Article:

Clasby, B., Hughes, N. orcid.org/0000-0002-5859-808X, Catroppa, C. et al. (1 more author) (2018) Community-based interventions for adolescents following traumatic brain injury: a systematic review. NeuroRehabilitation, 42 (3). pp. 345-363. ISSN 1053-8135

https://doi.org/10.3233/NRE-172385

Community-based interventions for adolescents following traumatic brain injury: a systematic review

Betony Clasby[1,2, *], Nathan Hughes, PhD[1,3,4], Cathy Catroppa, PhD[1,4], and Elle Morrison[1]

[1] Murdoch Children's Research Institute, Melbourne, Australia, [2] The University of Birmingham, UK,[3] The University of Sheffield, UK, and [4] The University of Melbourne, Australia

* Corresponding author: Betony Clasby, Centre for Adolescent Health, Murdoch Children's Research Institute, Royal Children's Hospital, Flemington Road, Parkville, Victoria, 3052, Australia. T: 0+44 114 222 6439; E: betony.clasby@mcri.edu.au

Abstract

Background: Chronic impairment following childhood traumatic brain injury has the potential to increase risk of negative outcomes. This highlights potential value of community-based rehabilitation programs. Objectives: To identify research studies examining existing intervention programmes available in community-based rehabilitation to adolescents following TBI to assist with the transition back into the community. Methods: A systematic review of community-based interventions was conducted across different national contexts. All included studies involved a clinical population with TBI, aged 11 to 25 years inclusive. Risk of bias was rated for each included study. Results: Seventeen studies were identified for inclusion in the review, of these eleven distinct interventions were found. The quality of evidence was largely weak and highly variable. Conclusion: The results suggest some improvement in adolescent outcomes following community-based interventions, however higher quality evidence is needed to support specific interventions.

Keywords

Brain injury; Rehabilitation; Intervention; Community; Home; Adolescence.

1. Introduction

Traumatic brain injury (TBI) is a major cause of mortality and morbidity in children worldwide, and is involved in almost half of all trauma deaths (World Health Organization, 2006). There are well-documented significant ongoing impairments for children and adolescents following TBI, across physical, cognitive, educational, and behavioural domains (Catale, Marique, Closset, & Meulemans, 2009; Catroppa & Anderson, 2004; Catroppa, Anderson, Godfrey, & Rosenfeld, 2011; Catroppa et al., 2015; Crowe, Anderson, Barton, Babl, & Catroppa, 2014; Ganesalingam et al., 2011; Hawley, Ward, Magnay, & Mychalkiw, 2004; Max et al., 2005; Ryan et al., 2015). Such impairments contribute to increased risk of adverse outcomes in adolescence, such as school dropout, substance abuse, self-injurious behaviour, and entrance into the criminal justice system (Gunter, Chibnall, Antoniak, Philibert, & Black, 2013; McKinlay, Corrigan, Horwood, & Fergusson, 2014; Stoddard & Zimmerman, 2011). This can culminate in significant social and economic burden for families, communities and society (Lash, 2004; Parsonage, 2016).

The potential for chronic impairment highlights the need for effective interventions subsequent to inpatient clinical rehabilitation as, following a TBI, children and adolescents are required to transition back into the community and resume everyday activities. Long-term rehabilitative primary service providers after paediatric TBI are often located in a home or community setting (Savage, DePompei, Tyler, & Lash, 2005) and rely on availability of resources and multi-agency cooperation (Anderson & Catroppa, 2006). Access to effective community-based rehabilitation services and interventions for TBI could assist in long-term monitoring and recovery, promoting positive outcomes (Cronin, 2001), and a smooth transition from hospital to school (Chevignard, Brooks, & Truelle, 2010). This is particularly important as paediatric TBI is often considered a ‘hidden’ disability as chronic sequelae may not be evident initially, and may only surface at developmental milestones when specific functional skills are attained, making identifying or predicting the need for future support more challenging (Anderson, Levin, & Jacob, 2002).

Despite its potential value, appropriate support within the community appears limited, with reported gaps in rehabilitation service delivery and demand, especially amongst those identified as requiring additional support (Cronin, 2001; Laatsch et al., 2007). For example, in the US, a follow-up study of 24,021 children and adolescents hospitalized for TBI showed that, among those demonstrating evidence of functional impairment, 75% were discharged with no active outpatient or community based rehabilitation program, and only 1.8% were referred to learning support services (Di Scala, Osberg, & Savage, 1997). Poor service provision may be due to a combination of factors, including limited community-based services to refer to, and ineffective service transition from hospital to home, as well as poor interagency communication, low referral rates, inadequate family resources, and a lack of understanding of the long-term consequences of TBI (Cronin, 2001). Following TBI there is also an emphasis towards reintegration into education and school settings, which may also partly explain the limited availability and accessing of community-based services (Anderson & Catroppa, 2006). Considering the open-ended nature of rehabilitation post-TBI, further focus on home- and community-life outside of education may positively impact progression during school career, and later the transition from school into the workplace and wider community.

Developing successful community-based rehabilitation programs may be more problematic due to the range of abilities, relationships and biological vulnerabilities which are characteristic of the developmental age of the individual with TBI (Ylvisaker, 1998). Growth, development, and maturation could bring to the forefront latent impairments (Yen & Wong, 2007), and interventions targeting adolescents may not be suitable for a younger audience (Semrud-Clikeman, 2010). Therefore, rehabilitation may be most effective if age appropriate. During adolescence, in addition to transitioning back into school and the community, there is the added complication of facing developmental transitions between primary, secondary, and college education and into professional training (Chevignard et al., 2010; Semrud-Clikeman, 2010). The adolescent brain – more specifically the prefrontal cortex - is still developing up until the age of 25, suggesting that, until this age, cognitive analysis, abstract thought, and the moderation of social behaviour are still maturing (Arain et al., 2013; Casey, 2008). Interventions need to take into consideration the complex difficulties associated with adolescence specifically, whilst remaining aware that this group may refuse active rehabilitation in the interests of being independent and identifying with their peers (Anderson & Catroppa, 2006).

A further difficulty for service planning and delivery of community-based rehabilitation is the broad range of definitions associated with ‘community-based interventions’. Previous authors have suggested that a comprehensive and dynamic approach to community-based rehabilitation with service users and their families may be beneficial, consisting of multiple providers, such as social services, health services, schools, and legal support services (Gillett, 2004; Glang, Tyler, Pearson, Todis, & Morvant, 2004). These complex interventions reflect the heterogeneous forms of need following TBI, and have resulted in the development of key-coordinator roles to manage holistic community-based rehabilitation and school-based rehabilitation strategies (Gillett, 2004).

1.1. Objectives

The main objective of this systematic review was to examine the effectiveness of existing community-based supports and intervention programmes available to adolescents following TBI. For the purposes of this review, a community-based intervention was defined by setting and geographical location, including those delivered in a home environment via the internet, or using community facilities. For widespread coverage of community-based rehabilitation strategies, all settings outside of clinical inpatient care and school-based rehabilitation were included. This was to ensure that neither the context of intervention development nor where the intervention was initiated could bias the types of interventions included. It also guaranteed full-coverage across disciplines and sectors, including those which integrate multiple services, and those which involve repeated contact with professionals outside of a community setting.

2. Methods

2.1. Search strategy

A comprehensive search of peer-reviewed studies was conducted in ten databases: Medline(Pubmed); Medline(Ovid); PubMed Central; PSYCHinfo; EBSCOhost; JSTOR; Cochrane Library; Web of Science; ASSIA and Scopus. In each search, all combinations of keywords were grouped into those relating to sample age, injury, intervention, intervention delivery setting, and outcomes. Adaptations to search strategies were made as per the requirements of individual databases. The reference lists of included studies were also examined, alongside a keyword search of the grey literature.

2.2. Eligibility criteria

Studies were eligible for inclusion if they involved a clear clinical population group diagnosed with a TBI or concussion. If the sample was inclusive of other forms of acquired brain injury, studies were only included if the TBI data was presented separately. To ensure a comprehensive view of community-based interventions there was no specific diagnostic criteria of TBI required for studies to be included. The searches were limited to a sample age of 11 to 25 years inclusive; studies including children or adults outside of this range were only included if the data for the required age range was presented separately. Included studies had to apply intentional interventions that were delivered in a community setting, such as web-based packages accessed at home, or rehabilitation programmes in the local youth centre. Interventions delivered in schools, hospital or neurorehabilitation inpatient settings were excluded. Research designs had to be experimental, and include at least two points of measurement, including one at baseline and one post-intervention. Qualitative studies and opinion articles were excluded. All outcome measures were considered. No restrictions were placed on the year of publication of the study, with databases searched in their entirety. No language restrictions were applied, and the searches were completed in March 2017.

2.3. Study selection and data extraction

Results from all databases were merged using reference management software and duplicates were removed. All abstracts from the initial search were reviewed by two independent reviewers and categorised into (i) ‘likely include’, (ii) ‘maybe include’, and (iii) ‘exclude’. The same method was followed for secondary abstract screening, and lastly full text review, using a study inclusion form to identify eligible studies. In the cases where reviewers disagreed, a third reviewer resolved this by reaching a consensus. A log of decisions at each strategy was maintained to provide an audit trail.

Two independent reviewers then used a data extraction form to systematically obtain the relevant data items for assessment. The data items extracted from each study included: study characteristics; overall intervention focus; specific characteristics of the intervention; delivery setting; mode and intensity of delivery; intervention provider; economic and replication costs of the intervention; outcome measurements; summary of intervention effectiveness; and conclusions of the study. Due to the clinical heterogeneity and marked variation in the components, modes and delivery of interventions, and intended outcomes, a meta-analysis could not be conducted.

2.4. Risk of bias assessment

The methodological quality of studies was assessed using a strategy based on the guidelines proposed by Hayden and colleagues-(2006). This strategy involves assessing risk of bias on 25 separate domains, which are grouped into six key areas including: study participation; study attrition; prognostic factor measurement; outcome measurement; confounding measurement and account; and analysis. On each domain study quality was categorised as either: (i) ‘criteria fulfilled’; (ii) ‘criteria partly fulfilled’; (iii) ‘criteria not fulfilled’; (iv) ‘unclear whether criteria fulfilled’; or (v) ‘criteria not applicable’. The quality of evidence for each of these key areas was summarized according to a template that was consistent with that of the Scottish Intercollegiate Guidelines Network (SIGN) methodology (Mollayeva et al., 2014). For each of the 6 key areas, studies are categorized into a methodological quality hierarchy of: ‘high quality’ (+++) when all or most of the quality criteria in an area are fulfilled; ‘good quality’ (++) when the majority of criteria are fulfilled;

‘fair quality’ (+) when few criteria are fulfilled; and ‘low quality’ (-) when no criteria are fulfilled. Decisions were recorded at every stage of the assessment process.

INSERT FIGURE 1 HERE

3. Results

Figure 1 outlines the phases of the review. The search strategy initially identified 3226 records, which was reduced to 2390 after removing duplicates. Following the first stage of abstract review, 2140 articles were excluded, predominantly because no intervention was described, or the intervention was targeting adults or a non-brain injured population, or was not community-based. At this stage, there was inter-reviewer agreement for 2253 studies reviewed (94%). At the second stage of screening 250 studies were reviewed using abstracts and supplementary full-texts when clarification was needed. At this stage 223 studies were excluded. The third and final full-text screening stage resulted in 17 studies being assessed as eligible for inclusion in the review, with inter-rater agreement at 100%.

Examination of the reference lists of included studies revealed a further 4 potential studies, which were then excluded for reasons including: a qualitative research design; an acquired brain injury sample without a TBI subgroup; or a sample outside of the age range specified for inclusion. Searches of the grey literature resulted in the further identification of 9 interventions developed by service providers for adolescents with TBI, from animal-assisted therapies, to exercise therapies. However, there were no available assessments of adolescent outcomes for the interventions found, resulting in their exclusion from the review.

INSERT TABLE 1 HERE

Table 1 includes summary characteristics for each of the seventeen eligible studies. Included studies were published from 1998 to 2017, and were predominantly conducted in the USA (n=14), with one study each conducted in Australia, the Republic of Ireland, and Canada. Eleven distinct community-based interventions for adolescents with TBI were identified in the included studies. Of the eligible studies, seven used a randomized control trial design, two were randomized control pilot studies, seven used case study designs, and the last used a single-arm design, which involves only one treatment group, and therefore no randomization.

INSERT TABLE 2 HERE

3.1. Study quality

Table 2 provides a detailed account of individual study bias ratings. Inter-rater agreement in assessing risk of bias was good at 88%. Overall, potential risk of bias in the included studies was highly variable, which is a reflection of the quality and range of study designs. Risk of bias assessment of study participation found that whilst reporting was clear for some included studies, in others it was not, making risk of bias difficult to assess (study participation). It was also more difficult to assess participation bias due to case study designs. The prognostic factor for all studies included was brain injury. Assessment of whether TBI was adequately measured (prognostic measurement) found that comprehensive diagnostic criteria (such as that of the Diagnostic and Statistical Manual of Mental Disorders, 5th edition) were often not followed, with many studies dependent on loss of consciousness measures alone, yet not clearly reporting their interpretation of score when diagnosing severity (e.g. Glasgow Coma Scale). The risk of bias assessment of whether outcomes were adequately measured (outcome measurement) showed that the case studies tended to be of lower quality, due to the use of non-validated scales, self-reported observations dependent on memory, and caregiver- and staff- observation at limited time points. There appeared to be less consideration of confounders in research design (confounding measurement and account), which resulted in an increase in the number of studies considered lower quality.

INSERT TABLE 3 HERE

3.2. Intervention features

Table 3 shows a summary of the intervention components used in each included study. All interventions included neurorehabilitation approaches with an aim to circumvent any impairments by developing strengths, either through a compensatory (n=14), or restorative approach (n=3) (SIGN, 2013).

Interventions sought to address specific aspects of neurorehabilitation across the range of categories developed by SIGN (2013), which include: physical rehabilitation and management; cognitive rehabilitation; rehabilitation of behavioural and emotional disorders; communication and swallowing; and vocational rehabilitation. Cognitive rehabilitation strategies included an intervention targeting gist reasoning and memory, attention process training, and assistive technology to aid orientation. Behavioural and emotional rehabilitation included verbal and non-verbal communication, social participation, and behaviour management techniques. Rehabilitation of communication problems included providing supportive relationships for service users', and a theatre-based creative arts therapy seemingly focused on intonation and prosody using strategies, such as voicework, breathing, movement, character development, and group dynamics. The vocational rehabilitation interventions provided social and communication support strategies and functional skills training to compensate for any residual impairments.

It should be noted that the same web-based counsellor assisted problem-solving intervention (CAPS) was replicated in five different studies, which use similar study design, and the same sample population. (Study identifiers in table: ‘Kurowski 2013’;- ‘Tlustos 2016’; ‘Wade 2014’;-‘Wade, Kurowski…2015’; Wade, Taylor…2015’) These studies used a comprehensive approach to rehabilitation, focused on family problem-solving and adjustment, as well as emphasizing specific strategies regarding individual behavioural, social, and cognitive rehabilitation. CAPS was designed with the participation of assigned clinical psychologists to deliver counselling, which involved designing a treatment overview, goal planning, and assistance coping with injury-related issues. A further three studies also described a Teen Online Problem Solving intervention (TOPS), which also used a similar comprehensive rehabilitation approach consisting of self-guided web exercises and linked family video-conference therapy sessions (Wade, Walz, Carey, & Williams, 2008; Wade et al., 2010; Wade et al., 2011).

A variety of underlying intervention components were used to deliver these neurorehabilitation strategies, from using a creative arts therapy to a computerised gist reasoning training package. In all of the included studies, interventions were delivered in community-based settings, either solely face-to-face (n=6), via a combination of face-to-face, web-based, and/or by phone (n=11).

INSERT TABLE 4 HERE

3.3. Effectiveness of the interventions

A summary of key findings related to the effectiveness of the interventions is reported in Table 4. All studies concluded that their community-based intervention seemed to have some level of improvement for persons with TBI. This is despite six of the studies providing only descriptive statistics, with one reporting such data graphically (although unclear labelling made it difficult to assess the impact of the intervention). These studies reported descriptive improvements in social skills (O'Reilly, Lancioni, & O'Kane, 2000), social participation (Johnson & Davis, 1998), caregiver-burden (Palmisano & Arco, 2007), productivity (Feeney & Achilich, 2014), behavioural difficulties (Feeney & Achilich, 2014), orientation (Kirsch et al., 2004), and communication (Agnihotri et al., 2014). One of the CAPS studies reported results approaching significance, which suggested possible improvements in social skills (Tlustos et al., 2016), and an Attention Process Training intervention reported no meaningful functional change in attentional capacity however discussed the possibiliy of some improvement having occurred.

Nine studies reported statistically significant results regarding treatment effect (Cook, Chapman, Elliott, Evenson, & Vinton, 2014; Kurowski et al., 2013; Wade et al., 2008; Wade et al., 2010; Wade et al., 2011; Wade et al., 2014; Wade, Kurowski et al., 2015; and Wade, Taylor et al., 2015; Babcock et al., 2017). Of these, Cohen’s d effect sizes were reported in three (Cook, Chapman, Elliott, Evenson, & Vinton, 2014; Kurowski et al., 2013; and Wade et al., 2008). All effect sizes were moderate to strong and ranged from .580 to 1.868. The cognitive training intervention, self-management intervention, and the comprehensive approach of CAPS and TOPS were the only strategies which led to statistically significant improvements. However, this is in part due to the creative arts and social skills interventions being case studies with limited outcome data collected.

Four studies reported statistically significant similar improvement in executive functioning. One of these studies used cognitive training through a gist-reasoning intervention and found an increase in performance on a working memory and inhibition task (p = .02, d = .939), alongside statistically significant improvement in three gist reasoning tasks (p = < .01, d = 1.868; p = .04, d = .750; p = .04, d = .766) (Cook, Chapman, Elliott, Evenson, & Vinton, 2014). The second study used self-management training strategies and found an increase in parent-reported executive functioning (p = .03) (Babcock et al., 2017). The third study used the TOPS multi-component intervention and reported an increase in executive functioning only for more severely injured participants (p < .05) (Wade et al, 2010). The final study used the CAPS multi-component intervention and found an increase in executive functioning for the older subgroup (p = .01, d = .630), although this was not the case for the sample as a whole, nor the younger subgroup (Kurowski et al., 2013).

In addition to executive functioning, both the CAPS and the TOPS interventions resulted in statistically significant improvement in behavioural functioning, depression, and/or community functioning. One of the CAPS studies reported a significant decrease in problematic behavioural functioning post-intervention, including decreases in internalizing (p < .05), aggressive (p < .05), attention problems (p < .05), ADHD (p < .05), and conduct disorder symptoms (p < .05) (Wade et al., 2014). A decrease in externalizing behaviours was reported consistently at multiple follow up points compared to an internet resource comparison (p < .01; p = .01; p < .01) (Wade, Taylor, et al., 2015). One of the TOPS studies also found a decrease in internalizing behaviours for the intervention group (p = .03, d = .580) (Wade et al., 2008). However, another TOPS study found the decrease in parent reported internalizing behaviour was limited to those with a higher injury severity (p = .01). Similarly, improvements in parent reported externalizing behaviours were also moderated, though by socio-economic status; results showed a decrease for those from a lower SES following the TOPS intervention (p = .09). Conversely in the same study, adolescent reported externalizing behaviours decreased significantly only for participants of higher income families (p = .01) (Wade et al., 2011).

Additionally post-TOPS a significant reduction in depressive symptoms for both adolescent (p = .02, d = .750) and parent (p = .01, d = .800) was reported, as well as significant improvement in a number of adolescent-parent family dynamics. The study also reported decreases in parent-adolescent conflict (p = .04, d = .740), number of parent-adolescent problem issues (p = .01, d = .920) and in ratings of severity of family problems (p = .01, d = 1.450) (Wade et al., 2008). A further TOPS study also reported a significant decrease in parent-adolescent conflict (p < .01) (Wade et al., 2011). Another study reported a significant increase in community functioning post-CAPS (p = .04) (Wade, Kurowski, et al., 2015). A vocational rehabilitative skills study also reported significant reductions in perceived adolescent-related symptom burden for both parents and adolescents (p < .01; p < 0.01), and for parent-reported functional disability (p < .01) (Babcock et al., 2017).

Eight of the studies reported on outcomes at least 6 months post intervention (Agnihotri et al., 2014; Kurowski et al., 2013; Tlustos et al., 2016; Wade et al., 2010; Wade et al., 2011; Wade, et al., 2014), with a follow up period of 18 months for two of the CAPS studies (Wade, Kurowski et al., 2015; Wade, Taylor, et al., 2015). In the remaining studies, the follow up period was 8 weeks or less (Babcock, et al, 2007; Cook et al., 2014; Johnson & Davis, 1998; Kirsch et al., 2004; O’Reilly et al., 2000; Palmisano et al., 2007; Youse et al., 2009), with two studies capturing outcomes only at the end of the intervention (Feeney et al., 2014; Wade et al, 2008).

3.4. Costs and resources required to replicate interventions

Costs and resources associated with the interventions are presented in table 1. The resources required to replicate the CAPS intervention, whilst systematically incorporating it into clinical practice, are high; the continued involvement of a trained clinical psychologist and the therapy provided is a core component of the intervention (Kurowski et al., 2013; Tlustos et al., 2016; Wade et al., 2014; Wade, Kurowski et al., 2015; and Wade, Taylor et al,. 2015). Whilst the mode of delivery was generally web-based, clinicians attended the service user's home address for an initial 90-minute meeting, and scheduled biweekly meetings with service users over the duration of three months. Considering the potential demand, a large time and resource commitment would be required to help ensure that service provision is adequate. Similar comments can be made regarding the TOPS intervention and the other problem-solving intervention, which both also involved continued clinical participation (O'Reilly et al., 2000; Wade et al., 2008; Wade et al., 2010; Wade et al., 2011).

The creative arts theatre-based intervention also required professional involvement, from professional theatre artists or equivalent; however as a group based intervention it has the potential to be scaled up (Agnihotri et al., 2014). The cognitive training gist-reasoning intervention involved an 'interventionist' having to complete approximately 30 hours of in-person training to be considered qualified to conduct the intervention, which then also had to be delivered in-person, individually, increasing the resources needed (Cook et al., 2014). Similarly, although the assistive technology intervention was largely web-based, this was sometimes supplemented by a one-to-one therapist retracing the route alongside the participant. Furthermore the lack of sustainability of treatment gains suggest that an even longer duration of intervention is required for consolidation, further increasing the resources needed (Kirsch et al., 2004).

Other interventions, such as the comprehensive daily goal planning, routine management, communication, and behavioural consequence interventions, did not require staff training to implement the intervention, reducing resources needed; however each intervention was individualised and required significant preplanning and development

(Feeney & Achilich, 2014; Palmisano & Arco, 2007). The supported relationships intervention required active engagement and participation from an interest-matched nondisabled community participant, which was not always possible, perhaps suggesting that the commitment was too great (Johnson & Davis, 1998). This was also a component of the Attention Process Training, alongside active participation from a therapist (Youse et al., 2009).

4. Discussion

To our knowledge this is the first comprehensive systematic review of community-based interventions and supports for adolescents following TBI. In contrast to another review in this area which focuses on hospital to school reintegration following paediatric ABI (Lindsay et al., 2015), our review considers the home and wider community as an additional resource to hospital- and school-based rehabilitation. Our focus on a community-based delivery setting provides a summarized and evaluative resource of effective interventions for community-based rehabilitation services for adolescents following TBI. However, despite this review identifying seventeen different studies, covering eleven distinct community-based interventions for adolescents following TBI, the quality and applicability of the evidence is limited and highly variable. This finding is consistent with the conclusions of other paediatric TBI rehabilitation systematic reviews and meta-analyses, suggesting limited development of the research area despite repeated calls for higher quality evidence (Rosema, Crowe, & Anderson, 2012; Lindsay et al., 2015; Ross, Dorris, & McMillan, 2011; Laatsch et al., 2007).

In our review, only the CAPS and TOPS multi-component interventions have an evidence base strong enough to support their more general use as a community-based rehabilitation tool (Kurowski et al., 2013; Tlustos et al., 2016; Wade et al., 2014;-Wade, Kurowski et al., 2015; and Wade, Taylor et al., 2015; Wade et al., 2008; Wade et al., 2010;

Wade et al., 2011). Whilst these studies largely report significant treatment effect reduction in symptoms and injury-related challenges that is sustained from 6 to 18 months after intervention, CAPS appears to be age-sensitive and subsequently only helpful for older adolescents. Similarly, reduction of symptoms following TOPS was found to be moderated by both injury severity and SES. In addition, studies were often completed by the same group of researchers, in the same geographical location, with what appears to be the same cohort of participants. The generalizability of these findings, and therefore the application of these interventions to other populations, therefore remains in question. Additionally, the interventions need to be evaluated to see how successfully they may be integrated into community-based intervention programs elsewhere, and the costs and resources required in doing so fully assessed.

The remaining studies have either not been replicated in this population, have limited descriptive statistical analysis, low power, or a combination of other limitations, such as inadequate information in relation to costs, feasibility, and possible harms. In the seven case studies reported outcome measurements were not comprehensive, either quantitatively or qualitatively (Agnihotri et al., 2014; Feeney et al., 2014; Johnson & Davis, 1998; Kirsch et al., 2004; O'Reilly et al., 2000; Palmisano et al., 2007; Youse et al., 2009). Two studies were pilot interventions with small sample sizes, and so are likely to be underpowered (Cook et al., 2014; Wade et al., 2008). Nine of the studies offered no evidence as to the sustainability of any improvements in functioning beyond an immediate two month period (Babcock, et al, 2007; Feeney et al., 2014; Johnson & Davis, 1998; Kirsch et al., 2004; O'Reilly et al., 2000; Palmisano et al., 2007; Wade et al, 2008; Youse et al., 2009).

Nonetheless, the evidence identified through this systematic review suggests the potential for various modes of community-based rehabilitation to improve a broad range of functional domains known to be affected by paediatric TBI. In particular, the studies of

CAPS and TOPS suggest the particular potential of web-based approaches to support adolescents following TBI. Such findings are echoed elsewhere in the evaluation of other interventions for this age group (Hamel & Robbins, 2013; Hamel, Robbins, & Wilbur, 2011; Stinson, Wilson, Gill, Yamada, & Holt, 2009), suggesting value in broader application and replication of these studies. There are also several interventions in the process of being developed which may provide new forms of rehabilitative support, such as app-based coaching to promote social participation in adolescents with TBI (Bedell, Wade, Turkstra, Haarbauer-Krupa, & King, 2017).

4.1. Review limitations

Due to heterogeneity in study design there was some difficulty making valid comparisons in this review; definition of injury severity, time since injury, and age-related group comparisons are all important predictors of outcome, and when they were reported there was large variation. Due to these factors, only a limited evaluation of the interventions could be conducted, and this is exacerbated by incomplete reporting, particularly regarding details of the intervention. Despite the use of a comprehensive search strategy, devised in consultation with an experienced librarian, limiting the search to studies to articles published in peer-reviewed journals may leave some publication bias, due to the likelihood of some service evaluations appearing as reports in the grey literature, although attempts were made to highlight such literature. Data synthesis was challenging; the large heterogeneity of included studies meant that conducting a meta-analysis would have been meaningless, misleading, and possible harmful. However, even descriptive synthesis was difficult making comprehensive internal quality appraisals more problematic.

5. Conclusion

Community-based interventions and supports have the potential to improve outcomes for adolescents following TBI, nonetheless the collective evidence base remains weak, with a lack of robust study designs or replicated studies. The limited scope of the interventions available, and the clear dominance in the size and quality of the evidence base of a single intervention, does not provide a clear answer as to what community-based intervention interventions are of particular value. In this context, evaluation design is key, as the case for the effectiveness of an intervention is determined by the quality of the study design; even the most effective intervention will fail to influence practice development if its evidence base remains weak. A step change is therefore needed. Practitioners and researchers need to get wiser when demonstrating impact, to highlight best practice and therefore inform future service funding, development and delivery. This means greater emphasis on robust study design, larger sample sizes (where possible), and replication of studies, as well as ensuring analysis takes adequate consideration of the context of service delivery and possible confounders.

Of course, the push for such an evidence base cannot ignore or deny the complexities of this service context. It must be acknowledged that effective support for this population is likely to require multicomponent interventions that are necessarily responsive to the specific needs of the individual service user, as seen in many of the interventions evaluated here. Therefore, there must be recognition that experimental designs requiring randomisation, manualised approaches, and treatment integrity might not serve to identify promising approaches. It is also clear that costs of robust evaluation are prohibitive, particularly in a context of low resources, in which the funding of services and support is understandably prioritised. Appropriate experimental design is therefore required to establish an initial evidence base, before these interventions can be successfully integrated into community-based intervention programs.

Conflicts of Interest

None

References

Agnihotri, S., Gray, J., Colantonio, A., Polatajko, H., Cameron, D., Wiseman-Hakes, C., . . . Keightley, M. (2014). Arts-based social skills interventions for adolescents with acquired brain injuries: five case reports. Developmental Neurorehabilitation, 17(1), 44-63. doi:10.3109/17518423.2013.844739

Anderson, V., & Catroppa, C. (2006). Advances in Postacute Rehabilitation After Childhood-Acquired Brain Injury: A Focus on Cognitive, Behavioral, and Social Domains. American Journal of Physical Medicine and Rehabilitation, 85(9). doi:10.1097/01.phm.0000233176.08480.22

Anderson, V., Levin, H., & Jacob, R. (2002). : Developmental and acquired lesions of the frontal lobes in children: Neuropsychological implications. In D. Stuss & R. Knight (Eds.), Principles of Prontal Lobe Function. New York: OUP.

Arain, M., Haque, M., Johal, L., Mathur, P., Nel, W., Rais, A., . . . Sharma, S. (2013). Maturation of the adolescent brain. In Neuropsychiatric Disease and Treatment (Vol. 9, pp. 449-461).

Bedell, G. M., Wade, S. L., Turkstra, L. S., Haarbauer-Krupa, J., & King, J. A. (2017). Informing design of an app-based coaching intervention to promote social participation of teenagers with traumatic brain injury. Developmental Neurorehabilitation, 20(7), 408-417. doi:10.1080/17518423.2016.1237584

Casey, B. J., Jones, R. M., & Hare, T. A. (2008). The adolescent brain. Annals of the New York Academy of Sciences, 1124(1), 111-126.

Catale, C., Marique, P., Closset, A., & Meulemans, T. (2009). Attentional and executive functioning following mild traumatic brain injury in children using the Test for Attentional Performance (TAP) battery. Journal of Clinical and Experimental Neuropsychology, 31(3), 331-338. doi:10.1080/13803390802134616

Catroppa, C., & Anderson, V. (2004). Recovery and predictors of language skills two years following pediatric traumatic brain injury. Brain and Language, 88(1), 68-78.

Catroppa, C., Anderson, V., Godfrey, C., & Rosenfeld, J. V. (2011). Attentional skills 10 years post-paediatric traumatic brain injury (TBI). Brain Injury, 25(9), 858-869. doi:10.3109/02699052.2011.589794

Catroppa, C., Crossley, L., Hearps, S. J., Yeates, K. O., Beauchamp, M., Rogers, K., & Anderson, V. (2015). Social and behavioral outcomes: pre-injury to six months following childhood traumatic brain injury. Journal of Neurotrauma, 32(2), 109-115. doi:10.1089/neu.2013.3276

Chevignard, M. P., Brooks, N., & Truelle, J. L. (2010). Community integration following severe childhood traumatic brain injury. Current Opinion in Neurology, 23(6), 695-700. doi:10.1097/WCO.0b013e328340296f

Cook, L. G., Chapman, S. B., Elliott, A. C., Evenson, N. N., & Vinton, K. (2014). Cognitive gains from gist reasoning training in adolescents with chronic-stage traumatic brain injury. Frontiers in Neurology, 5, 87. doi:10.3389/fneur.2014.00087

Cronin, A. F. (2001). Traumatic brain injury in children: issues in community function. American Journal of Occupational Therapy, 55(4), 377-384.

Crowe, L. M., Anderson, V., Barton, S., Babl, F. E., & Catroppa, C. (2014). Verbal ability and language outcome following traumatic brain injury in early childhood. Journal of Head Trauma Rehabilitation, 29(3), 217-223. doi:10.1097/HTR.0b013e31829babfd

Di Scala, C., Osberg, J. S., & Savage, R. C. (1997). Children Hospitalized for Traumatic Brain Injury: Transition to Postacute Care. Journal of Head Trauma Rehabilitation, 12(2), 1-10.

Feeney, T. J., & Achilich, J. (2014). Structured flexibility and context-sensitive behavioral support for the chronically cranky. NeuroRehabilitation, 34(4), 709-723. doi:10.3233/nre-141088

Ganesalingam, K., Yeates, K. O., Taylor, H. G., Walz, N. C., Stancin, T., & Wade, S. (2011). Executive functions and social competence in young children 6 months following traumatic brain injury. Neuropsychology, 25(4), 466-476. doi:10.1037/a0022768

Gillett, J. (2004). The Pediatric Acquired Brain Injury Community Outreach Program (PABICOP) - an innovative comprehensive model of care for children and youth with an acquired brain injury. NeuroRehabilitation, 19(3), 207-218.

Glang, A., Tyler, J., Pearson, S., Todis, B., & Morvant, M. (2004). Improving educational services for students with TBI through statewide consulting teams. NeuroRehabilitation, 19(3), 219-231.

Gunter, T. D., Chibnall, J. T., Antoniak, S. K., Philibert, R. A., & Black, D. W. (2013). Childhood trauma, traumatic brain injury, and mental health disorders associated with suicidal ideation and suicide-related behavior in a community corrections sample. Journal of the American Academy of Psychiatry and the Law, 41(2), 245-255.

Hamel, L. M., & Robbins, L. B. (2013). Computer- and web-based interventions to promote healthy eating among children and adolescents: a systematic review. Journal of Advanced Nursing, 69(1), 16-30. doi:10.1111/j.1365-2648.2012.06086.x

Hamel, L. M., Robbins, L. B., & Wilbur, J. (2011). Computer- and web-based interventions to increase preadolescent and adolescent physical activity: a systematic review. Journal of Advanced Nursing, 67(2), 251-268. doi:10.1111/j.1365-2648.2010.05493.x

Hawley, C., Ward, A., Magnay, A., & Mychalkiw, W. (2004). Return to school after brain injury. Archives of Disease in Childhood, 89(2), 136-142. doi:10.1136/adc.2002.025577

Hayden, J. A., Cote, P., & Bombardier, C. (2006). Evaluation of the quality of prognosis studies in systematic reviews. Annals of Internal Medicine, 144(6), 427-437.

Johnson, K., & Davis, P. K. (1998). A supported relationships intervention to increase the social integration of persons with traumatic brain injuries. Behaviour Modification, 22(4), 502-528. doi:10.1177/01454455980224004

Kirsch, N. L., Shenton, M., Spirl, E., Rowan, J., Simpson, R., Schreckenghost, D., & LoPresti, E. F. (2004). Web-based assistive technology interventions for cognitive impairments after traumatic brain injury: A selective review and two case studies. Rehabilitation Psychology, 49(3), 200.

Kurowski, B. G., Wade, S. L., Kirkwood, M. W., Brown, T. M., Stancin, T., & Taylor, H. G. (2013). Online problem-solving therapy for executive dysfunction after child traumatic brain injury. Pediatrics, 132(1), e158-166. doi:10.1542/peds.2012-4040

Laatsch, L., Harrington, D., Hotz, G., Marcantuono, J., Mozzoni, M. P., Walsh, V., & Hersey, K. P. (2007). An evidence-based review of cognitive and behavioral rehabilitation treatment studies in children with acquired brain injury. Journal of Head Trauma Rehabilitatin, 22(4), 248-256. doi:10.1097/01.HTR.0000281841.92720.0a

Lash, M. (2004). Children and Youth with Traumatic Brain Injury. NeuroRehabilitation, 19(3), 173-174.

Linden, M. A., Braiden, H. J., & Miller, S. (2013). Educational professionals' understanding of childhood traumatic brain injury. Brain Injury, 27(1), 92-102. doi:10.3109/02699052.2012.722262

Lindsay, S., Hartman, L. R., Reed, N., Gan, C., Thomson, N., & Solomon, B. (2015). A systematic review of hospital-to-school reintegration interventions for children and youth with acquired brain injury. PLoS one, 10(4), e0124679.

Max, J. E., Levin, H. S., Landis, J., Schachar, R., Saunders, A., Ewing-Cobbs, L., . . . Dennis, M. (2005). Predictors of personality change due to traumatic brain injury in children and adolescents in the first six months after injury. Journal of the American Academy of Child and Adolescent Psychiatry, 44(5), 434-442. doi:10.1097/01.chi.0000156280.66240.61

McKinlay, A., Corrigan, J., Horwood, L. J., & Fergusson, D. M. (2014). Substance abuse and criminal activities following traumatic brain injury in childhood, adolescence, and early adulthood. Journal of Head Trauma Rehabilitation, 29(6), 498-506. doi:10.1097/htr.0000000000000001

Mollayeva, T., Kendzerska, T., Mollayeva, S., Shapiro, C. M., Colantonio, A., & Cassidy, J. D. (2014). A systematic review of fatigue in patients with traumatic brain injury: the course, predictors and consequences. Neuroscience and Biobehavioural Reviews, 47, 684-716. doi:10.1016/j.neubiorev.2014.10.024

Moore, M., Jimenez, N., Rowhani-Rahbar, A., Willis, M., Baron, K., Giordano, J., . . . Ebel, B. E. (2016). Availability of Outpatient Rehabilitation Services for Children After Traumatic Brain Injury: Differences by Language and Insurance Status. American Journal of Physical Medicine and Rehabilitation, 95(3), 204-213. doi:10.1097/phm.0000000000000362

O'Reilly, M., Lancioni, G. E., & O'Kane, N. (2000). Using a problem-solving approach to teach social skills to workers with brain injuries in supported employment settings - IOS Press. Journal of Vocational Rehabilitation, 14(3), pp. 187-194.

Palmisano, B., & Arco, L. (2007). Changes in Functional Behaviour of Adults With Brain Injury and Spouse-Caregiver Burden With In-Home Neurobehavioural Intervention. Behaviour Change, 24(1), 36-49. doi:10.1375/bech.24.1.36

Parsonage, M. (2016). Traumatic brain injury and offending: An economic analysis. Retrieved from https://www.centreformentalhealth.org.uk/traumatic-brain-injury

Rosema, S., Crowe, L., & Anderson, V. (2012). Social function in children and adolescents after traumatic brain injury: A systematic review 1989–2011. Journal of neurotrauma, 29(7), 1277-1291.

Ross, K. A., Dorris, L., & McMillan, T. (2011). A systematic review of psychological interventions to alleviate cognitive and psychosocial problems in children with acquired brain injury. Developmental Medicine & Child Neurology, 53(8), 692-701.

Ryan, N. P., Hughes, N., Godfrey, C., Rosema, S., Catroppa, C., & Anderson, V. A. (2015). Prevalence and predictors of externalizing behavior in young adult survivors of pediatric traumatic brain injury. The Journal of head trauma rehabilitation, 30(2), 75-85.

Savage, R. C., DePompei, R., Tyler, J., & Lash, M. (2005). Paediatric traumatic brain injury: a review of pertinent issues. Pediatric Rehabilitation, 8(2), 92-103.

Semrud-Clikeman, M. (2010). Pediatric traumatic brain injury: rehabilitation and transition to home and school. Applied Neuropsychology, 17(2), 116-122. doi:10.1080/09084281003708985

Scottish Intercollegiate Guidelines Network (SIGN). (2013). Brain injury rehabilitation in adults: a national clinical guideline. Edinburgh: SIGN; 2013. (SIGN publication no. 130). Available from URL: http://www.sign.ac.uk

Stinson, J., Wilson, R., Gill, N., Yamada, J., & Holt, J. (2009). A systematic review of internet-based self-management interventions for youth with health conditions. Journal of Pediatric Psychology, 34(5), 495-510. doi:10.1093/jpepsy/jsn115

Stoddard, S. A., & Zimmerman, M. A. (2011). Association of Interpersonal Violence With Self-Reported History of Head Injury. Pediatrics, 127(6). doi:10.1542/peds.2010-2453

Tlustos, S. J., Kirkwood, M. W., Taylor, H. G., Stancin, T., Brown, T. M., & Wade, S. L. (2016). A randomized problem-solving trial for adolescent brain injury: Changes in social competence. Rehabilitation Psychology, 61(4), 347-357. doi:10.1037/rep0000098

Wade, S. L., Kurowski, B. G., Kirkwood, M. W., Zhang, N., Cassedy, A., Brown, T. M., . . . Taylor, H. G. (2015). Online Problem-Solving Therapy After Traumatic Brain Injury: A Randomized Controlled Trial. Pediatrics, 135(2), e487-495. doi:10.1542/peds.2014-1386

Wade, S. L., Stancin, T., Kirkwood, M., Brown, T. M., McMullen, K. M., & Taylor, H. G. (2014). Counselor-assisted problem solving (CAPS) improves behavioral outcomes in older adolescents with complicated mild to severe TBI. Journal of Head Trauma Rehabilitation, 29(3), 198-207. doi:10.1097/HTR.0b013e31828f9fe8

Wade, S. L., Taylor, H. G., Cassedy, A., Zhang, N., Kirkwood, M. W., Brown, T. M., & Stancin, T. (2015). Long-Term Behavioral Outcomes after a Randomized, Clinical Trial of Counselor-Assisted Problem Solving for Adolescents with Complicated Mild-to-Severe Traumatic Brain Injury. Journal of Neurotrauma, 32(13), 967-975. doi:10.1089/neu.2014.3684

Wade, S. L., Walz, N. C., Carey, J., McMullen, K. M., Cass, J., Mark, E., & Yeates, K. O. (2011). Effect on behavior problems of teen online problem-solving for adolescent traumatic brain injury. Pediatrics, 128(4), 947-953.

Wade, S. L., Walz, N. C., Carey, J. C., & Williams, K. M. (2008). Preliminary efficacy of a Web-based family problem-solving treatment program for adolescents with traumatic brain injury. Journal of head trauma rehabilitation, 23(6), 369-377. doi:10.1097/01.htr.0000341432.67251.48

Wade, S. L., Walz, N. C., Carey, J., Williams, K. M., Cass, J., Herren, L., ... & Yeates, K. O. (2010). A randomized trial of teen online problem solving for improving executive function deficits following pediatric traumatic brain injury. The Journal of Head Trauma Rehabilitation, 25(6), 409-415.

Yen, H. L., & Wong, J. T. (2007). Rehabilitation for traumatic brain injury in children and adolescents. Annals Academy of Medicine Singapore, 36(1), 62-66.

Ylvisaker, M. (1998). Traumatic brain injury rehabilitation: Children and adolescents (2 ed.). Woburn, MA: Butterworth-Heinemann.

Youse, K. M., & Coelho, C. A. (2009). Treating underlying attention deficits as a means for improving conversational discourse in individuals with closed head injury: A preliminary study. Neurorehabilitation, 24(4), 355-364.