Physiotherapy after traumatic brain injury: A systematic review of the literature

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Abstract
Primary objectives: At present there are no standardized recommendations concerning physiotherapy of individuals with traumatic brain injury (TBI) resulting in a high variability of methods and intensity. The aim of this literature review is to develop recommendations concerning physiotherapy in the post-acute phase after TBI on the basis of scientific evidence.
Results: Fourteen studies met the inclusion criteria and were grouped into sub-groups: sensory stimulation, therapy intensity, casting/splinting, exercise or aerobic training and functional skill training. While for sensory stimulation evidence could not be proven, a strong evidence exists that more intensive rehabilitation programmes lead to earlier functional abilities. The recommendation due to casting for the improvement of passive range of motion is a grade B, while only a C recommendation is appropriate concerning tonus reduction. Strong evidence exists that intensive task-orientated rehabilitation programmes lead to earlier and better functional abilities.
Conclusion: Although some recommendations for the effectiveness of physical therapy interventions could be expressed, there are many questions concerning the treatment of humans with TBI which have not been investigated so far. Especially on the level of activity and participation only a few studies exist.

Keywords: Traumatic brain injury, physiotherapy, systematic review

Introduction
Physiotherapeutic methods used in the rehabilitation of persons who have suffered traumatic brain injury (TBI) differ greatly and depend upon the specific therapeutic concepts endorsed by the individual physiotherapist and/or the particular institution. It is unfortunate that the process of clinical reasoning is only very slowly finding acceptance with therapists involved in neurological treatment and is accompanied by a tendency to adhere to the expert opinions found in various existing concepts with questionable theoretical basis. As a consequence of this there is great variability in the nature and intensity of treatment methods.

This investigation aimed to identify evidence-based physiotherapeutic treatments for the rehabilitation of persons who have suffered TBI and refers to the scientific literature published on this subject. In contrast to stroke research, relatively few research studies have been published in the area of TBI. One possible reason for this might be the heterogeneity of the symptoms, which would also explain the paucity of high quality randomized controlled studies.

The possible benefits of the present investigation are defined as follows:
- A source to help medical specialists keep up to date with evidence-based knowledge;
- A manual for new colleagues involved in physiotherapy;
- An effort to improve treatment results/patient outcomes and to prevent complications;
Optimization of the rehabilitation process in terms of efficiency, cost and resources; and Identification of future research areas.

The literature search is concerned with persons with TBI in the post-acute phase, i.e. initial inpatient rehabilitation, whereby the following criteria must be met:

- Diagnostics and intensive care have been concluded;
- Vital parameters are stable;
- Intracranial pressure is stable or can be controlled by conservative methods; and
- Primary neurosurgical care has been concluded.

This investigation did not address issues relating to mild TBI.

Methods

A systematic literature search of the following databases was conducted in the period from January 2006 to May 2007: Cochrane, PubMed, CINAHL, PEDro and OT-Seeker. As well as literature searches of the databases, one also referred to the specialist literature in the professional journals and books on this subject. In addition, the reference lists of the pertinent literature were browsed in order to identify additional publications.

Key words

The searches commenced with the search term 'traumatic brain injury'. Since very few results were obtained with this search strategy, the umbrella term or mesh term 'brain injury' was entered. Due to the clarity of the Cochrane, PEDro and OT-Seeker databases, the search was not narrowed by adding more search terms. The searches in PubMed and in the Cinahl database were conducted as follows: 'brain injury' AND 'physical therapy' OR 'physiotherapy'.

Many of the studies found are contained in several databases, whereby there was a great deal of overlap for PEDro and OT-Seeker, in particular, with the result that only six new studies were found in OT-Seeker.

The abstracts of the identified studies were then scrutinized on the basis of specific inclusion and exclusion criteria.

Inclusion and exclusion criteria

The inclusion criteria were defined as follows:

- investigates the efficacy of a physiotherapeutic method,
- makes statements about treatment intensity,
- post-acute, inpatient rehabilitation, and
- meta analysis, review, practical guidelines, randomized controlled study or controlled study.

Exclusion criteria:

- Chronic phase;
- Outpatient setting;
- Intensive care ward;
- Children and adolescents under 12 years; and
- Case reports, expert opinions.

Rating scales for validation of the methodological quality of studies

Here reliance was placed on existing, well proven instruments. The PEDro Scale as developed by Verhagen [1] at the Institute of Epidemiology, University of Maastricht, was applied to rate RCTs. The scale consists of 11 criteria, whereby criteria 2–11 are assessed. Criterion 1 rates external validity and criteria 2–9 rate internal validity. Application of statistical methods is rated by criteria 10 and 11. The criteria should be clearly rated as 'yes' or 'no' so that a maximum of 10 points can be achieved.

Studies that achieve a score of 9–10 points set a gold standard that is almost never achieved in the practical realization of therapeutic intervention. A score of 8/10 or 7/10 points corresponds to a methodologically well designed study. Scores of 6/10 and 5/10 correspond to moderate quality. A score of 4/10 is rated as acceptable in this review study. Studies with a score less than 4/10 were excluded.

For the evaluation of review articles, six questions were adopted from the Centre for Reviews and Dissemination of the University of York, UK, page 6, Box 0.3 [2]. The more questions that can be answered and that are manageable, the higher the quality rating for the review. The inclusion criterion for the present study was that at least four of the six questions were answered and that manageability was given.

Level of evidence and grades of recommendation

An additional tool to facilitate adequate assessment of study outcomes is the classification of evidence. The SIGN scale was implemented due to its simplicity and the clarity of its divisions [3]. After classification of the level of evidence of each study, the grades of recommendation were derived by application of the SIGN scale (see Table I). This is presented in table form with sub-divisions from A to D and their precise definitions (see Table II).
Results

Fourteen studies that fulfilled the inclusion criteria and the defined methodological quality criteria were identified. These were two systematic reviews by the Cochrane Collaboration, two further systematic reviews, eight randomized controlled studies and two controlled studies (see Table III).

Of the 14 studies only four exclusively included persons with TBI, that is to say that the remaining studies also included persons with an acquired brain injury of other aetiology.

In order to arrive at a recommendation of the efficacy of specific physiotherapeutic methods, it is essential that the studies be divided into sub-groups according to subject area. The following sub-groups were defined:

- Sensory stimulation;
- Treatment intensity;
- Serial casting, splinting;
- Fitness or aerobic training; and
- Functional training:
  - Sit-to-stand training,
  - Gait training, and
  - Arm ability training.

Sensory stimulation

A particular difficulty with the comparability of studies on this subject is the inconsistent use and definition of the terms coma, vegetative state and ‘minimally conscious state’, which leads to great variability between the studies in the assessment of alertness after coma.

Two studies, namely, a systematic review by the Cochrane Collaboration (Lombardi evidence level 1++) [4] and a systematic review rated as evidence level 2++, were identified that addressed the subject within a sub-group [5].

Conclusion. Both studies emphasize that insufficient information has been recorded in the course of the existing studies to permit an evaluation of the efficacy of sensory stimulation programmes. The grade of recommendation corresponds to an A rating without verifiable evidence of the efficacy of sensory stimulation programmes.

Treatment intensity

A total of five studies on this subject were included, namely a systematic review by the Cochrane Collaboration (Turner-Stokes level of evidence 1++) [6], two simple blinded RCTs (Zhu level of evidence 1++ and Slade level of evidence 1-) [7, 8], one non-blinded RCT (Shiel level of evidence 1+) [9] and one systematic review (Watson level of evidence 2++) [5]. Two of the three RCTs had already been integrated into the systematic overviews of Turner-Stokes and Watson.

Table I. Level of evidence.

<table>
<thead>
<tr>
<th>Level of evidence</th>
<th>Description</th>
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<tbody>
<tr>
<td>1++</td>
<td>High quality meta analysis, systematic review of RCTs or RCTs with a very low risk bias for systematic errors.</td>
</tr>
<tr>
<td>1+</td>
<td>Well conducted meta analysis, systematic review of RCTs or RCTs with a very low risk bias for systematic errors.</td>
</tr>
<tr>
<td>1−</td>
<td>Meta analysis, systematic review of RCTs or RCTs with a high risk bias for systematic errors.</td>
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<tr>
<td>2++</td>
<td>High quality systematic reviews of case-control or cohort studies. High quality systematic reviews of case-control or cohort studies with a low risk of systematic errors, e.g. confounding with a high probability that the relationship is causal.</td>
</tr>
<tr>
<td>2+</td>
<td>Well conducted case control or cohort studies with a low risk of systematic errors, e.g. confounding with a high probability that the relationship is causal.</td>
</tr>
<tr>
<td>2−</td>
<td>Case control or cohort studies with a high risk of systematic errors, e.g. confounding with a high probability that the relationship is causal.</td>
</tr>
<tr>
<td>3</td>
<td>Non-analytical studies, e.g. case report, case series.</td>
</tr>
<tr>
<td>4</td>
<td>Expert opinions.</td>
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</tbody>
</table>

Table II. Grade of recommendation.

<table>
<thead>
<tr>
<th>Grade of recommendation</th>
<th>Description</th>
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<tbody>
<tr>
<td>A</td>
<td>At least one meta analysis, systematic review, or RCT rated as 1++ and directly applicable to the target population and yielding overall consistency of results.</td>
</tr>
<tr>
<td>B</td>
<td>A body of evidence including studies rated as 2++ and directly applicable to the target population and yielding overall consistency of results; or extrapolated evidence from studies rated as 1++ or 1+.</td>
</tr>
<tr>
<td>C</td>
<td>A body of evidence including studies rated as 2+ and directly applicable to the target population and yielding overall consistency of results; or extrapolated evidence from studies rated as 2++.</td>
</tr>
<tr>
<td>D</td>
<td>Evidence level 3 or 4; or extrapolated evidence from studies rated as 2+.</td>
</tr>
</tbody>
</table>
Table III. Studies involved.

<table>
<thead>
<tr>
<th>Study</th>
<th>Therapy/intervention</th>
<th>Patients or studies</th>
<th>Design</th>
<th>E</th>
<th>TBI</th>
<th>Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sensory stimulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[5]</td>
<td>Sensory stimulation</td>
<td>Not identifiable</td>
<td>SR</td>
<td>2++</td>
<td></td>
<td>Recommendation grade A: no verifiable evidence of the efficacy of sensory stimulations programmes</td>
</tr>
<tr>
<td>[4]</td>
<td>Sensory stimulation programme vs. standard rehabilitation</td>
<td>n = 68, 3 studies</td>
<td>SR</td>
<td>1++</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Treatment intensity</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>[6]</td>
<td>Multidisciplinary rehabilitation vs. routine programmes, Comparison of different treatment settings and intensities</td>
<td>n = 2564, 14 studies</td>
<td>SR</td>
<td>1++</td>
<td></td>
<td>Recommendation grade A: more intensive rehabilitation programmes lead to early functional skills</td>
</tr>
<tr>
<td>[8]</td>
<td>Comparison of conventional rehabilitation vs. intensified treatment (additional 1 hour PT/ET per day)</td>
<td>n = 36</td>
<td>RCT</td>
<td>1++</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[7]</td>
<td>Comparison experimental group: on average 67% more therapy than the control group</td>
<td>n = 141</td>
<td>RCT</td>
<td>1−</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[9]</td>
<td>Standard therapy vs. additional therapy as requested by the rehab team</td>
<td>n = 51</td>
<td>RCT</td>
<td>1+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[5]</td>
<td>Treatment intensity</td>
<td>Not identifiable</td>
<td>SR</td>
<td>2++</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Orthosis, cast treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>[5]</td>
<td>Orthosis, cast treatment</td>
<td>Not identifiable</td>
<td>SR</td>
<td>2++</td>
<td></td>
<td>Recommendation grade B: Improvement in PROM after serial casts or orthosis, Recommendation grade C: Reduced spasticity after serial casts or orthosis</td>
</tr>
<tr>
<td>[10]</td>
<td>Cast treatment of ankle, elbow and knee joints, combined in 4 studies with stretching or conventional physiotherapy</td>
<td>13 studies</td>
<td>SR</td>
<td>2++</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1 week cast treatment with stretching vs. 1 week without cast treatment and without stretching

| [12] | 1 week cast treatment with stretching vs. 1 week without cast treatment and without stretching | $n = 9$ | CT | 1-- | TBI |

1st group: standard PT, 2nd group: cast treatment with injection of salt solution, 3rd group: cast treatment combined with botulinum toxin

| [13] | 1st group: standard PT, 2nd group: cast treatment with injection of salt solution, 3rd group: cast treatment combined with botulinum toxin | $n = 35$ | RCT | 1-- | 

Routine therapy: 5×/week. 30 min individual motor training programme for the upper extremities, 2×30 min stretching of the upper extremities 5×/week for 5 weeks; Intensive group: additional hand splint worn for 12 hours a day for 4 weeks

| [11] | Routine therapy: 5×/week. 30 min individual motor training programme for the upper extremities, 2×30 min stretching of the upper extremities 5×/week for 5 weeks; Intensive group: additional hand splint worn for 12 hours a day for 4 weeks | $n = 28$ | RCT | 1++ | 

Strength training

| [5] | Strength and fitness training | SR | 2++ | 

Recommendation grade A: no verifiable clinical improvement after night splints in functional position

Intensive group: 3×30 min/week. Individual strength training on the ergometer bicycle for 12 weeks; Control group: individual relaxation: breathing exercises, progressive relaxation, autogenous training, visualization

| [15] | Intensive group: 3×30 min/week. Individual strength training on the ergometer bicycle for 12 weeks; Control group: individual relaxation: breathing exercises, progressive relaxation, autogenous training, visualization | $n = 38$ | RCT | 1+ | 

Recommendation grade A: Improvement in cardiovascular fitness after strength training

Functional training

| [16] | Intensive group: For 4 weeks intensive sit-stand and step-up training 5 days a week; Control group: no additional training | $n = 24$ | RCT | 1+ | TBI |

Recommendation grade A: for the efficacy of intensive task-oriented training programmes

Intensive group: Gait training with partial weight bearing 2×/week for 8 weeks; Control group: standard PT, whereby treatment time was identical for both groups

| [17] | Intensive group: Gait training with partial weight bearing 2×/week for 8 weeks; Control group: standard PT, whereby treatment time was identical for both groups | $n = 38$ | RCT | 1+ | TBI |

Recommendation grade A: Gait training with partial weight bearing is not superior to physiotherapeutic gait training

| [18] | 3 groups: (1) no AAT (functional arm training), (2) AAT, (3) AAT+ knowledge of results | $n = 60$ | RCT | 1+ | 

Recommendation grade A: proof of efficacy for AAT

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**Physiotherapy after TBI: A systematic review of the literature**
Conclusion. The levels of evidence for the identified studies are very high. The results of these studies are uniform so that an A recommendation grade is appropriate with regard to the statement that more intensive rehabilitation programmes lead to improved functional skills. There is also a large body of evidence to show that persons with moderate-to-severe brain injury benefit from formal interventions. Finally, there is limited evidence to show that specialist settings lead to additional improvements in function.

A ceiling effect was not observed as a result of more intensive therapy in any of the studies. Cost-benefit analysis is not available for any of these programmes. Two studies report a reduction in inpatient stay. However, there is only moderate evidence for this effect since length of stay is often dependent on external factors such as the follow-on solution.

Serial casting, splinting (botulinum toxin)

Five studies were found that met the inclusion criteria. These included two systematic reviews both rated as evidence level 2++ (Watson, Mortenson) [5,10] and three randomized controlled studies (Moseley evidence level 1-, Verplancke evidence level 1-, Lannin evidence level 1++) [11–13].

Since four studies addressed the subject of serial casting, these studies are summarized in the conclusion. Splinting will be discussed separately.

Conclusion. Only a recommendation grade B for serial casting to improve passive range of motion (PROM) can be awarded because of the lack of high quality studies, whereas a C recommendation is appropriate with regard to reduced muscle tone.

Overnight splinting in a functional position does not produce clinical improvements in adults with an acquired brain injury, recommendation grade A. A more recent study by Harvey et al. [14] supports the recommendation that overnight splinting does not lead to a reduction in contractures.

Fitness or aerobic training

In addition to the sub-group fitness or aerobic/fitness/aerobic training in the systematic review by Watson (evidence level 2++), a randomized controlled study by Batemann et al. [15] was also taken into account (evidence level:1+). The study by Batemann et al. is, however, already included in the review.

Conclusion. Both studies confirm an improvement in cardiovascular fitness after fitness or aerobic training. Recommendation grade A. No evidence was found for transfer of the improved cardiovascular parameters to the activity/participation level.

Functional training

A total of three RCTs that referred to functional training were found. Since the validity of the Watson study on this subject is very low, that study was not taken into account. Two of the three studies (Canning evidence level 1+, Wilson evidence level 1+) [16,17] exclusively included persons who had suffered TBI, whereas the study by Platz et al. [18] also included persons with acquired brain injuries of various aetiologies (evidence level 1+).

Sit-to-stand training conclusion. The improvements in the experimental group are statistically significant in terms of number of repetitions in 3 minutes (62%), although the control group also achieved improvements. From this it was deduced that intensive, task-oriented, repetitive training can be recommended as an important part of rehabilitation—recommendation grade A.

Gait training conclusion. This study concludes that gait training with partial body-weight support for persons with TBI is not superior to conventional physiotherapeutic gait training. Recommendation grade: A.

Arm ability training conclusion. The conclusion is that arm ability training for persons who have suffered stroke or TBI can improve function relevant to activities of daily living. The efficacy of arm ability training was proven in this study—recommendation grade A—but its superiority in comparison to other concepts was not.

Discussion

Investigation of the scientific literature revealed a few subject areas within which recommendations for physiotherapeutic and/or treatment intensity are made and which can be confirmed on the basis of the currently available literature. Although the re-learning of functional skills after brain injury is essentially one of the main tasks of physiotherapy, only three studies addressing the subject of ‘functional training’ were found. These are all recent studies so that there is hope that research will focus more on activity and participation levels in future rather than on body function and structure.

Furthermore, the ERABI working group (evidence-based review of moderate-to-severe acquired brain injury) set itself the objective of identifying those areas of rehabilitation for which there is currently no proof of efficacy and, therefore, require research [19]. By November 2007 the working group had drawn up a very comprehensive
literature overview of evidence-based rehabilitative methods for persons with acquired brain injury (revised three times), whereby the results of that literature overview correspond largely with the results of this study.

Fourteen studies were included in this investigation. The specific recommendations are summarized according to sub-groups: sensory stimulation, treatment intensity, serial casting or splinting, fitness or aerobic training and functional training.

**Sensory stimulation**

Sensory stimulation programmes exist for comatous patients or patients in a ‘vegetative state’ and gained in popularity, particularly during the 1980s. The aim of this method is faster and better recovery from the coma, that is, to ‘wake up’ sooner. Sensory stimulation programmes differ from standard therapy in terms of deliberate stimulation of various perception modalities, on the one hand, and structured, time-consuming stimulation, on the other, whereby no evidence for these methods has been found.

The same applies to experience gained in routine clinical care. One can attend to patients in coma or in a minimally conscious state therapeutically and control secondary problems as far as possible, but one has no influence over the ‘speed of the waking process’. Specifically, this may mean that the time to conduct high intensity therapy needs to be questioned very critically.

**Treatment intensity**

In contrast, patients who are already at a high level of alertness benefit significantly from intensive treatment programmes.

Although there is a large body of evidence for the efficacy of more intensive treatment programmes, the studies, with the exception of the study by Zhu et al. [8], must be criticized for a lack of transparency with regard to precise data on the increase in treatment intensity and the nature of the treatment, which makes the implementation of the study conclusions in routine practice difficult.

It is important that the availability of strong evidence is to be viewed with caution since it is essentially based on three studies. Of these three studies only Zhu et al. [8] exclusively recruited persons with TBI. In this prospective randomized controlled study, conventional rehabilitation consisting of 1 hour of physiotherapy and 1 hour of ergotherapy in the morning was compared with an intensive programme that took twice the time. The Glasgow Outcome Scale (GOS) and the Functional Independence Measure (FIM) were employed as outcome parameters. The outcomes from the GOS show superiority of the intensive group over the conventional group. In particular, comparison of the groups at the 2- and 3-month follow-up assessments were significant, whereas the differences after a full 6 months had decreased and there was an approximation of the two groups. If further consideration is given to the basic differences between the rehabilitation of persons with stroke and those with TBI, then heterogeneity and spontaneous remission are important factors.

**Serial casting and splinting (botulinum toxin)**

In this investigation, the recommendation grade derived from the studies of serial casting for the improvement of passive range of motion is B, whereas a C recommendation can be given for reduction of spasticity.

It is unfortunate that the Verplancke et al. [13] and Moseley [12] studies did not conduct follow-up. In clinical routine it is repeatedly observed that some patients cannot retain the results despite continuous splinting.

The reasons given by the various authors for contractures are worthy of comment. Whereas Moseley [12] finds that mechanical factors are responsible for changes in the soft tissues that are, in turn, associated with shortening of muscles and tendons, sarcomere loss and an increase of connective tissue in the muscles and muscle fibres, other authors support the hypothesis that hyperactivity of the stretch reflexes is an important contributing factor that leads to morphological changes in the soft tissue.

In all the studies, the primary reason for serial casting was loss of passive range of motion. None of the studies differentiated further as to which structures were primarily responsible for the loss.

Experience in clinical practice shows that by far not all patients are suited to treatment with serial casting. Regrettably, there are no reliable assessment tools currently available to facilitate the decision-making process.

The Verplancke et al. [13] study demonstrates this indirectly. In their group 2 ‘serial casting and injection of salt solution’, four of 12 patients continued to deteriorate and had to be given additional injections of botulinum toxin.

Overnight splints in functional position applied to adults with acquired brain injury do not lead to clinical improvement, for example, improvement in the range of passive motion. This statement corresponds very closely with clinical experience. In addition, patients often perceived splints as very upsetting. Furthermore, a critical view must be taken as to whether or not splinting actually encourages non-use of the affected arm.
Fitness or aerobic training

An improvement in cardiovascular fitness due to aerobic training is confirmed with a recommendation grade A. In addition, improvements in the patient’s general state of health and a reduction in depression are also recorded. However, no evidence was found for transfer of the improvements to the functional level.

In the course of rehabilitation it often becomes apparent that fitness or aerobic training is being neglected, especially for patients with FIM values for locomotion of between 4–6, whereby Lerner-Frankiel [20] has defined outdoor walking ability as the ability to walk for a distance of at least 300 m and to achieve a speed of 80 m min⁻¹ for 13–27 m.

Functional training

In the area of functional training, proof of efficacy was obtained for sit-to-stand transfer and arm ability training, although the experimental group was compared with a control group that had not received any training so that conceptional superiority could not be proven.

With regard to arm rehabilitation it is surprising that none of the studies fulfilled the inclusion criteria with regard to ‘constrained induced movement therapy (CIMT)’. The main reason for this was that the studies in this area included primarily patients in the chronic phase. On the other hand, this is in keeping with clinical experience. It frequently occurs that patients either do not yet fulfil the inclusion criteria to participate in a CIMT programme or there is a lack of compliance on the part of the patient to participate in such a programme. However, once a patient has been home and experienced his or her limitations in daily living, willingness to participate in an intensive programme such as the CIMT programme often increases.

In contrast to studies from stroke research, no proof of superiority was obtained for treadmill training with partial body weight support for persons with TBI. These results are supported by the study by Brown et al. [21].

Gait training with partial body weight support for persons with TBI is not superior in comparison to conventional task-oriented physiotherapeutic gait training, recommendation grade A.

When training walking ability under everyday conditions, it is important to practice walking on different surfaces, uneven ground, up and down slopes and over obstacles. It is also important to practice walking with selective head control but without loss of postural stability, walking under different lighting conditions and walking in crowds. The treadmill is not ideally suited to training these aspects of walking but it is superior to conventional gait training in terms of endurance and fitness or aerobic fitness.

Overall, it is important to analyse the immediate primary concerns of the patient through the process of clinical reasoning and to select and modify treatment methods appropriately.

Limitations of the study

The available literature dictated the inclusion of studies concerning persons with acquired brain injuries of other aetiologies as well, since very few studies had recruited persons with TBI exclusively. Every effort was made to define clearly whether a mixed collective of persons with brain injuries or exclusively TBIs had been recruited and to take this into account in the analysis.

Furthermore, it is important to scrutinize the key words carefully. ‘Brain injury’ was deliberately not modified for searches in the PEDro, OT-Seeker and Cochrane databases in order to locate as many studies as possible and to avoid selection bias from the outset. Due to the sheer size of the database the search term ‘brain injury’ did have to be supplemented by AND ‘physical therapy’ OR ‘physiotherapy’ in the PubMed and Cinahl databases. Here, umbrella terms or so-called mesh terms were deliberately chosen.

SIGN validation, a well established instrument, was applied to classify the studies according to evidence level. This instrument was used consistently but led to the conflicting situation that some systematic overviews that had included poor quality studies in their investigation and included them in their analysis had to be given a lower rating than randomized controlled studies of rather moderate design (e.g. Mortenson and Eng [10], systematic review, evidence level 2++ vs. Verplancke et al. [13], randomized controlled study PEDro 4/10, evidence level 1—).

Conclusions

Current research in the area of TBI only permits a very few statements to be made on the subject of physiotherapeutic recommendations. There are a few randomized controlled studies that deliver proof of efficacy for specific methods but, in most cases, they do not prove superiority in comparison with other methods so that further research is imperative.

It is however also desirable that the currently available evidence should be more fully integrated into clinical reasoning and should lead to differentiated decision-making on the application of therapeutic procedures in routine clinical practice,
while also taking into account individual expertise and the preferences of the patient.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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