)).ab,ti.
6. (encephaliti* or mening*).ab,ti.
7. or/1-6
8. exp Rehabilitation/
9. "Rehabilitation and Physical Medicine".ec.
10. exp Rehabilitation Care/
11. exp REHABILITATION CENTER/
12. rehabilitat*.ab,ti.
13. rh.fs.
14. or/8-13
15. 7 and 14
16. exp Clinical Pathway/
17. exp Treatment Planning/
18. exp Health Care Delivery/
19. exp Daily Life Activity/
20. ((multi?disciplinary or inter?disciplinary or integrated or multi?modal or multi?professional) adj3 (therap* or restor* or care* or team*)).ab,ti.
21. ((activit* adj3 daily living) or ADL or EADL).ab,ti.
22. ((self or personal or alone or own) adj3 (care or manag*)).ab,ti.

23. ((self or personal or alone or own) adj3 (dress* or feed* or eat* or toilet* or bath* or mobil* or driving or drive or (public adj1 transport*))).ab,ti.
24. ((daily or domestic or house or home) adj3 (activit* or task* or skill* or chore*)).ab,ti.
25. (social adj3 (activit* or function* or support* or skill* or adjust* or behavio?r or facilitat*)).ab,ti.
26. (community adj5 (re?integrat* or rehabilit*)).ab,ti.?
27. or/16-26
28. 15 and 27
29. exp animal model/
30. Animal Experiment/
31. exp ANIMAL/
32. exp Experimental Animal/
33. 29 or 30 or 31 or 32
34. Human/
35. 33 not 34
36. (randomised or randomized or randomly or random order or random sequence or random allocation or randomly allocated or at random or controlled clinical trial$).tw,hw.
37. exp clinical trial/
38. 36 or 37
39. 38 not 35
40. 28 and 39
41. (2004* or 2005* or 2006* or 2007* or 2008*).em.
42. 40 and 41

ISI Web of Science: Science Citation Index Expanded (SCI-EXPANDED) (1970 to April 2008)
ISI Web of Science: Conference Proceedings Citation Index-Science (CPCI-S) (1990 to April 2008)
Topic=((brain or head or intracran* or cerebr* or cerebellar or brainstem or vertebrobasilar) and (injur* or infarc* or ischem* or ischaem* or thrombo* or apoplexy or emboli* or hemorrhag* or haemorrhage* or hematoma* or haematoma* or aneurysm* or anoxi* or hypoxi*)) AND Topic=(rehabilitat*) AND Topic=((multi-disciplinary or inter-disciplinary or integrated or multi-modal or multi-professional) and (therap* or restor* or care* or team*))

WHAT'S NEW

Last assessed as up-to-date: 22 April 2008.

Date	Event	Description
23 November 2010	Amended	The tables have been reformatted. The content of the manuscript is unchanged

HISTORY

Protocol first published: Issue 2, 2003

Review first published: Issue 3, 2005

Date	Event	Description
23 March 2009	New search has been performed	Two new trials are included in this update. The results and conclusions of the review have been amended accordingly
11 July 2008	Amended	Converted to new review format.

CONTRIBUTIONS OF AUTHORS

LTS: planned the review protocol and methodology, with input from DTW and PD. She also co-ordinated the search with support from the Cochrane Injuries group, and led the selection and evaluation of the trials.

AN, IS and LTS: independently handscreened the article abstracts and agreed the shortlist of trials for inclusion. Where opinion differed, DTW arbitrated.

AN, IS, LTS and DTW: performed independent quality assessments and then agreed the final quality scores for articles included in the analysis.

LTS: played the role of lead author but all the authors contributed to the final write up and discussion.

DECLARATIONS OF INTEREST

All authors are clinicians, engaged in the field of brain injury rehabilitation, who naturally wish to provide an effective and efficient service for their patients. None have any personal or financial interests in the findings of this review.

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Internal sources

- King's College London, UK.

External sources

- Luff Foundation, UK.
- Department of Health Research and Development Programme, UK.

INDEX TERMS

Medical Subject Headings (MeSH)

Age Factors; Brain Injuries [*rehabilitation]; Cognitive Therapy; Counseling; Intensive Care [*methods; standards]; Randomized Controlled Trials as Topic; Rehabilitation, Vocational

MeSH check words

Adolescent; Adult; Aged; Humans; Middle Aged