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Original Research

Neurobehavioural rehabilitation of dysexecutive syndrome following traumatic brain injury – a narrative review of management

ORIGINAL RESEARCH

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ABSTRACT

Background: Traumatic brain injury (TBI) leads to >200,000 hospital admissions in the UK annually. Frontal lobes are frequently affected, leading to a sequela of symptoms affecting behaviour, emotions, and cognition; a cluster of symptoms referred to as dysexecutive syndrome (also known as frontal lobe syndrome). People who survive this, experience long-term sequelae and require long-term support through neurological rehabilitation. The UK has robust guidelines on the medical/physical aspects of rehabilitation following brain injury. However, these guidelines mention little information on the management of neurobehavioural problems following TBI. The aim of this review is to determine what the evidence-based neurobehavioural management of patients with dysexecutive syndrome following TBI is in the UK.

Methods: A narrative review of articles using MEDLINE, EMBASE (1974 – present) and Web of Science was conducted. Search terms included frontal lobe syndrome, dysexecutive syndrome, traumatic brain injury, neurorehabilitation, neurological rehabilitation, neurological management, behaviour therapy and behavioural management. Additional references were sourced from the search results and author Neel Halder "NH", a medical director within a hospital catering to people with brain injury.

Results: 168 results were obtained. 21 articles remained following exclusions: 19 original articles and 2 reviews. Interventions mentioned included: behavioural psychotherapy, memory training, feedback, awareness interventions, goal management training, social skills training, work placements, problem solving training, metacognitive skills, token economy and response cost. Interventions were utilised using a person-centred approach, however, generally there was a lack of consensus on the most effective one. Only 2 studies considered the long-term outcomes of rehabilitation.

Discussion: Successful rehabilitation of dysexecutive syndrome post-TBI involves using a person-centred approach, to determine which intervention will target the problem of concern to the patient. Few papers address behavioural rehabilitation of dysexecutive syndrome post-TBI. Further research is required to determine the most effective and beneficial interventions for patients in both the short- and long-term.

BACKGROUND

Traumatic brain injury (TBI) is a leading cause of mortality in the UK, defined as a sudden injury from an external force that affects the way the brain functions, resulting from either a direct insult to the head or through a penetrating injury. Approximately 200,000 people annually require hospitalisation following a head injury in the UK. (1) Around 20% of these patients have a suspected skull fracture or evidence of brain damage, (1) with peaks in the 15–24 and >75-year age groups. Moderate to severe brain injury is estimated to occur in 25/100,000 people per year, and around 10–20% of them are likely to have severe disability or prolonged coma, and 65–85% experiencing good physical but not necessarily cognitive or psychosocial recovery. (1)

The anatomical position of the frontal lobes makes them highly vulnerable to damage following TBI, (2) leading to a sequalae of cognitive and behavioural symptoms (such as anger, aggression, apathy, disinhibition, and problems with planning), typical of dysexecutive syndrome (DS) otherwise also known as frontal lobe syndrome, or executive dysfunction. DS can also be caused by other disease processes, e.g., cerebrovascular disease, infections, tumours, neurodegenerative diseases, and epilepsy. (3) The frontal lobes are involved in higher level cognition, behaviour and personality, attention, and social functioning. (4)

The initial management of patients with brain injury, involves care through multidisciplinary teams consisting of emergency, neurosurgery, and intensive care healthcare workers. Importantly, experiences of people with brain injury do vary in acute care so this would not apply to all. In the UK, initial management is largely based on 3 sources of national guidance for adults with brain injury:

1. National Institute for Health and Care Excellence (NICE) Clinical Guideline 176: Head injury: assessment and early management (1)
2. Scottish Intercollegiate Guidelines Network (SIGN) Guide 130: Brain injury rehabilitation in adults (5)
3. Rehabilitation following acquired brain injury (National clinical guidelines, by British Society of Rehabilitation Medicine and Royal College of Physicians, 2003) (6)

These guidelines tend to heavily focus on the medical and physical aspects of rehabilitation following brain injury. For example, the NICE guidelines only have a brief paragraph on the management of behavioural problems following brain injury and DS is not mentioned. (1)
DS is a heterogeneous condition with expression varying greatly between patients and insight into the condition often being poor. (4) One of the greatest barriers facing patients with DS are persisting behavioural deficits or unwanted behaviours, which cause difficulty with community reintegration, obtaining and maintaining employment and interactions with family and friends. (7) These behaviours can cause social isolation. (6) Intensive rehabilitation, specifically neurobehavioural rehabilitation is commonly required in patients with DS post-TBI to enable them to either return to normal functioning or adapt to their given state so that they can maximise their potential. It has become crucial to identify those with behavioural problems post-TBI, to provide early neurobehavioural rehabilitation to try to mitigate the long-standing social problems they face. The All-Party Parliamentary Group on Acquired Brain Injury report 'Time for Change: Acquired Brain Injury and Neurorehabilitation' highlights the need for 'Rehabilitation Prescriptions' for all brain injury survivors. (8) This paper acknowledges that there are large variations in the funding, provision, and access to neurorehabilitation services across the country. (9)
To our knowledge, whilst review articles exist regarding dysexecutive syndrome and various biological diseases like Alzheimer's or Parkinson's, there are no review articles looking at the management of dysexecutive syndrome following TBI. Additionally, there is a large variation in the way DS post-TBI is managed, with no consensus on management or timing of interventions.
This narrative review aims to clarify and provide an overview on the information available on DS post-TBI and determine:
1. What types of neurobehavioural rehabilitation are available for patients with DS post-TBI?
2. What the most effective neurobehavioural management option is?
3. How decisions are made on what type of rehabilitation will be offered?
4. What is the best time-frame for offering rehabilitation?

METHODS

Studies were identified by carrying out searches on three different electronic databases: MEDLINE, EMBASE (1974 – present) and Web of Science. No limits were applied for language. The last search was run on 29th June 2020.

The following search terms were used: frontal lobe syndrome, dysexecutive syndrome, frontal lobe disorder, frontal lobe impairment, frontal lobe damage, frontal lobe, brain injury, acquired brain injury, traumatic brain injury, neurobehavioural, neurological management, neurological rehabilitation, neurorehabilitation, behaviour therapy, behaviour management, behavioural management. The terms were ran including both UK English spellings, American English spellings, and singular/plural forms.

Articles in foreign languages, conference abstracts with no further follow-up and those focussing on medical or pharmacological management with no focus on rehabilitation were excluded. All articles focussing on rehabilitation of behavioural problems in patients with dysexecutive syndrome post-TBI were included.

A total of 153 records were identified. 119 records remained following duplicate exclusion. Initial screening involved reading title names and abstracts which led to 37/153 suitable articles remaining. Following this, the full text of all 37 articles were read. Access could not be gained for 18/37 articles; therefore, these articles were screened by title and abstract again. Out of the 18/37 articles not accessible, 5/18 articles could have been related to this review; however, the other 13/18 were deemed to be unrelated. Access was available to 19/37 of the articles and these were fully read and analysed. At the end, a total of 6/19 articles remained which were

suitable. Additional articles were sourced from the database search results and from author NH. This yielded a further 15 articles of interest. In summary, a total of 21 articles were reviewed to determine the neurobehavioural management of frontal lobe syndrome following TBI (Figure 1).

RESULTS

A total of 21 articles (19 articles and 2 reviews) were analysed to determine the neurobehavioural interventions that may aid the rehabilitation of patients following frontal lobe damage (Table 1).
Table 1: A table of all articles reviewed to make up this narrative review

Several behaviours and neurobehavioural interventions were reported in the 21 articles reviewed. Behaviours being targeted for treatment included:
• Anger, aggression, irritability (10, 12, 15, 18, 19, 29, 30)
• Apathy, lack of interest, adynamia (10, 19, 24)
• Goal setting, planning, strategic behaviours (11, 14, 15, 20, 23, 24, 26, 27)
• Problem identification and error recognition (16, 17, 19, 21)
• Disinhibition, insight, flexibility (10–12, 15, 19–21, 23–25, 27, 28, 30)
• Self-initiation, self-awareness, self-monitoring (11–17, 20–25, 27–30)
The interventions reported have been grouped into 6 different subsections as mentioned below:
1. Behaviour therapy, behavioural psychotherapy, and cognitive behavioural therapy
2. Response cost and token economy
3. Vocational and social skills training
4. Paging systems and checklists
5. Verbal and videotaped feedback
6. Goal management training, problem solving training, metacognitive skills training

Behaviour therapy, behavioural psychotherapy, and cognitive behavioural therapy

Becker et al. (1973) published case reports for two patients with frontal lobe injury who presented with disinhibition and adynamia (loss of motivation and ability to initiate tasks), respectively, and the use of outpatient behavioural psychotherapy for their rehabilitation. (10) They described behavioural psychotherapy in a model of 6 stages: establishing a therapeutic alliance with the patient, diagnostic evaluation, selection of a problem to manage, behavioural intervention, working through resistances to change and finally, generalisation and internalisation of the behavioural change. (10)

This was a step-by-step model, primarily focussing on the patient-doctor relationship, before targeting problem behaviours. In their practice, Becker et al. (1973) showed the importance of a balanced relationship between patient, doctor, and carer, to allow the patient to retain their autonomy, to prevent overdependency and simultaneously offer the greatest chance of recovery to the patient. (10)

The first case by Becker et al. (1973) involved a 30-year-old female with disinhibition, sexual promiscuity, impulsive overeating, temper outbursts and inappropriate use of funds. (10) Using a patient-centred approach to find the problem of most concern, they decided firstly, to support her to manage her funds through positive reinforcement in the form of rewards for good behaviour and setting goals. At her baseline, the patient had no control over her finances, which were controlled by her mother. Over time, the researchers found that she was able to gain back control over her finances, however, 100% financial independence could not be achieved. The patient described how she found this intervention beneficial and more so than any other rehabilitation programme, with an overall improvement in her budgeting and quality of life.

The second case Becker et al. (1973) described was a man with social functioning issues. (10) He felt that he was being criticised for not initiating social interactions and was therefore given relaxation therapy to aid. The patient described a subjective feeling of social isolation and behavioural interventions helped him find ways of seeing the positive in people, how to form simple interactions and be comfortable in front of others. Over time he was able to form an intimate relationship.

The two cases highlight that behavioural therapy was beneficial and allowed both people to have more normality in their lives, i.e., partial financial control in case one and development of a personal relationship for case two. (10) One drawback of behavioural psychotherapy is that it is usually only beneficial to those who have retained some insight and it is known for people with little to no insight to be usually excluded from these programmes. (18) Subsequently, behavioural psychotherapy may only be useful to those with mild-moderate behavioural problems, nevertheless, it is important to identify those it may help.

Alderman (2003) described the use of both cognitive behavioural therapy (CBT) and behavioural therapy for two patients with DS following TBI who presented with irritability and aggression. (18) The first case dealt with an aggressive person, lacking insight and with memory problems. Due to the severity of his aggression, he was kept isolated from other patients, which added to his anger. A four-stage model incorporating CBT was used for rehabilitation which included enhancing monitoring skills, cognitive appraisal, coping strategies, and graded task assignment with increasing demands. To improve patient awareness, he was asked to journal all incidences of aggression. Additionally, his behaviour was assessed over time to identify the cause of aggression. This was written down and presented to him, so it was always there as a guide for him. Various coping strategies to deal with anger were also taught to the patient, e.g. breathing exercises. He received 22 weeks of CBT resulting in a reduction in the number of angry outbursts.

The key to success for this patient involved improving his self-insight, increasing self-monitoring of behaviours and motivation from the healthcare workers along with the goal of being transferred to the ward from an isolated secure room. (18)

The second case involved an individual with aggression who was highly distractible and disorientated. (18) His level of aggression meant that he was unable to access appropriate rehabilitation and therefore the primary goal of treatment was to manage the aggression through behaviour therapy. Again, the cause of anger was assessed and found to occur when effort was required to complete an activity, or when he wanted to avoid an activity. One such activity was bathing. Despite receiving help from staff with bathing, this activity was considered highly troublesome for the person. Additionally, researchers found that the level of support received varied greatly between staff which did not help him. As a result, staff were given a structured programme for bathing which they had to follow, which came with spoken instructions to the individual on what he should do. The increased consistency led to more structure for the person. In addition, he was given praise after every correct step and his poor behaviour was not reinforced, a problem that existed before. He was also given a goal for the number of angry outbursts allowed and if he was below this, he would receive a reward. The researchers found that over the course of the rehabilitation, the patient had less angry outbursts and was better able to bath himself. Both cases presented show that identification of the problem behaviours is important in being able to alter them and allow successful rehabilitation.
A review of interventions by Fleming et al. (2006) has also shown that behavioural psychotherapy can aid in improving self-awareness. (16)

Response Cost and Token Economy

Token economy aims to increase desirable behaviour and decrease undesirable behaviour using tokens. (31) If a desirable behaviour is shown, a reward in the form of tokens is given. These tokens can later be exchanged for something special, e.g., an object, an outing or privilege. In the case of undesirable behaviours, the tokens must be returned. Response cost is the removal of a positive reinforcer when certain behaviours are shown, with the goal of reducing unwanted behaviours. (32, 33)

Eames et al. (1985) carried out a follow-up study of 24 people with severe brain injury and disturbed behaviours following rehabilitation with token economy. (22) Only 1/24 patients had frontal lobe damage, however, due to the role the frontal lobe plays in behaviour this paper was relevant to our review. The other 23 patients had either severe brainstem or forebrain damage. The patients were part of a rehabilitation programme involving token economy. Whilst patients were given praise for good behaviours, effort and attention were made to ensure poor behaviours were not reinforced. This was done in a structured inpatient unit. After an average follow-up period of 18.8 months, token economy led to a significant reduction in undesirable behaviours in 18/24 patients - namely manipulation, aggression, sexual behaviours, and motivation. Additionally, it was noted that patients were able to generalise the reduction of these poor behaviours in society. 6/24 patients had no benefit from token economy and no change in behaviour was noted. In more depth, these 6 patients had very diffuse brain injuries and one had a history of severe psychopathy. Importantly, this was one of the first studies neously offer the greatest chance of recovery to the patient. (10)
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of this kind in 1985 and with more knowledge now, each patient would have to be individually assessed whether they'd benefit from such rehabilitation or not.

Alderman et al. (1994) described four case reports of people with behavioural problems and the use of response cost versus token economy for their rehabilitation, whereby tokens could be exchanged for gifts. (29) The first case described an individual with severe head injury who had issues with verbal abuse. His rehabilitation was in three phases and continuously changed based on his response. The first stage involved giving him tokens for every 15 minutes of good behaviour and no token if this was not the case, along with feedback. However, this did not help his behaviours. The second stage involved a similar plan but with no feedback to stop the positive reinforcement of bad behaviours. This led to a worsening of his verbal outbursts. The final stage involved giving him all the tokens from the start, however, as soon as he behaved badly the tokens were taken away. This led to a significant reduction in verbal outbursts. This case represented that response cost had a greater effect in improving this patient's behaviour than token economy. Similarly, the other three cases described the patients were better able to cope with their irritability and frustrations following the use of token economy and response cost with added feedback on performance. They worked well when other methods such as time out and other positive reinforcement methods did not work. This study showed that by increasing the persons internal locus of control and their ability to take charge leads to an improvement in behaviour.

Alderman et al. (1991) have shown that response cost also has a role in the reduction of repetitive speech. (25) They used response cost with overlearning to aid a person with repetitive speech problems. This involved the patient having to self-verbalise every time she repeated and cue herself that this was wrong. This led to a significant improvement in her speech, and she was able to take part in other forms of rehabilitation to aid her recovery. Burgess et al. (1994) have also shown that response cost and token economy do lead to an improvement in behaviours from baseline to post-rehabilitation in patients with DS and frontal lobe injury. (30) However, they note the difficulty in generalising behaviours outside of the rehabilitation programme and the need for more long-term studies.

Vocational and Social Skills Training

Wood et al. (2004) described the case of a 40-year-old man with bilateral frontal lobe damage following a road traffic accident whom they followed for 18 years. (15) He came from a professional family with no psychiatric problems and was known to be highly intelligent and friendly. However, following his injury he was found to be irritable and agitated with poor concentration and memory. They found that he lacked initiative, was unable to plan or organise his time well. As a result, he was provided with rehabilitation providing him a structured routine, social skills training, feedback and given a work placement reflecting his career aspirations prior to the injury. Unfortunately, these didn't help, and he frequently failed to attend therapy despite it being moved to suit him, and he was unable to live independently. He was provided with inpatient rehabilitation, but it was his family and the routine that they provided which helped him significantly. Despite longstanding issues with his behaviour, he was able to maintain a job whereby money management and dealing with customers was needed. This case study highlighted that patient focussed rehabilitation may take a long time to work, and multiple rehabilitation approaches may be required before any improvement in problem behaviours. This was one of the only long-term studies found in this review and highlights that further long-term studies on the impact of frontal lobe injury and rehabilitation are needed.

Burke et al. (1991) presented three studies on the rehabilitation of executive function in brain injured people. (28) The first study involved vocational training for a person with TBI working in a woodshop, who frequently made mistakes with the sequence of activities and had problems with planning. He was given four tasks to complete in the same order in the woodshop. The first three tasks were given with a checklist whilst the fourth one was not. The percentage of tasks completed was measured at baseline following which the checklist was implemented and then again withdrawn with measurements taken at each stage. The researchers found a large improvement in his ability to complete tasks 1-3 with the checklist and this continued even once it was withdrawn. Additionally, without implementation of a checklist for task 4 he was able to complete it correctly, showing that generalisation across different vocational behaviours is possible. The second study they presented involved three patients with self-initiation problems in their vocations. The researchers introduced a self-initiation checklist and found that this prompted and increased the number of tasks they completed correctly.

Barrier to employment is a debilitating issue faced by those with DS and is associated with a lower quality of life and increased psychological and emotional problems which become exacerbated over extended times of unemployment. (34) Both studies above have shown that vocational training with checklists can aid frontal lobe injured patients to re-enter employment successfully and remain there long-term.

Paging Systems and Checklists

Two papers have reported the use of a paging system known as NeuroPage, developed by a father whose son had brain injury. (26, 27) This paging system was developed with the aim of improving planning and organisation. The initial set up involved inputting reminders into a computer with times at which the paging system rings, following which no more human interaction with the computer was required. One paper reported fifteen participants trialling this paging system for three months. (26) Results showed that there was a significant improvement in the percentage of tasks being completed and that three months was enough time to establish a routine. The majority (n=13) regained their independence, were re-employed and experienced reduced stress levels whilst at the same time being highly affordable. Similarly, another case study reports the use of NeuroPage for a patient with executive problems

alongside a checklist to aid with planning activities and remaining attentive to tasks she was doing. (27) The patient had complicated routines for tasks such as bathing, and a cue from the NeuroPage or a checklist which she had to fill in as she was doing each task helped to improve her problems. Additionally, by having a checklist of her performance in each task on the wall and seeing results week-on-week led to an improvement in her behaviour, acting as a positive reinforcement. These studies show that paging systems and memory aids such as checklists can significantly help people with memory and self-initiation problems following frontal lobe injury.

Verbal and Videotaped Feedback

Feedback has been shown to help patients with DS gain a better insight into their condition and monitor maladaptive behaviours, with the aim of potentially changing them. (13, 16) Beer et al. (2006) conducted a study comparing self-monitoring outcomes in eight patients with frontal lesions versus healthy controls following completion of an interpersonal task with videotape feedback. (13) The task involved taking part in a structured conversation with a stranger with subsequent videotape feedback and asked to rank their emotions for how they felt (e.g., amused, embarrassed, scared, angry, disgusted). Results showed that the patients with frontal lesions made more inappropriate disclosures than the controls. Combining both the self-monitoring component with the emotions felt, led to greater awareness of the patient regarding their behaviour with the stranger.

Cicerone et al. (1997) described a case report of a patient with orbitofrontal brain injury following a road traffic accident who underwent rehabilitation with videotaped feedback, social cues and awareness increasing exercises. (12) She presented with multiple unacceptable social behaviours such as abrupt crying/laughing, obsessions, inability to handle criticism and frequent arguments and conflicts with family and children. Videotaped feedback helped increase awareness, but she was not able to use the subtle or complex pieces of information from social interactions. Interestingly, this patient became resistant to treatment via feedback and started displaying increased anger and depression in response. This case highlights how feedback may work for some but not for all and that timing and individual cases must be taken into consideration.

Goal Management Training, Problem Solving Training, Metacognitive Skills Training

Problem solving training (PST) involves identifying problematic behaviours and targeting them for change. Winkens et al. (2019) evaluated a PST programme known as the ABC method for behavioural problems following acquired brain injury. (28) The ABC method involved identification of Antecedent events, target Behaviours and Consequent events with the aim of identifying observable problem behaviours and triggers which could be changed by staff. The researchers could not conclude whether this method was useful or not for patients with acquired brain injury.

Other studies have shown that PST can have positive benefits for patients with DS. (29) They incorporated both PST and vocational training with emphasis on self-observation, positive reinforcement, and feedback under normal life conditions for a 33-year-old man with bilateral frontal lobe damage post-TBI. The patient was a doctor, but he couldn't identify problems, solve errors, and needed many prompts and instructions to complete tasks and showed socially inappropriate behaviours. Strategies to help included checklists, written information, asking for senior advice when uncertain. This process led to an overall improvement in his performance and acceptance of weaknesses. However, his self-insight was still lacking as he went to overstate his own abilities. This case demonstrates that PST is an effective method in aiding an individual retain their job on a long-term basis.

A prospective randomised control trial with 75 patients (38 experimental group; 37 controls) comparing goal management training (GMT) and PST versus a computer based cognitive training programme for the control group has been conducted. (30) The rehabilitation programme involved two parts: the first phase was GMT with increasing self-awareness, goal setting and planning and once these were mastered initiation, execution, and regulation of the tasks. The second phase involved PST to address problems that may arise when certain tasks were being conducted. Throughout the process questions were asked to stimulate the patients and feedback was given. The control group similarly were also given feedback, but all their activities were online. Both groups had to set three goals they wanted to achieve by the end of the rehabilitation. The researchers found a statistically significant improvement in planning, self-initiation, and self-awareness for the patients who received GMT/PST, with a smaller improvement in the controls.

Additionally, the change in the experimental group was found to be significant compared to baseline levels up to 6 months after the rehabilitation programme had ended. Similarly, others have shown that GMT can help with behaviour problems for patients with executive dysfunction and frontal lobe injury. (31, 32) Metacognitive skills training (MST) is another form of rehabilitation whereby patients self-monitor, self-assess and self-correct themselves. (33) Ownsworth et al. (2010) used a case-based study to compare combined MST with behavioural training to behavioural training alone in three people with TBI and severe executive dysfunction. (34) The participants were given the goal of cooking two separate meals and had to make each meal, alternating every week with the aim of assessing their error self-regulation. During the process they were also given praise, interrupted if there was immediate danger and prompted if need be if self-error recognition had not occurred with a gradual reduction over time in these prompts. The first study looking at MST with behaviour therapy resulted in a significant decrease in errors with a significant reduction in checks and significant increase in self-corrections. However, for the participant who only received behavioural therapy alone, errors and self-corrections did not change but checks significantly increased. This study showed that combination behavioural therapies may be more useful than just using a single intervention.

The Strategic Memory Advanced Reasoning Training (SMART)

programme is a strategy based metacognitive programme to help improve cognitive control, reasoning, and innovative behaviours. Vas et al. (2016) compared the SMART programme to another programme based on active learning known as the Brain Health Workshop (BHW) by using a blinded randomised controlled trial across 60 patients with TBI. (35) This was to determine the benefits of both the programmes. The SMART programme is based on three principles: maintaining attention, reasoning, and cognitive flexibility. The BHW involved explaining the anatomy and physiology of the brain, how the brain evolves following injury, and the impacts brain health has on lifestyle. The patients in the SMART group showed improved executive function with an associated reduced level of stress and depression as well in comparison to the BHW. They also conducted brain imaging of both the groups of patients before and after the programmes and found a greater increase in cerebral blood flow for the SMART group over the BHW group. (3) This is interesting, as SMART, and metacognitive training may have the potential to improve recovery following brain injury.

DISCUSSION

DS is a common problem experienced by people following TBI. The executive functions controlled by the frontal lobe have been described as volition, planning, purposive action, and effective performance. (37) Individuals with DS experience problems with their behaviour, ability to interact with family/friends and the ability to lead an independent lifestyle. There is relatively less information regarding the neurobehavioural compared to physical rehabilitation of patients with DS. (1, 5, 6).

Neurobehavioural rehabilitation involves using a holistic approach to help individuals manage their problems so that they can slowly adjust to their injury and be able to interact with people successfully. It involves helping them to reduce their disability to the most minimum level possible by helping the individual learn new skills and methods to aid in daily activity. This involves working with a wide range of healthcare workers and staff to adapt a person's work and home environment to minimise their disability. A good rehabilitation programme should involve helping the patient become aware of their deficits, learning, and using compensatory techniques, planning community reintegration and training in social appropriateness and survival skills. (2) This review has found that there is a large variation in the type of rehabilitation, timings, and methods of provision across the UK and high-income countries across the world.

Every person with dysexecutive syndrome presents differently, representing a heterogenous group of people. In some behaviours, particularly, anger/aggression and lack of insight can cause difficulty for the healthcare professionals to work with these patients. Therefore, these patients may be excluded from rehabilitation programmes, unless there is specific expertise and training among professionals looking after them. A successful rehabilitation programme would have to tackle these issues through increased education of healthcare workers in coping with anger/aggression. The token economy and response cost rehabilitation methods have shown how ignoring a patient's aggressive behaviour can positively reinforce that behaviour; therefore, inhibiting their participation in rehabilitation. (16) This leads to a cycle of problems which continue to get worse. Additionally, videotaped/verbal feedback has shown to help improve self-insight in multiple cases of DS, however, as found by Cicerone et al. (1997) there have also been instances where participants developed resistance to treatment. (26) Therefore, one may conclude it is highly dependent on each individual person whether a method of rehabilitation works or not.

Most of the research papers in this review have been case reports; there is a lack of randomised control trials. Most patients who experience TBI would also experience diffuse axonal injury, i.e., injury to multiple parts of the brain not just the frontal lobes. Therefore, one of the large difficulties experienced is determining what is considered a frontal lobe problem versus the executive problems faced by patients which may be controlled by multiple parts of the brain. Across the literature, there has been an inconsistent and interchangeable use of the physiological definition of executive problems versus the anatomical boundaries of the frontal lobes and both being joined up. (38) This is something that future research into the area needs to consider.

It is widely accepted that the sooner patients begin neurorehabilitation, the better their functional outcomes. (39) However, all the studies in this review have shown that patients received rehabilitation at varying timescales from their injury. Those with DS may perform well in cognitive/neuropsychological tests and therefore, problems they may experience are not picked until long after. (40) For any intervention to be widely used, it must be sustainable, low-cost, and highly effective for patients. There does not appear to be any consensus for what method to use when it comes to behaviour management in patients with DS following TBI, however, it is evident that interventions are person-centred. This review has found multiple rehabilitation methods for the behavioural management of DS, namely, behaviour therapies, response cost/token economy, vocational/social skills training, paging systems/checklists, verbal/videotaped feedback, and GMT/PST. Further research is needed into this area to determine which method is the most effective with large randomised controlled trials. In conclusion, the successful rehabilitation of patients with DS following TBI involves using a person-centred approach, to determine which intervention will most help the problem of concern.

APPENDIX 1: FIGURE SHOWING PRISMA FLOWCHART OF ARTICLES REVIEWED

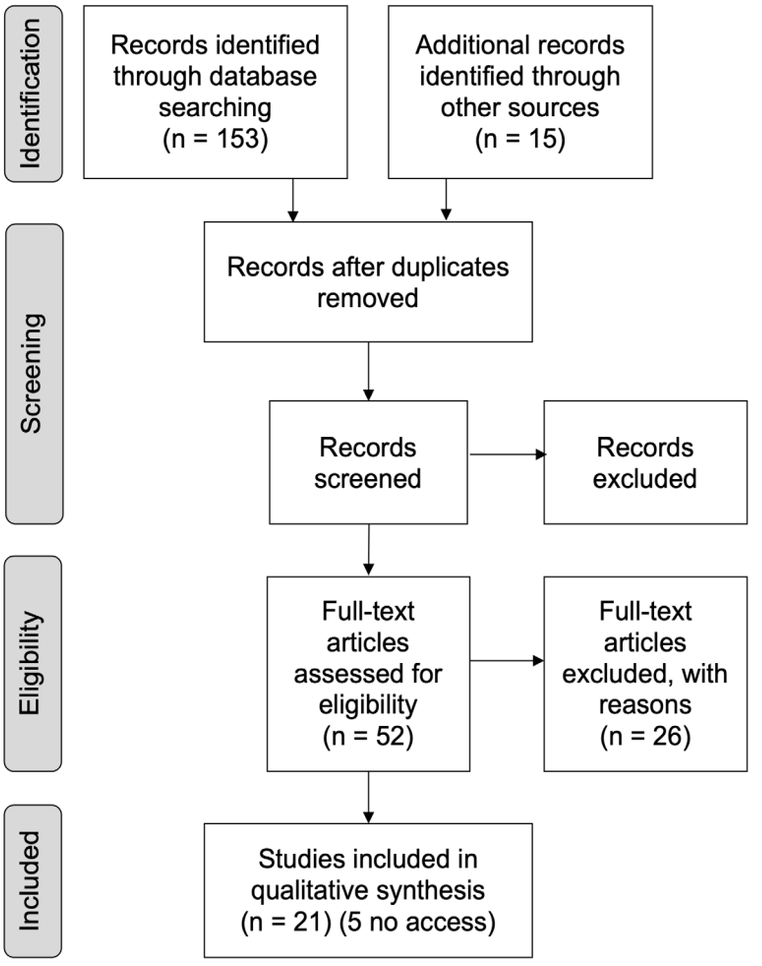

Figure 1: *A flowchart of studies included. This represents the identification of all articles, their screening and eligibility and the final number of articles that were included in this narrative review. approaches are presented around the outside of the circles.*

APPENDIX 2: A TABLE OF ARTICLES REVIEWED

Table of articles reviewed			
Title	**Intervention**	**Participants**	**Study Design**
Behavioural psychotherapy of the frontal-lobe-injured patient in an outpatient setting.	Behavioural psychotherapy	2 participants both with frontal lobe injury. 1- disinhibition behaviour. 2- adynamia	Case report
Reasoning training in veteran and civilian traumatic brain injury with persistent mild impairment.	Strategic Memory Advanced Reasoning Training (SMART) versus Brain Health Workshop (BHW)	SMART 31 participants; BHW 29 participants.	Comparative study
Disturbance of social cognition after traumatic orbitofrontal brain injury.	Community based trips, videotaped feedback, group treatment sessions, behavioural reinstatement procedure	1 patient - traumatic orbitomedial frontal lobe damage with problems with emotional regulation and social cognition	Case report
Orbitofrontal cortex and social behavior: integrating self-monitoring and emotion-cognition interactions.	Self-monitoring via an interpersonal task with videotape feedback	16 participants- 4 with orbitofrontal lesions, 4 with lateral prefrontal lesions and 8 healthy controls	Comparative study
Rehabilitation of executive functioning: an experimental-clinical validation of goal management training.	Study 1- Goal management training versus motor skills training. Study 2- GMT.	Study 1- TBI patients; 30 patients of which 13 had frontal lesions; 15 participants per group. Study 2- postencephalitic patient seeking to improve meal prep abilities.	Clinical trial- 2 study methods. 1st RCT. 2nd case report.
Relationships between measured cognitive ability and reported psychosocial activity after bilateral frontal lobe injury: An 18-year follow-up	Structured routine, social skills training, feedback, work placement	1 participant- bilateral frontal lobe injury	Case report with 18 year follow up
A review of awareness interventions in brain injury rehabilitation	-	-	Review article
Cognitive rehabilitation interventions for executive function: moving from bench to bedside in patients with traumatic brain injury	-	-	Review article
Contemporary approaches to the management of irritability and aggression following traumatic brain injury	Psychotherapy, behaviour therapy	2 participants. 1- dysexecutive syndrome with irritability and aggression. 2- severe TBI with irritability and aggression.	Case report
Effects of a behaviour management technique for nursing staff on behavioural problems after acquired brain injury	Problem solving training - ABC (identification of Antecedent events, target Behaviours and Consequent events)	56 patients with problematic behaviour, aggression, and apathy of which 7 had experienced contusions/trauma	Longitudinal intervention study with double baseline measurements
Effects of a multifaceted treatment program for executive dysfunction after acquired brain injury on indications of executive functioning in daily life	Goal management training, problem solving training	75 patients with dysexecutive problems reported by themselves or proxies who were referred for outpatient rehabilitation (38 experimental group; 37 control group). 55% of experimental group and 32.5% of the control group had experience TBI	Prospective randomised control trial
Error self-regulation following traumatic brain injury: a single case study evaluation of metacognitive skills training and behavioural practice interventions	Metacognitive skills training, behavioural practice interventions	3 patients all with severe TBI. 1- high speed motorbike accident with right frontal lobe, left internal capsule and right fronto-parietal damage. 2- left frontal lobe contusion post penetrating missile accident 3- TBI of unknown cause post fall with reduced blood flow to left cerebral hemisphere and right frontal lobe. 3-	Case report
Rehabilitation after severe brain injury: a follow-up study of behaviour modification approach	Token economy	24 patients with severe TBI and disturbed behaviours preventing rehabilitation or care. Only 1 patient had frontal lobe damage	Long-term follow up study (average follow up 18.8 months)
Rehabilitation of executive functioning in patients with frontal lobe brain damage with goal management training	Goal management training versus brain health workshop	19 participants (11 goal management training; 8 brain health workshop) with executive functioning problems and damage to the frontal systems	Randomised control trial
Back to work with a chronic dysexecutive syndrome? (A case report)	Stimulation/practice for 12 months with positive reinforcement and feedback	1 case study - severe TBI with bilateral frontal lobe damage	Case report
Behavioural treatment of the dysexecutive syndrome: reduction of repetitive speech using response cost and cognitive overlearning	Behavioural therapy - response cost and cognitive overlearning	1 case study - dysexecutive syndrome due to herpes simplex encephalitis and disturbed behaviour	Case report
Evaluation of NeuroPage: a new memory aid	Paging system via a portable device known as NeuroPage	15 head injury patients with memory problems, evaluation of NeuroPage for self-initiation behaviour	Report
External cueing systems in the rehabilitation of executive impairments of action	Paging system via a portable device known as NeuroPage, with checklist	1 patient with executive problems following a cerebrovascular accident effecting the right frontal lobe and parasagittal area	Case report
Improving executive function disorders in brain-injured clients	Vocational training with checklists then without, self-initiation checklists, scheduled feedback on inappropriate behaviours	6 patients- 1- problem solving. 2,3,4- self-initiation problems. 5,6- self-monitoring/self-regulation problems	Case report
Integrating cognition and behaviour: a pragmatic approach to brain injury rehabilitation	Response cost versus token system	4 case studies. 1-disinhibition, attention seeking behaviour, anger. 2- aggression, sexual disinhibition. 3- incontinent of urine despite no medical/physical cause. 4- herpes encephalitis with psychosocial and behavioural problems	Case report
Rehabilitation of dyscontrol syndromes following frontal lobe damage: a cognitive neuropsychological approach	Token economy, feedback, analysing causes, and environments in which certain behaviours appear	2 cases. 1- TBI with general sexual disinhibition, shouting/swearing at staff. 2- severe TBI with frontal lobe atrophy with impulsive and perseverative behaviour	Case report

Table 1: *A table of all articles reviewed to make up this narrative review*

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