Cognitive Rehabilitation for Traumatic Brain Injury in Adults

Tec

Assessment
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Executive Summary

Background
Traumatic brain injury can cause cognitive difficulties. Cognitive rehabilitation comprises a variety of intervention strategies or techniques that attempt to help patients reduce, manage, or cope with cognitive deficits caused by brain injury.

Objective
To determine whether there is adequate evidence to demonstrate that cognitive rehabilitation results in improved health outcomes. For the purposes of this Assessment, cognitive test performance is not considered a health outcome. Results of instruments assessing daily functioning or quality of life are considered health outcomes.

Search Strategy
Randomized, controlled trials of cognitive rehabilitation for traumatic brain injury cited in recent systematic review articles were obtained. MEDLINE® was searched (via PubMed) through January 2008 for randomized, controlled trials of cognitive rehabilitation. Rehabilitation programs characterized as “multidisciplinary” or “coordinated” were not considered cognitive rehabilitation unless the paper specifically stated that the program incorporated cognitive rehabilitation components or theory.

Selection Criteria
For the main evidence review, randomized, controlled trials of cognitive rehabilitation were selected. A recent nonrandomized study of a comprehensive holistic program of cognitive rehabilitation was also included.

Main Results
Two studies of comprehensive holistic cognitive rehabilitation were reviewed. The one randomized study found no differences in the outcomes of return to work, fitness for military duty, quality of life, and measures of cognitive and psychiatric function at 1 year. Rates of returning to work were greater than 90% for both the intervention and control groups, raising the question whether the subjects included in the study were not severely injured enough to be able to demonstrate an effect of rehabilitation. The other study of comprehensive rehabilitation was nonrandomized. The intervention group showed greater improvements in functioning as assessed by a questionnaire that evaluated community integration, home integration, and productivity assessed upon completion of the intervention. However, there were many differences in baseline characteristics between intervention and control groups, particularly regarding the time since injury. Patients were not followed beyond completion of the intervention program.

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Eleven randomized, controlled trials of cognitive rehabilitation for specific cognitive defects showed inconsistent support for cognitive rehabilitation. Out of the 11 studies, 8 reported on health outcomes. Three of the studies showed statistically significant differences between intervention groups and control groups on one outcome. However, 2 of the studies were extremely small. The findings were not consistent across other outcomes measured in the studies, and in one study, significant findings after the intervention were no longer present at 6 months of follow-up.

All 11 studies also reported outcomes of various cognitive tests. We did not consider these to be valid outcomes for the purposes of assessing health benefit. Evaluation of these cognitive test outcomes is plagued by numerous methodologic problems, such as small sample size, lack of long-term follow-up, minimal interventions, and multiple outcomes. Seven of the studies reported at least one outcome showing that cognitive rehabilitation was associated with better performance on a specific cognitive test. Of these positive studies, 2 of them had no follow-up beyond the time of treatment, and 2 had sample sizes smaller than 20. In only one study was there consistency across several cognitive test scores showing better performance with cognitive rehabilitation.

Authors' Comments and Conclusions

The randomized trial literature of cognitive rehabilitation does not show strong evidence for efficacy in the treatment of traumatic brain injury. Many of the clinical trials of specific cognitive rehabilitation interventions evaluated cognitive tests rather than health outcomes. Demonstration of the effectiveness of cognitive rehabilitation, either as an integrated holistic program, or as a separable component that treats a specific cognitive defect, requires prospective randomized designs that employ validated measures of health outcomes.

Based on the available evidence, the Blue Cross and Blue Shield Association Medical Advisory Panel made the following judgments about whether cognitive rehabilitation for traumatic brain injury in adults meets the Blue Cross and Blue Shield Association Technology Evaluation Center (TEC) criteria.

1. **The technology must have final approval from the appropriate government regulatory bodies.**

Cognitive rehabilitation is a procedure and, therefore, is not subject to U.S. Food and Drug Administration (FDA) regulation.

2. **The scientific evidence must permit conclusions concerning the effect of the technology on health outcomes.**

The number of clinical trials is relatively small. Many of the studies suffer from small sample sizes, insufficient follow-up, and lack of assessment of health outcomes. Only the nonrandomized study shows benefits of cognitive rehabilitation in terms of health outcomes. Unknown biases in the selection of subjects for inclusion in the cognitive rehabilitation program may have confounded the results of the study.

3. **The technology must improve the net health outcome; and**
4. **The technology must be as beneficial as any established alternatives.**

Most of the randomized studies do not show an improvement in health outcomes after a program of cognitive rehabilitation. The one nonrandomized study showing improvement in health outcomes had differences in types of patients enrolled in the two groups, and no long-term follow-up beyond the end of the cognitive rehabilitation program.

5. The improvement must be attainable outside the investigational settings.

Whether cognitive rehabilitation improves health outcomes in adults with traumatic brain injury has not been demonstrated in the investigational setting.

Based on the above, cognitive rehabilitation for traumatic brain injury in adults does not meet the TEC criteria.

Contents

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Assessment Objective

Cognitive rehabilitation is a structured set of therapeutic activities designed to retrain an individual's ability to think, use judgment, and make decisions. The focus is on improving deficits in memory, attention, perception, learning, planning, and judgment. The term "cognitive rehabilitation" is applied to a variety of intervention strategies or techniques that attempt to help patients reduce, manage, or cope with cognitive deficits caused by brain injury. The desired outcome of cognitive rehabilitation is an improved quality of life or an improved ability to function in home and community life.

The term "rehabilitation" broadly encompasses re-entry into familial, social, educational and working environments, the reduction of dependence on assistive devices or services, and the general enrichment of quality of life. Patients recuperating from traumatic brain injury have traditionally been treated with some combination of physical therapy, occupational therapy, and psychological services as indicated. The goal of this Assessment is to evaluate the independent effect of a distinct and definable component of the rehabilitation process known as cognitive rehabilitation. Cognitive rehabilitation is considered a separate service from other rehabilitative therapies, with its own specific procedure codes.

Because so many different types of interventions may potentially improve cognitive outcomes, this Assessment only reviews studies that had been specifically classified in previous literature reviews as "cognitive rehabilitation." If a program was multidisciplinary and was said to include or incorporate cognitive rehabilitation, it was only included in the review if it was compared to a similar regimen without cognitive rehabilitation.

A 2002 Technology Evaluation Center (TEC) Assessment evaluated the benefits of cognitive rehabilitation in the treatment of cognitive deficit as a consequence of traumatic brain injury (Vol. 17, No. 20). Available evidence was reviewed to determine whether, when used as an adjunct to conventional rehabilitation or compared with no treatment, cognitive rehabilitation improved the health outcomes of patients with cognitive deficit as a result of traumatic brain injury. Cognitive rehabilitation for this indication did not meet TEC criteria.

This Assessment is an update to the 2002 TEC Assessment, and again focuses on traumatic brain injury. Evidence is reviewed to determine whether, when used as an adjunct to conventional rehabilitation or compared with no treatment, cognitive rehabilitation improves the health outcomes of patients with traumatic brain injury. The health outcomes of interest are improved patient functioning and quality of life. Although not considered a true health outcome for the purposes of this Assessment, outcomes in terms of cognitive test performance as reported in the studies will be shown in data tables.

Background

Cognitive Rehabilitation

Definition. Cognitive rehabilitation is a structured set of therapeutic activities designed to retrain an individual's ability to think, use judgment, and make decisions. The focus is on improving deficits in memory, attention, perception, learning, planning, and judgment. The term cognitive rehabilitation is applied to a variety of intervention strategies or techniques that attempt to help patients reduce, manage, or cope with cognitive deficits caused by brain injury. Cognitive rehabilitation has also been proposed as a treatment for cognitive deficits caused by stroke and dementia. The desired outcome of cognitive rehabilitation is an improved quality of life or an improved ability to function in home and community life.[1]

There are some conceptual problems in the evaluation of cognitive rehabilitation. Patients undergoing rehabilitation after brain injury are commonly treated with a number of different rehabilitation regimens. These have traditionally been offered by disciplines such as physical therapy, occupational therapy, speech therapy, and psychological therapy. The amount and content of these therapies may or may not be integrated or coordinated; when coordinated, they often fall under the rubric of multidisciplinary rehabilitation. Some of these multidisciplinary programs appear to include cognitive

[1] Cognitive rehabilitation is distinct from the group of psychotherapeutic techniques known as "cognitive behavior therapy (CBT)." A treatment for psychological disorder and maladaptive behavior, CBT attempts to change a patient's style of thinking, feeling and behavior. CBT is used primarily in the treatment of individuals who present with emotional and behavioral difficulties or formal psychiatric disorder. This Assessment does not address the effectiveness of CBT.

rehabilitation as one of the disciplines included, or to incorporate cognitive rehabilitation principles throughout the rehabilitation program, so-called “holistic” cognitive rehabilitation. In other instances, cognitive therapies may be offered as distinct services separate from the other health disciplines.

It is possible, indeed likely, that services such as occupational therapy, speech therapy, and physical therapy, can contribute to cognitive improvement in traumatic brain injury patients. However, because cognitive improvement occurs does not mean that such treatments should be classified as cognitive therapy, even if organized in a coordinated or integrated manner. If such a coordinated program is infused with principles of cognitive rehabilitation, it is difficult to separate out which services constitute cognitive rehabilitation and what are the incremental benefits beyond a multidisciplinary program without such principles.

Thus, for the purposes of this Assessment, multidisciplinary rehabilitation in general will not be considered cognitive rehabilitation. If a multidisciplinary or organized program of rehabilitation is labeled by the researchers as cognitive rehabilitation or includes components that are called cognitive rehabilitation, then the incremental benefit of such a program can only be evaluated if, in the study, it is compared to a similar program that does not include components of cognitive rehabilitation. If the program is only compared to minimal or no treatment, then it is impossible to separate out the benefit of cognitive rehabilitation from the separate components of physical, speech, and occupational therapy.

Patient Populations. Cognitive rehabilitation has been used to treat a range of brain insults and neurological impairments. However, the majority of cognitive rehabilitation research and application has focused on two prevalent patient indications: stroke and traumatic brain injury. Cognitive rehabilitation for these other indications has been reviewed in several review articles that also have reviewed it for the indication of traumatic brain injury (Cicerone et al. 2005; Cappa et al. 2005). The level of evidence presented in these reviews for these other indications seems to be similar in quantity and rigor to that for traumatic brain injury.

Traumatic brain injury is broadly defined as brain injury caused by externally inflicted trauma, principally the result of motor vehicle incidents, violence, sports injuries, and falls. Each year, in the U.S., an estimated 70,000–90,000 individuals incur traumatic brain injury severe enough to cause long-term substantial impairment (National Institutes of Health [NIH] 1999). Advances in emergency care, transport systems, and acute medical management have improved survival rates in recent years. The result is a continually increasing number of traumatic brain injury survivors with long-term disability.

Patients surviving severe traumatic brain injury often suffer from residual impairments in motor control, communication skills, cognition, and social behavior. The cognitive and behavioral deficits are generally among the more problematic impairments, and include a spectrum of changes in memory, language, attention and concentration, visual processing, reasoning and problem-solving, executive functions, and emotional and behavioral regulation. Resulting psychosocial limitations include high levels of anxiety and depression and pervasive personal loss (e.g., interpersonal relationships, social supports, employment, leisure activity). Consequently, traumatic brain injury has a profound effect on everyday functioning and independent living.

Models of Brain Injury Rehabilitation. Programs differ in treatment setting, techniques, intensity, duration, and their specific aims. Some programs target an isolated cognitive function while others offer a general mix of rehabilitation therapies. Training may be directed at the improvement of a single task (e.g., a visual reproduction task) or attempt to remediate global impairment, such as memory. Some programs use a single strategy (e.g., computer-assisted training), while others use a range of multidisciplinary approaches.

Cognitive rehabilitation is delivered in a number of different practice settings. The settings overlap to varying degrees and cover the full continuum of care. Cognitive recovery proceeds in overlapping stages, with more marked improvements in some skills occurring at different times. Therefore, the practice setting and the specific interventions used are often linked to the injury stage, with early rehabilitation taking place in more structured settings while later rehabilitation is dispersed to home and community.

Therapeutic Strategies. There is significant practice variation in the therapeutic interventions used in brain injury rehabilitation programs. Table 1 lists common cognitive rehabilitation interventions as described by the NIH-sponsored Consensus Development Panel on Rehabilitation of Persons with Traumatic Brain Injury (National Institutes of Health 1999). In general, therapeutic strategies in cognitive rehabilitation can be divided into approaches that attempt to recover cognitive abilities and approaches that attempt to compensate for cognitive impairment. The rationale for recovery is that with extensive practice or exercise, it is possible to retrain and improve impaired cognitive function by re-establishing previously learned patterns of behavior. Example techniques include reinforced practice on auditory, visual and verbal tasks, number manipulation, computer-assisted stimulation, and video feedback. In contrast, compensation interventions concede the unrecoverable loss of function and instead focus on adapting to the cognitive deficit. Example compensatory mechanisms include visual cues, memory books, mnemonics, self-monitoring techniques, and pagers that trigger behavior. The two approaches are not mutually exclusive, and in practice most cognitive rehabilitation programs combine both restorative and compensatory strategies.

Although this consensus panel identified all of these approaches as cognitive rehabilitation, this TEC Assessment will not evaluate every therapy that might result in cognitive improvement as a direct or indirect outcome. Our strategy in defining the studies of interest will be described in the “Methods” section.

Outcomes. A standard set of outcome measures has not been used in the evaluation of cognitive rehabilitation. The clinical practice of highly individualized treatment in traumatic brain injury rehabilitation has led to a vast array of outcomes and measures. Most of the measures assess performance of a specific set of tasks in a testing situation. For example, a well known test is the Paced Auditory Serial Attention Task, or PASAT (Gronwall 1977). Subjects are presented with a string of digits and are required to add each number to the one preceding. The PASAT is considered a test of attention.

Using a categorization defined by a review by the former Agency for Health Care Policy and Research (now the Agency for Healthcare Research and Quality [AHRQ]; Chestnut et al. 1999), we decided to classify outcomes as 1) direct or 2) intermediate. The AHRQ report defined the following types of outcomes as direct outcomes:

a. activities of daily living (ADLs);
b. long-term measure of disability (restriction or, as the result of an impairment, inability to perform an activity in the manner or within the range considered normal for a human being);
c. long-term measure of impairment (loss or abnormality of psychological, physiological, or anatomical structure or function);
d. independence, relationships, family life, satisfaction; and
e. long-term financial burden.

In contrast to the direct health outcomes recommended by Chestnut et al. (1999), intermediate

Table 1. Cognitive Rehabilitation Interventions Described in NIH Consensus Panel

- Cognitive or academic exercises
- Computer-assisted training
- Compensatory technique training
- External aids
- Communication skill training
- Psychotherapy
- Behavior modification
- Comprehensive interdisciplinary (milieu) models
- Vocational rehabilitation
- Pharmacotherapy
- Physical exercise, physical therapy, or aerobic training
- Art and music therapy
- Nutrition
- Spirituality
- Alternative or nontraditional therapies

outcomes are generally laboratory-based measures of cognitive function such as neuropsychological test batteries. Neuropsychological tests are measures of highly defined and narrow aspects of human performance, designed to assess brain function rather than to reflect life activities valued by the patient or society. In asking the question of whether intermediate measures of cognitive function associate with health outcomes or employment, Chestnut and colleagues found no association between laboratory-based measures and health outcomes such as functional independence, ADLs, or everyday use of memory. In 1996, the American Academy of Neurology (AAN) had also recommended against using neuropsychological test data as a primary indicator for the success of rehabilitation programs (American Academy of Neurology, Therapeutics and Technology Assessment Subcommittee 1996).

Systematic Reviews. Systematic reviews of the literature examining the effectiveness of cognitive rehabilitation for traumatic brain injury have yielded somewhat mixed results.

The Chestnut et al. (1999) AHRQ report evaluated evidence for the effectiveness of cognitive rehabilitation methods to improve outcomes for persons with traumatic brain injury. Two small, randomized, controlled trials and one observational study provided evidence that specific forms of cognitive rehabilitation reduce memory failures and anxiety, and improve self-concept and interpersonal relationships for persons with traumatic brain injury. Three other randomized, clinical trials showed no effectiveness of the treatment. The durability and clinical relevance of the findings were not established according to the report (Chestnut et al. 1999). Recommendations suggested the need for future research that makes use of control groups and multivariate methods to address subject variability, and includes standard definitions of the cognitive rehabilitation intervention, and relevant outcome measures that reflect health and function (Carney et al. 1999; Chestnut et al. 1999).

Similar to the AHRQ findings, an NIH-sponsored Consensus Development Panel on Rehabilitation of Persons with Traumatic Brain Injury identified studies that showed improvements in specific cognitive processes (National Institutes of Health 1999). Demonstrated improvements were found in attention, memory and executive functions, and in some cases involved the use of compensatory aids (such as memory books). Comprehensive, interdisciplinary rehabilitation programs were the primary intervention in these studies, making it difficult to evaluate the effect of specific cognitive rehabilitation programs. The Panel concluded that evidence does support the use of certain cognitive and behavioral rehabilitation strategies for individuals with traumatic brain injury, yet the research needs to be replicated in larger, more definitive clinical trials (National Institutes of Health 1999).

A review by Cicerone et al. (2005), which was an update of a prior evidence-based review published in 2000 (Cicerone et al. 2000), concluded that overall support exists for the effectiveness of several forms of cognitive rehabilitation for individuals with traumatic brain injury. The review evaluated 47 randomized studies of cognitive rehabilitation for all indications, including stroke and dementia. Seventeen of the studies evaluated patients with traumatic brain injury. The published review did not distinguish types of outcomes assessed in the studies, as did the AHRQ report (Chestnut et al. 1999).

Gordon et al. (2006) published a review of several types of interventions for traumatic brain injury rehabilitation, of which cognitive rehabilitation was one category of intervention reviewed. In their review of the literature published between 1998 and 2004 (but with selected studies included before 1998), they identified 6 randomized, controlled trials of cognitive rehabilitation. Based on the results of other nonrandomized studies of comprehensive holistic cognitive rehabilitation studies, they concluded that cognitive rehabilitation results in improvements in community functioning. They noted that the randomized, controlled trials of cognitive rehabilitation suffered from small sample sizes, lack of representative samples, and assessment of only test performance or subjective reports.

Laatsch et al. (2007) reviewed cognitive rehabilitation studies in children with acquired brain injury. They found 2 randomized, controlled studies. However, one of the studies does not have an untreated control group, and thus the effect of rehabilitation in general cannot be assessed. The results of the review led them to conclude that attention remediation therapy is effective, and that family members should be involved in the treatment plan.

The prior BCBSA TEC Assessment on cognitive rehabilitation (2002) for traumatic brain injury reviewed 4 studies, of which 3 were randomized trials. However, upon revisiting our definition of cognitive rehabilitation to exclude those interventions that are solely described as “multidisciplinary,” “comprehensive,” or “intensive,” 2 of those studies (Powell et al. 2002; Willer et al. 1999) are not studies of cognitive rehabilitation. The other two studies (Salazar et al. 2000; Novack et al. 1996) did not show benefits of cognitive rehabilitation, but the report cited several limitations of each study. It should be noted that of the 4 studies reported in the TEC Assessment, only the study by Salazar et al. (2000) is included in the review articles by Cicerone et al. (2005) and Gordon et al. (2006). The study by Novack et al. (1996) was cited in the AHRQ report (1999), but not in any other review article

FDA Status. Cognitive rehabilitation is a procedure and, therefore, is not subject to U.S. Food and Drug Administration (FDA) regulation.

Methods

Search Methods

Table 1 shows the potentially wide range of interventions that some experts believe can be classified as cognitive rehabilitation. In order to avoid an overly broad and unwieldy review of literature, yet provide a fair inclusion of studies that experts in the field believe are representative of cognitive rehabilitation, we decided to review the studies of cognitive rehabilitation for traumatic brain injury that have been cited in the review articles by Cicerone et al. (2005), Gordon et al. (2006), Laatsch et al. (2007), and the prior BCBSA TEC Assessment (2002), that meet our selection criteria. The selection criteria essentially selected studies characterized in most review articles as Class I studies, randomized assignment to different interventions. Because one particular nonrandomized study is often prominently mentioned as a study supportive of cognitive rehabilitation (Cicerone et al. 2004), this study was also selected for inclusion in this review.

In addition, a MEDLINE® database (via PubMed) search was performed for the period 2004 through January 2008. Keywords used for the search included: “cognitive rehabilitation,” “cognitive retraining,” “cognitive training,” “neuropsychological rehabilitation,” “cognitive remediation,” and “cognitive therapy.” Additional material was identified through reviews of current relevant journals, reference lists in previously identified articles, meta-analyses, and evidence-based reports. Because only randomized trials were eligible for selection, this resulted in the addition of only a few studies.

Study Selection

Studies selected for review met the following criteria:

- The study sample consisted of 8 or more adults.
- The study sample consisted exclusively of individuals with traumatic brain injury, or if a mixed sample was studied, the sample was predominantly traumatic brain injury or the results were reported by patient indication.
- Patients underwent a distinct and definable cognitive rehabilitation treatment program. Programs described as “multidisciplinary” or “comprehensive” were not included unless such programs included cognitive rehabilitation activities.
- The study was a randomized, controlled trial that compared the results of a treatment group to a control group (with the exception of Cicerone et al. 2004). If necessary to discern an effect of cognitive rehabilitation treatment or theory, the control group might need to undergo conventional rehabilitation at a similar intensity.
- Tests of cognitive performance or health outcomes were reported.
- Treatment processes, patient selection, and technically adequate measures of health outcome were described in adequate detail.

Medical Advisory Panel Review

This Assessment was reviewed by the Blue Cross and Blue Shield Association Medical Advisory Panel (MAP) on February 12, 2008. In order to maintain the timeliness of the scientific information in this Assessment, literature searches were performed subsequent to the Panel’s review (see “Search Methods,” above). If the search updates identified any additional studies that met the criteria for detailed review, the results of these studies were included in the tables and text where appropriate. There were no studies that would change the conclusions of this Assessment.

Formulation of the Assessment

Patient Indications
Patients are adult patients experiencing cognitive deficit as a consequence of traumatic brain injury. The severity of injury, the acuteness of the injury, and other specific inclusion and exclusion criteria are specific to the particular study. In general, specific cognitive rehabilitation interventions were indicated for patients having a particular cognitive deficit, but with other cognitive functions mostly intact.

Technologies to be Compared
Cognitive rehabilitation is used in addition to any other rehabilitation that might be indicated. In the available studies cognitive rehabilitation was generally compared to an attention control, so that outcomes could be assessed independent of training and other effects. If a holistic program of cognitive rehabilitation was the intervention, where separate components of cognitive rehabilitation might be difficult to identify, the comparison is to an adequate program of rehabilitation that did not include cognitive rehabilitation components or theory.

Health Outcomes
The principal outcome to determine efficacy is health outcomes, rather than cognitive test performance, as described by Chestnut et al. (1999).

However, since some studies included in this review do not have direct measures of health outcomes, results of cognitive test performance were also abstracted. These indirect outcomes have been cited in review articles supportive of cognitive rehabilitation. In order to streamline the presentation of these results, given the complexity of some of these tests, their uncertain validity in some cases, and unknown clinically relevant effect sizes, these results have been abstracted as "positive" (+) or "negative" (-), depending on whether the outcome of the study showed a statistically significant result for that particular test. Tests are described by their best known name or acronym, or summarized briefly in the text or tables.

Specific Assessment Questions
Does the available evidence demonstrate that cognitive rehabilitation improves the health outcomes of adults with traumatic brain injury?

Does the available evidence demonstrate that cognitive rehabilitation improves the results of cognitive test performance in adults with traumatic brain injury?

Review of the Evidence

Twelve randomized controlled trials and the one prominent nonrandomized trial were included in this review based on a search of the bibliographies of the previously mentioned review articles and a MEDLINE search for randomized controlled trials published after 2003. Table 2 provides a description of the intervention and control groups, setting and duration of treatment and follow-up, and types of traumatic brain injury patients included in the studies.

Two of the studies (Salazar et al. 2000; Cicerone et al. 2004) evaluated comprehensive holistic cognitive rehabilitation programs. These studies will be reviewed in more detail than the other studies. Results of the outcomes of these two studies are shown in Table 3. The other 11 studies evaluated more limited cognitive rehabilitation interventions meant to improve a specific aspect of cognitive functioning such as memory, attention process, or time management. For these studies of specific cognitive interventions, patients were generally selected for these studies based on the specific cognitive defect addressed in the program, and also to have sufficient cognitive capability that they were aware of the specific problem.

Comprehensive Holistic Cognitive Rehabilitation
Salazar et al. (2000). A total of 107 active-duty military personnel with moderate or severe traumatic brain injury were randomly allocated to either inpatient or home study arms by concealed methods. An intensive program of multidisciplinary rehabilitation delivered in an inpatient milieu environment was compared with a low-intensity home intervention consisting of weekly telephone support. No differences were observed in return to work or fitness for military duty nor were any significant differences found in cognitive, behavioral, and quality of life measures.

Return to work and fitness for military duty at 1 year follow-up served as the main outcome measures. Work was defined as either full-time or part-time military or civilian employment. Fitness for duty included those still on active

Table 2. Description of Randomized, Controlled Trials of Cognitive Rehabilitation

Study	Intervention	Control	Setting and Duration, Follow-Up Assessment	Type of TBI Patients
Comprehensive Holistic Cognitive Rehabilitation				
Salazar et al. 2000	Inpatient multidisciplinary program with multiple components of therapy	Home Discharge instructions Weekly phone contact Social supports	Inpatient full-time intervention for 8 weeks Outcomes assessed at 1 year	Moderate-to-severe head injury <3 months post TBI Mild TBI excluded Recovery sufficient for home discharge
Cicerone et al. 2004 (nonrandomized study) Unclear how patients selected for intervention or control groups	Community-based outpatient multidisciplinary cognitive rehabilitation	Physical, occupational, and speech therapy and neuropsychological treatment as dictated by patient needs and clinical recommendations.	Intervention group Outpatient 20 hours per week for 16 weeks, of which 6 hours is cognitive group treatment Control group Between 12–24 hours a week for 16 weeks	Majority with moderate-to-severe TBI, with “significant cognitive limitations and self-awareness” Mean time after injury 34 months for intervention 5 months for control
Cognitive Rehabilitation for Specific Cognitive Defects				
Berg et al. 1991 Milders et al. 1995 (4-year follow-up)	Memory rehabilitation techniques, individualized	2 control groups “pseudorehabilitation” drill and practice No treatment	Outpatient 18 1-hour sessions, two 3-week sessions (3/week), 3-week gap between sessions for evaluation Follow-up after each 3 weeks of training, and 3 months after all training and evaluation 31 of 38 patients in original trial followed up at 4 years in Milders et al. 1995	Patients with subjective memory complaints, objective measures showing memory deficits, time since TBI >9 months More than half working or in educational programs

Table 2. Description of Randomized, Controlled Trials of Cognitive Rehabilitation (cont'd)

Study	Intervention	Control	Setting and Duration, Follow-Up Assessment	Type of TBI Patients
Cognitive Rehabilitation for Specific Cognitive Defects (cont'd)				
Schmitter-Edgecombe et al. 1995	Memory notebook training	Same amount of supportive therapy	Outpatient Two 60-minute sessions per week for 8 weeks Follow-up at post-training and 6 months	Impaired memory patients, prior TBI not severe, time since TBI >2 years for the majority of subjects
Novack et al. 1996	Focused cognitive stimulation program therapy	Unstructured cognitive stimulation program	30-minute sessions, 5 days per week for 20 sessions (4 weeks) Follow-up after training	Inpatient, post-acute phase of recovery, mean of 5.9 weeks post-TBI
Fasotti et al. 2000	Time pressure management training based on Model of Michon	Concentration training	Outpatient 1-hour sessions, 3 hours/week for 3 weeks Follow-up at post-training and 6 months	Evidence of slowed speed of information processing (low PASAT, ACT tests) IQ >75 No severe disorder
Levine et al. 2000	Goal management training for rehabilitation of executive functioning	Motor skills training	Outpatient One 1-hour session Follow-up immediately after training	Independently living, good recovery, moderate disability, 3–4 years post-TBI
Medd and Tate 2000	Anger management program	Wait-listed	Outpatient 1-hour individual sessions once a week for 6 weeks Followed-up after treatment and 2 months after treatment	Patients referred with anger management problems, without prior history before TBI. Have sufficient cognitive capability

Table 2. Description of Randomized, Controlled Trials of Cognitive Rehabilitation (cont'd)

Study	Intervention	Control	Setting and Duration, Follow-Up Assessment	Type of TBI Patients
Cognitive Rehabilitation for Specific Cognitive Defects (cont'd)				
Sohlberg et al. 2000	Attention process training	Brain injury education and supporting listening	Outpatient 24 hours of training over 10 weeks, crossing over to 10 hours control over 10 weeks Follow-up immediately after each 10-week period	Attention deficits documented, >1 year post-TBI
Kaschel et al. 2002	Imagery mnemonics training	Unspecified, "standard" memory training as delivered by their home institution	Outpatient Thirty 70- to 90-minute sessions over 10 weeks Follow-up after training and at 3 months post-training	Patients with primary need for memory rehabilitation, but not severe memory problems, capability to generate mental images Average 5 years post-TBI
McMillan et al. 2002	Attentional control training, individual visits with clinical psychologist	Two control groups Physical exercise group No treatment group	Outpatient Four 45-minute visits over 4 weeks Follow-up at post-training, 6 months, 12 months	Reported problems with attention 3–12 months post-injury living at home fully oriented, aware of attention problems
Dou et al. 2006	Two treatment groups; Computerized memory rehabilitation or therapist-delivered memory rehabilitation	No specific treatment	Computer—1 month unspecified time Therapy—20 sessions, 45 minutes, 6 days a week Followed-up 1 month after completion of training	Outpatient, at least >3 months post-injury, basic attention span of at least 5 minutes, poor memory performance on tests
van't Hooft et al. 2007	Broad-based cognitive program called the Amsterdam Memory and Attention Training for Children	Freely chosen cognitive exercises without guidance, but with self-monitoring with diary	Outpatient Weekly visits to reinforce program of exercises to be performed 30 minutes per day for 17 weeks Follow-up out to 6 months	Children age 9–17 years, 1–5 years after injury, IQ >70, but poor performance on attention and memory tests. Approximately half of patients with TBI

Table 3. Outcomes of Studies of Integrated Cognitive Rehabilitation Programs

Study	Sample Size Follow-up Interval	Outcome Quantified Findings if Results Statistically Significant	Significance between Groups (+) or (–) or not Reported
Salazar et al. 2000	Treatment=60	**Health Outcomes**	
	Control=47	Return to Work	–
		Fitness for Duty	–
	12-month follow-up	Quality of Life scales (Katz adjustment scale)	
		Belligerence	–
		Social Responsibility	–
		Antisocial Behavior	–
		Social Withdrawal	–
		Apathy	–
		Test Outcomes	
		Buschke Selective Reminding Test	–
		Trahan Continuous Visual Memory Test	–
		PASAT	–
		Wisconsin Card Sorting	–
		Wechsler Memory Scale-Revised	–
		Auditory Consonant Trigrams	–

Table 3. Outcomes of Studies of Integrated Cognitive Rehabilitation Programs (cont'd)

Study	Sample Size Follow-up Interval	Outcome Quantified Findings if Results Statistically Significant				Significance between Groups (+) or (–) or not Reported
Cicerone et al. 2004	Treatment=27	Community Integration Questionnaire (CIQ)				+
	Control=29	Treatment	pre: 11.6	post: 16.8		
		Control	pre: 13.7	post: 16.1	p<0.05	
	Follow-up after treatment	CIQ Home Integration subscale				+
		Treatment	pre: 3.1	post: 5.1		
		Control	pre: 3.5	post: 4.5	p<0.05	
		CIQ Social Integration subscale				–
		Treatment	pre: 7.0	post: 8.6		
		Control	pre: 6.8	post: 8.0	p=NS	
		CIQ Productivity subscale				+
		Treatment	pre: 1.4	post: 3.1		
		Control	pre: 3.4	post: 3.6	p<0.01	
		Clinically significant improvement in CIQ				+
		Treatment 52%		Control 31%		
		Satisfaction with community integration				favor control
		Treatment	post: 27.1			
		Control	post: 29.7			
		Satisfaction with cognitive function				–
		Treatment	post: 16.7			
		Control	post: 18.2			

military duty or had received an honorable discharge from the service. Decisions regarding fitness for duty were made independently of the study team. Data were analyzed using intention-to-treat analysis with all randomized subjects.

No between-group difference was found in return to work (90% for inpatient treatment versus 94% for home treatment). Among subjects working at 1 year, 91% and 93% were employed full time. No between-group difference was detected in fitness for military duty (73% versus 66%), nor were differences detected in quality of life as measured by the Katz Adjustment Scale or on general measures of cognitive and psychiatric function.

A subgroup analysis suggested a trend toward beneficial effect of the milieu program for patients who were unconscious for more than 1 hour post-injury. Eighty percent of the hospital group (28/35) with period of unconsciousness over 1 hour versus 58% of the home group (23/40) were evaluated as fit for duty ($p<0.05$). The sample size and the fact that the effect was demonstrated in the single outcome “fitness for duty” make it difficult to conclude that the treatment is effective for the general population of patients with loss of consciousness over 1 hour.

A number of questions are raised by the Salazar report. First, the return to work statistics are uncommonly high (≥90%) in comparison to reported figures that approach roughly 40% after 2–4 years (Prigatano et al. 1994). The mean time since onset of injury was only 38 days, making it difficult to compare these results with the more conventional post-acute programs delivered at roughly 1 to 2 years post-severe injury. It is possible, of course, that the unique influences of a military environment had a positive effect on outcomes. Patients in non-military programs may not achieve the same results. Other explanations include the possibility that patients were returned to work inappropriately or that patients were not sufficiently impaired to benefit from the intensive intervention. In fact, the generally high functional level of these subjects seems apparent by their ability to participate in vocational counseling for several hours per day in the early post-injury stage. It is reasonable to consider that the treatment intervention as described by Salazar might be effective if targeted to those patients most likely to benefit (i.e., those with greater injury severity).

Cicerone et al. (2004). Patients from 2 different rehabilitation programs were compared in this study. One group was screened and selected for the intervention program called intensive cognitive rehabilitation program (ICRP). According to the article, these participants had significant cognitive limitations, but were considered to have some capacity to develop a realistic awareness of their strengths and weaknesses. The control group participated in a standard rehabilitation program. A strong imbalance between the two groups was noted particularly in the time from injury. The ICRP group was a mean of 34 months from injury, and the control group was a mean of 5 months from injury. The authors argued that the ICRP group had less potential to improve since they were more distant in time from their injury.

The interventions were roughly equal in terms of intensity and duration. Both groups received outpatient treatment for 20 hours per week for 16 weeks. In addition to coordinated rehabilitation services, the ICRP group received specific cognitive group treatment for 2 hours a day, 3 days a week. The control group received a traditional mix of physical, occupational, speech, and neuropsychological therapies. It appears that these treatments were monitored and coordinated to some extent by a staff neuropsychologist, and would thus meet a definition of multidisciplinary rehabilitation.

The principal measure of outcome was a measure of community integration (Community Integration Questionnaire, CIQ), which evaluates 15 aspects of functioning in 3 categories, home integration, social integration, and productivity. In addition to mean changes in scores from prior to post participation in rehabilitation, a dichotomous measure of “clinically significant change” was based on whether the change in questionnaire scare improved by more than 4.2 points (the 90% confidence interval [CI] for change in CIQ score). Satisfaction with functioning was also assessed in relation to satisfaction with level of community integration and satisfaction with level of cognitive functioning.

It appears, but is not stated, that outcomes were assessed only at the end of the rehabilitation program. The results of the study showed that the increase in CIQ scores from baseline to post training was greater in the ICRP group (11.6 to 16.8) than in the control group (13.7 to 16.1). In terms of an improvement of 4.2 points, 52% of the ICRP group showed improvement versus 31% of the control group. The subscales of the CIQ showed similar improvements. Paradoxically, the control group showed greater satisfaction with functioning. The principal analysis did not adjust for any baseline differences between subjects. Additional stepwise regressions were carried out showing that baseline CIQ and treatment group were both significantly associated with post-treatment CIQ scores. Time since injury apparently did not enter the model, but details on the regression analysis are sketchy.

Several issues regarding this study are worth noting. Most important, the study was not randomized and patients were specifically screened for participation in ICRP. Unknown selection factors such as motivation or social supports could cause selection of persons judged likely to benefit from a rehabilitation program. Baseline differences in time from injury were very different between the 2 groups. Although improvements in cognitive function are more likely early in the period after TBI, it is difficult to know the effect of time since injury on outcomes such as community integration and social functioning. Finally, outcomes were apparently assessed only at the end of the intervention. It is unknown whether one group might catch up to the other at some point in time after the end of the program.

In sum, both studies of comprehensive holistic cognitive rehabilitation have important limitations, making it difficult to determine whether such programs are effective.

Cognitive Rehabilitation for Specific Cognitive Defects

Many of the 11 studies of specific cognitive rehabilitation interventions have rather severe limitations. The sample sizes tend to be very small; only 2 studies have sample sizes larger than 40 (Novack et al. 1996; McMillan et al. 2002), and 3 studies have fewer than 20 subjects (Schmitter-Edgecombe et al. 1995; Medd and Tate 2000; Sohlberg et al. 2000). Maximum duration of follow-up was 1 month or less in 5 studies (Novack et al. 1996; Levine et al. 2000; Medd and Tate 2000; Sohlberg et al. 2000; Dou et al. 2006).

Health Outcomes. Eight of the 11 studies reported some kind of health outcome (Table 4). Only 3 of the studies report a statistically significant difference in one outcome between the intervention and control groups.

Schmitter-Edgecombe et al. (1995) reported a difference in observed memory failures in an ongoing 7-day diary between patients who had received training in using a memory book versus patients who had received supportive therapy only. This difference was present only in the evaluation that took place immediately after training; at 6 months there was no difference. For other outcomes assessed in the study, a retrospective assessment of memory failures and a symptom distress questionnaire, there was no difference at any time point. This study had an extremely small sample size of 4 subjects per group.

Sohlberg et al. (2000), in another small trial (total n=14) showed a statistically significant difference in self-reported changes in cognitive function as scored in a structured interview. However, the other outcome assessed in the trial, a multivariate analysis of the Attention Questionnaire, Brock Adaptive Functioning Questionnaire, and the Dysexecutive Questionnaire, showed no difference between groups. These outcomes were all assessed immediately after treatment or control period in a cross-over design study, which might be considered a problematic design for this type of intervention.

McMillan et al. (2002), in a relatively large trial for this type of intervention (total n=130) showed a difference in self-reported cognitive failures between treatment and control group at 12 months. However, an attention control group getting physical exercise showed similar improvement, and the authors noted that at baseline both the intervention and physical exercise groups had higher baseline scores (indicating greater severity of cognitive failures). The authors themselves suspected either a chance finding or regression to the mean given the lack of any other statistically significant findings in any other outcomes favoring the intervention.

In sum, then, the studies of cognitive rehabilitation for specific cognitive deficits evaluating health outcomes show only a few positive findings in studies with the smallest sample sizes of the selected studies. These same studies evaluated several other outcomes, none of which showed effects consistent with a benefit of cognitive rehabilitation.

Table 4. Study Results of Specific Cognitive Rehabilitation Treatments: Health Outcomes Results

Study	Sample Size Follow-up Interval	Outcome Quantified Findings if Results Statistically Significant	Significance between Groups (+) or (–) or not Reported
Berg et al. 1991 Milders et al. 1995	Treatment=17 PseudoRx=11 No treatment=11 Evaluated primarily at 3 months after treatment	None assessed in original trial at 3 months	
	Milders et al., evaluated at 4 years Treatment=15 PseudoRx=8 No treatment=8	Memory Complaints Questionnaire (37-item questionnaire, sum of 1-7 ratings of questions)	–
		Evaluation Questionnaire (sum of 1–10 ratings of several questions)	–
Schmitter-Edgecombe et al. 1995	Treatment=4 Control=4 Evaluated immediately after and 6 months after treatment	**Immediate results**	
		Everyday Memory Questionnaire (retrospective, average of family and patient)	–
		Observed Memory Failures (ongoing 7-day diary, by family and patient) (29 vs. 45.9)	+
		Symptom Distress	–
		6-month follow-up results	
		Everyday Memory Questionnaire (retrospective, average of family and patient)	–
		Observed Memory Failures (ongoing 7-day diary, by family and patient)	–
		Symptom Distress	–

Table 4. Study Results of Specific Cognitive Rehabilitation Treatments: Health Outcomes Results (cont'd)

Study	Sample Size Follow-up Interval	Outcome Quantified Findings if Results Statistically Significant	Significance between Groups (+) or (–) or not Reported
Novack et al. 1996	Treatment=22 Control=22 Follow-up after treatment	Functional Independence Measure (FIM)	–
Fasotti et al. 2000	Treatment=12 Control=10 6-month follow-up	Psychosocial Well-being sum score (standardized sum of several well-being and symptoms scores)	–
Levine et al. 2000	Treatment=15 Control=15 Evaluated immediately after treatment	None assessed	
Medd and Tate 2000	Treatment=8 Control=8 Evaluated compared to control immediately after treatment. No comparison to controls at 8 weeks after treatment	**Results after treatment** Self-Esteem Inventory (25 items) Hospital Anxiety and Depression-Anxiety Hospital Anxiety and Depression-Depression Patient Competency Rating Scale	 – – – –
Sohlberg et al. 2000	Treatment=7 Control=7 Cross-over design, evaluated after each 10-week period	Reported changes in everyday, psychosocial, and cognitive functioning in structured interview 0.91 treatment vs. 0.58 control Multivariate analysis of Attention Questionnaire, Brock Adaptive Functioning Questionnaire, and Dysexecutive Questionnaire	+ –

Table 4. Study Results of Specific Cognitive Rehabilitation Treatments: Health Outcomes Results (cont'd)

Study	Sample Size Follow-up Interval	Outcome Quantified Findings if Results Statistically Significant	Significance between Groups (+) or (–) or not Reported
Kaschel et al. 2002	Treatment=9 Control=12 3 dropouts not reported Evaluated 3 months after treatment	Memory Assessment Clinics Rating Scale (relatives' rating) MAC-F	–
McMillan et al. 2002	Treatment=44 Physical exercise control=38 No therapy control=48 12-month follow-up	Self-reported cognitive failures (magnitude of reduction not reported) General Health Questionnaire	+ –
Dou et al. 2006	Computer Rx=13 Therapy Rx=11 Control=13 Follow-up 1 month after training	None assessed	
van't Hooft et al. 2007	Treatment=18 Control=20 Follow-up 6 months after training	None assessed	

Cognitive Test Outcomes. All 11 studies evaluated patients with several test of cognitive performance. Results of these analyses are shown in Table 5. Some of the tests are common between studies, but many were apparently created for the purpose of the specific study. Although several of the studies report statistically significant findings for at least some of the tests, it is difficult to put in a clinical context the importance of the findings in terms of an important health outcome. Several of the results derive from tests given right after treatment (Novack et al. 1996; Levine et al. 2000; Medd and Tate 2000; Sohlberg et al. 2000; Dou et al. 2006), and thus provide no information regarding the durability of the intervention. Other interventions seem so minimal that an important clinical effect seems implausible: Levine et al. (2000; 1 hour total), Medd and Tate (2000; 6 hours total over 6 weeks), Fasotti et al. (2000; 9 hours total, over 3 weeks) and McMillan et al. (2002; 3 hours total over 4 weeks).

Only one of the studies that examined only cognitive test outcomes appears to have consistent and robust findings, a reasonable sample size, and follow-up at a reasonable interval after the program (6 months). van't Hooft et al. (2007) performed a randomized clinical trial of an intervention called the Amsterdam Memory and Attention Training for Children (AMAT-C). The program consisted of daily practice, games, and exercises in attention and memory techniques. The intervention consisted of supplying the training materials and weekly visits to provide encouragement and feedback on performance. The exercises were to be performed 30 minutes a day at home for 17 weeks. The control group kept diaries and were contacted weekly by phone. At 6 months, the intervention group achieved statistically significant improvement compared to the controls in 10 of 15 cognitive test scores. However, the authors recognize that only test scores were evaluated in the study, and that further evaluation of this particular training program is necessary to evaluate how the program may affect everyday life.

In sum, the studies evaluating cognitive test outcomes show inconsistent findings. Several of the studies suffer from small sample sizes, minimal interventions, and lack of long-term follow-up.

The randomized trial literature of cognitive rehabilitation does not show strong evidence for efficacy in the treatment of traumatic brain injury. Many of the clinical trials of specific cognitive rehabilitation interventions evaluated cognitive tests rather than health outcomes. Demonstration of the effectiveness of cognitive rehabilitation, either as an integrated holistic program, or as a separable component that treats a specific cognitive defect, requires prospective, randomized designs that employ validated measures of health outcomes.

Summary of Application of the Technology Evaluation Criteria

Based on the available evidence, the Blue Cross and Blue Shield Association Medical Advisory Panel made the following judgments about whether cognitive rehabilitation for traumatic brain injury in adults meets the Blue Cross and Blue Shield Association Technology Evaluation Center (TEC) criteria.

1. **The technology must have final approval from the appropriate governmental regulatory bodies.**

Cognitive rehabilitation is a procedure and, therefore, is not subject to U.S. Food and Drug Administration (FDA) regulation.

2. **The scientific evidence must permit conclusions concerning the effect of the technology on health outcomes.**

The number of clinical trials is relatively small. Many of the studies suffer from small sample sizes, insufficient follow-up, and lack of assessment of health outcomes. Only the nonrandomized study shows benefits of cognitive rehabilitation in terms of health outcomes. Unknown biases in the selection of subjects for inclusion in the cognitive rehabilitation program may have confounded the results of the study.

3. **The technology must improve the net health outcome; and**
4. **The technology must be as beneficial as any established alternatives.**

Most of the randomized studies do not show an improvement in health outcomes after a program of cognitive rehabilitation. The one nonrandomized study showing improvement in health outcomes had differences in types

Table 5. Study Results of Specific Cognitive Rehabilitation Treatments, Cognitive Test Result Outcomes

Study	Sample Size Follow-up Interval	Test Name	Significance between Groups (+) or (–) or not Reported
Berg et al. 1991	Treatment=17	**Overall results at 3 months**	
	PseudoRx=11	Summary memory score	+
Milders et al. 1995	No treatment=11	(standardized score of 6 tests)	
		Acquisition subset score	+
	Evaluated primarily at 3 months	(immediate recall)	
	after treatment	Delayed recall subset score	+
		(delayed recall)	
		4-year follow-up	
	Milders et al., evaluated at 4 years	Summary memory score	–
	Treatment=15	(standardized score of 6 tests)	
	PseudoRx=8	Acquisition subset score	–
	No treatment=8	(immediate recall)	
		Delayed recall subset score	–
		(delayed recall	
Schmitter-Edgecombe et al. 1995	Treatment=4	**Immediate results**	
	Control=4	Summary memory score	–
		(normalized sum of 4 tests)	
	Evaluated immediately after and 6 months after treatment	Rivermead Behavioral Memory Test	–
		6-month follow-up results	
		Summary memory score	–
		(normalized sum of 4 tests)	
		Rivermead Behavioral Memory Test	–
Novack et al. 1996	Treatment=22	Digit span, mental control, reaction time subtests of Wechsler Memory Scale	–
	Control=22		–
	Follow-up after treatment	Composite neuropsychiatric battery	

Table 5. Study Results of Specific Cognitive Rehabilitation Treatments, Cognitive Test Result Outcomes (cont'd)

Study	Sample Size Follow-up Interval	Test Name	Significance between Groups (+) or (–) or not Reported
Fasotti et al. 2000	Treatment=12	**Visual observation of simulated tasks**	
	Control=10	Preventive steps “waterbed” task	–
		Preventive steps “Harvard graphics” task	+
		Managing steps “waterbed” task	–
	Evaluated after treatment and at 6-month follow-up	Managing steps “Harvard graphics” task	+
		Task performance, both tasks	–
		Cognitive Functioning sum score after treatment (standardized sum of test battery)	+
		Cognitive Functioning score at 6 months (standardized sum of test battery)	–
Levine et al. 2000	Treatment=15	Proofreading task	+
	Control=15	Grouping task	+
		Room layout task	–
	Evaluated immediately after treatment	Time to completion of above tasks (more time considered better)	+
Medd and Tate 2000	Treatment=8	**Results after treatment**	
	Control=8	Subscores of State-Trait Anger Expression Inventory	
		Trait anger	–
	Evaluated compared to control immediately after treatment. No comparison to controls at 8 weeks after treatment	Anger-expression-IN	–
		Anger expression-OUT	+
		Anger expression-CONTROL	–
Sohlberg et al. 2000	Treatment=7	PASAT	+
	Control=7	Stroop and Trails B	+
		Memory task for letters	–
	Crossover design, evaluated after each 10-week period	Memory task for locations	+
		COWAT (word association task)	–

Table 5. Study Results of Specific Cognitive Rehabilitation Treatments, Cognitive Test Result Outcomes (cont'd)

Study	Sample Size Follow-up Interval	Test Name	Significance between Groups (+) or (–) or not Reported
Kaschel et al. 2002	Treatment=9	Logical memory subtest of RBMT-immediate	+
	Control=12	Logical memory subtest of RBMT-delayed	+
	3 dropouts not reported	Appointments test-immediate	–
		Appointments test-delayed	–
	Evaluated 3 months after treatment		
McMillan et al. 2002	Treatment=44	Rivermead PCS (self-report)	–
	PE control=38	Rivermead PCS (relative)	–
	No therapy control=48	Sunderland memory questionnaire	–
		HADS anxiety scale	–
	12-month follow-up	HADS depression scale	–
		TEA Map Search	–
		TEA visual elevator accuracy	–
		TEA telephone search	–
		TEA telephone search dual task	–
		TEA Lottery	–
		AMIPB List learning	–
		PASAT	–
Dou et al. 2006	Computer Rx=13	**Computer versus Control Results**	text and tables contradict,
	Therapy Rx=11	Neurobehavioral Cognitive Status Exam	uncertain results
	Control=13	Memory subscore	
		Rivermead Behavioral Memory Test	
	Follow-up 1 month after training	Hong Kong List Learning Test	
		Therapy versus Control	
		Neurobehavioral Cognitive Status Exam	
		Memory subscore	
		Rivermead Behavioral Memory Test	
		Hong Kong List Learning Test	

Table 5. Study Results of Specific Cognitive Rehabilitation Treatments, Cognitive Test Result Outcomes (cont'd)

Study	Sample Size Follow-up Interval	Test Name	Significance between Groups (+) or (–) or not Reported
van't Hooft et al. 2007	Treatment=18	**6 months**	
	Control=20	Gordon test (correct answers)	+
		Gordon test (errors)	+
	Follow-up 6 months after training	Binary Choice (mistakes)	–
		Binary Choice (correct answers)	+
		Trail Making Test A	–
		Trail Making Test B	+
		Stroop 1	–
		Stroop 2	–
		Stroop 3	+
		WISC-III Coding	+
		WISC-III Digit Span	–
		15 words–immediate recall	+
		15 words–delayed recall	+
		Rey-Osterrieth Complex Figure	+
		Rivermead Behavioral Memory Test	+

of patients enrolled in the two groups, and no long-term follow-up beyond the end of the cognitive rehabilitation program.

5. The improvement must be attainable outside the investigational settings.

Whether cognitive rehabilitation improves health outcomes in adults with traumatic brain injury has not been demonstrated in the investigational setting.

Based on the above, cognitive rehabilitation for traumatic brain injury in adults does not meet the TEC criteria.

References

American Academy of Neurology, Therapeutics and Technology Assessment Subcommittee. (1996). Assessment: neuropsychological testing of adults. Considerations for neurologists. *Neurology*, 47:592-599.

Berg IJ, Koning-haanstra M, Deelman BG. (1991). Long-term effects of memory rehabilitation: a controlled study. *Neuropsychol Rehabil,* 1:97-111.

Cappa SF, Benke T, Clarke S et al. (2005). EFNS guidelines on cognitive rehabilitation: report of an EFNS task force. *Eur J Neurol,* 12:665-80.

Carney N, Chestnut RM, Maynard H et al. (1999). Effect of cognitive rehabilitation on outcomes for persons with traumatic brain injury: a systematic review. *J Head Trauma Rehabil*, 14 (3): 277-307.

Chestnut RM, Carney N, Maynard H et al. (1999). Rehabilitation for traumatic brain injury. Evidence report no. 2 (Contract 290-97-0018 to Oregon Health Sciences University). Rockville, MD: *Agency for Health Care Policy and Research*. February 1999.

Cicerone KD, Dahlberg C, Kalmar K et al. (2000). Evidence-based cognitive rehabilitation: recommendations for clinical practice. *Arch Phys Med Rehabil*, 81: 1596-1615.

Cicerone KD, Mott T, Azulay J et al. (2004). Community integration and satisfaction with functioning after intensive cognitive rehabilitation for traumatic brain injury. *Arch Phys Med Rehabil,* 85:943-50.

Cicerone KD, Dahlberg C, Malec JF et al. (2005). Evidence-based cognitive rehabilitation: updated review of the literature from 1998 through 2002. *Arch Phys Med Rehabil,* 86:1681-92.

Dou ZL, Man DW, Ou HN et al. (2006). Computerized errorless learning-based memory rehabilitation for Chinese patients with brain injury: a preliminary quasi-experimental clinical design study. *Brain Inj,* 20:219-25.

Fasotti L, Kovacs F, Eling PATM et al. (2000). Time pressure management as a compensatory strategy training after closed head injury. *Neuropsychol Rehabil,* 10:47-65.

Gordon WA, Zafonte R, Cicerone K et al. (2006). Traumatic brain injury rehabilitation: state of the science. *Am J Phys Med Rehabil,* 85:343-82.

Gronwall DM. (1977). Paced auditory serial-addition task: a measure of recovery from concussion. *Percept Mot Skills,* 44:367-73.

Kaschel R, Della Salla S, Cantagallo A et al. (2002). Imagery mnemonics for the rehabilitation of memory: a randomized group controlled trial. *Neuropsychol Rehabil,* 12:127-153.

Laatsch L, Harrington D, Hotz G et al. (2007). An evidence-based review of cognitive and behavioral rehabilitation treatment studies in children with acquired brain injury. *J Head Trauma Rehabil,* 22:248-56.

Levine B, Robertson IH, Clare L et al. (2000). Rehabilitation of executive functioning: an experimental-clinical validation of goal management training. *J Int Neuropsychol Soc,* 6:299-312.

McMillan T, Robertson IH, Brock D et al. (2002). Brief mindfulness training for attentional problems after traumatic brain injury; a randomized control treatment trial. *Neuropsychol Rehabil,* 12:117-125.

Medd J, Tate RL. (2000). Evaluation of an anger management therapy programme following acquired brain injury: a preliminary study. *Neuropsychol Rehabil,* 10:185-201.

Milders MV, Berg IJ, Deelman BG. (1995). Four-year follow-up of a controlled memory training study in closed head injured patients. *Neuropsychol Rehabil,* 5:223-238.

National Institutes of Health. (1999). Rehabilitation of persons with traumatic brain injury. *JAMA*, 282(10): 974-983.

Novack TA, Caldwell SG, Duke LW et al. (1996). Focused versus unstructured intervention for attention deficits after traumatic brain injury. *J Head Trauma Rehabil*, 11(3): 52-60.

Powell J, Heslin J, Greenwood R. (2002). Community based rehabilitation after severe traumatic brain injury: a randomised controlled trial. *J Neurol Neurosurg Psychiatry*, 72:193-202.

Prigatano GP, Klonoff PS, O'Brien KP et al. (1994). Productivity after neuropsychologically oriented milieu rehabilitation. *J Head Trauma Rehabil,* 9:91-102.

Salazar AM, Warden DL, Schwab K et al. (2000). Cognitive rehabilitation for traumatic brain injury: a randomized trial. *JAMA*, 283 (23):3075-3081.

Schmitter-Edgecombe M, Fahy JF, Whelan JP et al. (1995). Memory remediation after severe closed head injury: notebook training versus supportive therapy. *J Consult Clin Psychol,* 63:484-9.

Sohlberg MM, McLaughlin KA, Pavese A et al. (2000). Evaluation of attention process training and brain injury education in persons with acquired brain injury. *J Clin Exp Neuropsychol*, 22:656-76.

van't Hooft I, Andersson K, Bergman B et al. (2007). Sustained favorable effects of cognitive training in children with acquired brain injuries. *Neurorehabilitation*, 22:109-116.

Willer B, Button J, Rempel R. (1999). Residential and home-based postacute rehabilitation of individuals with traumatic brain injury: a case control study. *Arch Phys Med Rehabil*, 80:399-406.

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