Predictors of activities and participation six months after mild traumatic brain injury in children and adolescents

European Journal of Paediatric Neurology 25 (2020) 145–156

Contents lists available at ScienceDirect

European Journal of Paediatric Neurology

Original article

Predictors of activities and participation six months after mild traumatic brain injury in children and adolescents

M. Irene Renaud [a, b, c], Suzanne A.M. Lambregts [a, d], Ingrid G.L. van de Port [a], Coriene E. Catsman-Berrevoets [e], Caroline M. van Heugten [b, c, f, *]

[a] Revant Rehabilitation Centre, Breda, the Netherlands
[b] Department of Neuropsychology and Psychopharmacology, Maastricht University, Maastricht, the Netherlands
[c] Limburg Brain Injury Center, Maastricht, the Netherlands
[d] Erasmus University Hospital/Sophia Children's Hospital, Department of Rehabilitation Medicine, Rotterdam, the Netherlands
[e] Erasmus University Hospital/Sophia Children's Hospital, Department of Paediatric Neurology, Rotterdam, the Netherlands
[f] School for Mental Health and Neuroscience, Maastricht University Medical Centre, Maastricht, the Netherlands

A R T I C L E I N F O

Article history:
Received 20 June 2019
Received in revised form
30 September 2019
Accepted 19 November 2019

Keywords:
Mild traumatic brain injury
Predictors
Activities and participation
Children

A B S T R A C T

Objective: This study aimed to identify predictors of long-term consequences for activities and participation in children and adolescents with mild traumatic brain injury (mTBI).
Methods: A multicentre prospective longitudinal cohort study was conducted. The primary outcome measure was activities and participation measured with the Child and Adolescent Scale of Participation – CASP and completed by children (N = 156) and caregivers (N = 231) six months post-mTBI. The CASP items were categorized into home, community, school, and environment. Predictors were categorized according to the International Classification of Functioning, Disability and Health for Children and Youth. Predictors included pre-injury personal- and environmental factors, injury-related factors, symptoms, and resumption of activities in the first two weeks after mTBI. Univariate and multivariate logistic regression analyses were used to determine the predictive value of these factors.
Results: Results show that predictors differ across settings and perspectives (child or caregiver). Decreased activities and participation in children with mTBI can be predicted by adverse pre-injury behavioral functioning of the child ($p < .000 - p = .038$), adverse pre-injury family functioning ($p = .001$), lower parental SES ($p = .038$), more stress symptoms post-injury ($p = .017 - p = .032$), more post-concussive symptoms ($p = .016 - p = .028$) and less resumption of activities ($p = .006 - p = .045$).
Discussion: Pre-injury factors, more symptoms post-injury and less resumption of activities should be considered when children are screened for unfavorable outcomes. Additional factors may add to the prediction, but injury-related factors do not. It is recommended that future research explores psychosocial factors, such as coping styles, emotion-regulation, personality traits, social support, and other comorbid problems of both children and caregivers.

1. Introduction

Traumatic brain injuries (TBI) are considered the most common cause of disability or death in children, adolescents and young adults [1]. Although most children recover well from mild TBI (mTBI), approximately 20% suffer from a variety of post-concussion symptoms (PCS) [2–6]. It is suggested that these children may experience limitations in long-term activities and participation, for which support may be needed but is often not offered [7,8]. Outcome for activities and participation may differ depending on the perspective of either caregivers or the children themselves [9] and may differ across settings (e.g. at home, in the community, at school, and in the environment) [10]. Knowledge of predictive factors can help to identify the children and adolescents at risk of problems in activities and participation after mTBI. This enables application of early and focused interventions and may help

* Corresponding author. Department of Neuropsychology and Psychopharmacology, Faculty of Psychology and Neuroscience Maastricht University, PO Box 616, 6200 MD, Maastricht, the Netherlands.
E-mail address: caroline.vanheugten@maastrichtuniversity.nl (C.M. van Heugten).

https://doi.org/10.1016/j.ejpn.2019.11.008
1090-3798/

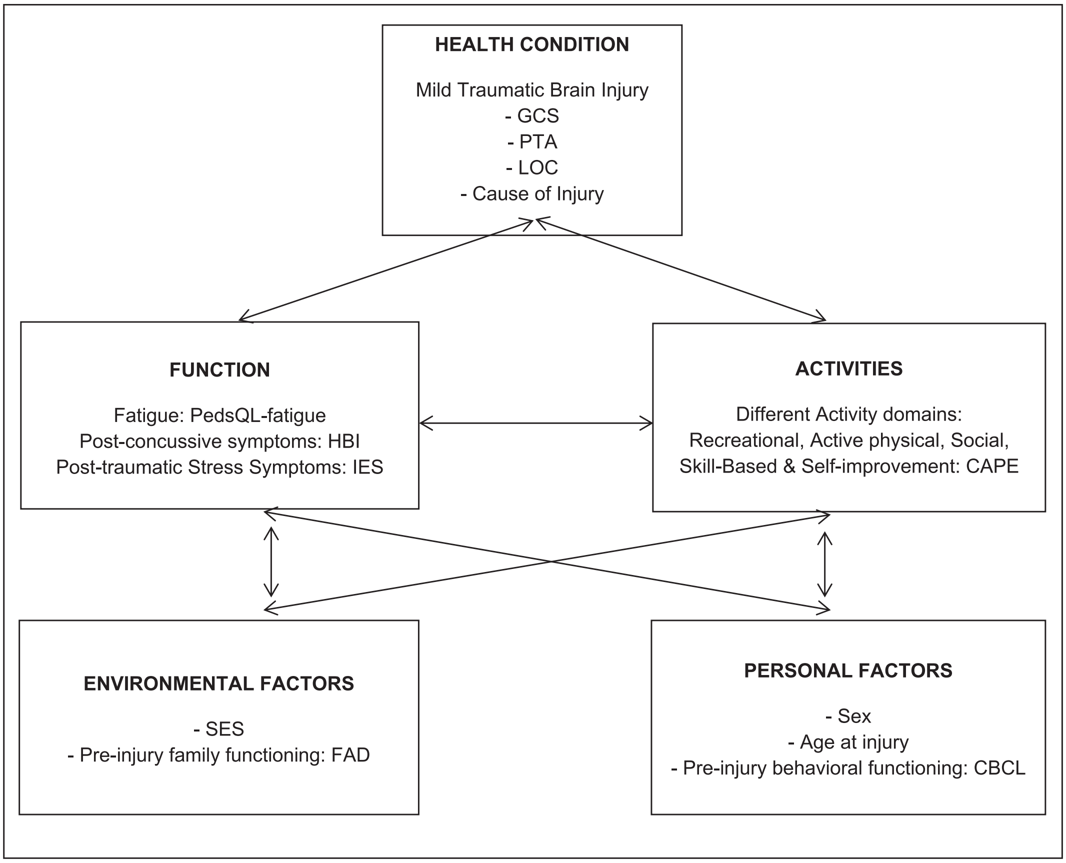

Fig. 1. Relevant predictors based on the categories from the ICF-CY model. ICF-CY model and predictors used for outcome on Activities and Participation [21]. Abbreviations: GCS, Glasgow Coma Scale score; PTA, Posttraumatic Amnesia; LOC, Loss of Consciousness; PedsQL-fatigue, Pediatric Quality of Life Inventory-fatigue scale; HBI, Health and Behavior Inventory; IES, Impact of Events Scale; SES, Socioeconomic Status; CAPE, Children's Assessment of Participation and Enjoyment; FAD, Family Assessment Device; CBCL, Child Behavior Checklist.

prevent such long-term problems.

Several studies have examined predictors for outcome after mTBI in children [3,5,11–22]. Most of these studies focus on predictors of PCS [3,5,18–21]. There are no studies on predictors of outcome for activities and participation after mTBI, specifically in children. Earlier outcome studies on the level of activities and participation were restricted to sport-related concussions [17] or included heterogeneous groups of children with brain injury (e.g. acquired brain injury and/or mixed samples of severity) therefore, sample sizes did not permit subgroup analyses of mTBI [11–16]. They show that better outcomes on the level of activities and participation could be predicted by less severe injury (e.g. moderate vs. severe TBI, higher Glasgow Coma Scale (GCS) score) [11–13,16], better pre-injury functioning of the child [14], better family functioning [11–13], higher Socioeconomic Status (SES) [11,13,16], and less cognitive-, behavioral-, and emotional symptoms early after injury [11,17]. Age was found to be a predictor in some studies [12], but not in others [11,15]. Cause of injury is not found to predict outcome for activities and participation after pediatric TBI [11,13,16].

These results suggest that not only injury-related, but also personal and environmental factors influence outcome after pediatric brain injury. In order to predict which children with mTBI are at risk of long-term consequences for activities and participation, it is therefore important to study relevant factors from a biopsychosocial perspective in a comprehensive model. Categories of the International Classification of Functioning, Disability and Health for Children and Youth (ICF-CY) may be useful for this purpose [23]. The abovementioned studies [11–17] did not differentiate for perspectives (i.e. child or caregiver/teacher) or for activities and participation across settings.

The present study is the first to examine multiple predictors for activities and participation six months post-mTBI, in children and adolescents, from a biopsychosocial perspective following the relevant ICF-CY categories [23] for activities and participation across different settings and perspectives (i.e. caregiver and child) in one model. Knowledge of predictive factors for activities and participation, should result in better identification of children at risk of long-term limitations and might benefit from early interventions.

2. Materials and methods

2.1. Design

This study was part of the larger Brains Ahead! study on the natural course of activities and participation of children after mTBI. The Brains Ahead! study protocol is described in detail elsewhere [7] and was approved by the medical ethics committee of Erasmus University Hospital in Rotterdam and by all local committees of participating hospitals (MEC-2015-047, NL51968.078.14, v08). The Brains Ahead! study consists of a multicenter prospective longitudinal cohort study with a nested randomized controlled trial (RCT). In the RCT, the effect of an early psychoeducational intervention is evaluated in comparison to care as usual [24]. We excluded patients who were randomized into the intervention

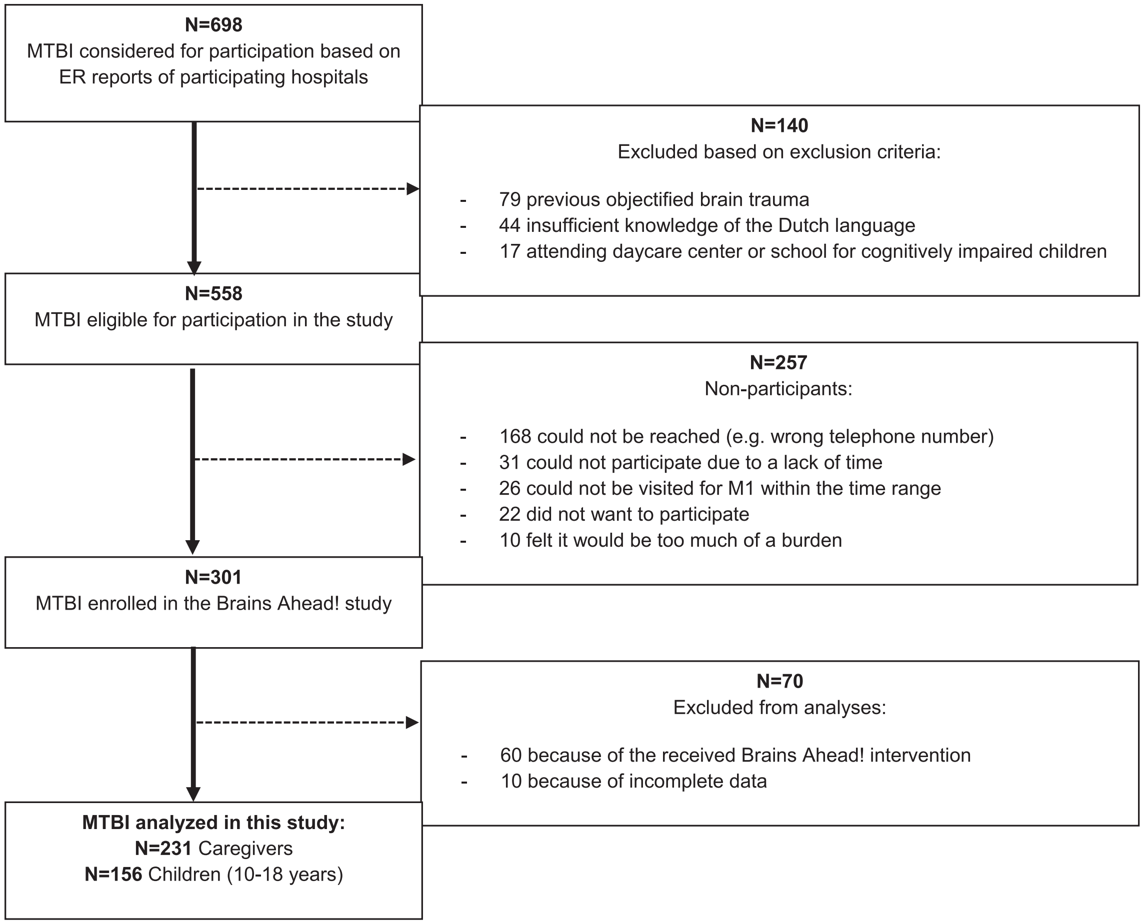

Fig. 2. Flow of participants.

group of the RCT from the current analysis in order to follow a natural occurring cohort receiving usual care.

2.2. Setting

All children aged 6–18 years, who presented with mTBI at the Emergency Departments of eight Dutch hospitals (Erasmus University Hospital, Rotterdam; Amphia Hospital, Breda; Haaglanden Medical Centre and Haga Hospital, The Hague; Rijnstate Hospital, Arnhem; Hospital Gelderse Vallei, Ede; Reinier de Graaf Hospital, Delft; and Elisabeth-Twee Steden Hospital, Tilburg) between May 2015 and April 2018, and their caregiver(s), were eligible for participation.

2.3. Participants

Children were included if they sustained a mTBI according to the criteria established by the American Congress of Rehabilitation Medicine and the World Health Organization Collaborating Centre for Neurotrauma Task Force on Mild Traumatic Brain Injury [25]. The treating physician confirms the diagnosis mild traumatic brain injury if the following criteria are met: 1) GCS score of 13–15 at 30 min after the incident or as soon as the child enters the emergency department of the participating hospital; and 2) one of the following criteria: change in mental functioning immediately after the incident (i.e. disoriented), loss of consciousness of max 30 min, post traumatic amnesia of max 24 h, other transient neurological signs such as seizures. These symptoms should not be caused by other etiologies or intoxications. Exclusion criteria were 1) a previous head trauma confirmed by a neurologist, 2) progressive neurological problems or disease, 3) attending a daycare center or school for cognitively impaired children, and 4) insufficient knowledge of the Dutch language (child or caregivers). Caregivers were defined as parents or guardians. There were no further exclusion criteria for caregivers.

2.4. Procedure

The full study procedure is described in the Brains Ahead! study design [7]. After written informed consent, obtained by the researcher, the baseline measurement was scheduled for two weeks (T0) post-injury at home. The final measurement took place six months (T1) post-injury, also at the participant's home. No procedural differences between participating hospitals existed.

2.5. Materials

All instruments have been used in several international studies, have sound psychometric properties, and are recommended as instruments for evaluating predictors [26] in terms of function level (e.g. fatigue, post-concussive symptoms (PCS) and posttraumatic stress symptoms (PTSS) [27–30], environmental factors (e.g. family functioning) [30,31], personal factors (e.g. behavioral functioning) [32], and outcome in terms of activities and participation in

Table 1
Predictor characteristics (*N* = *231*).

	Characteristics	*N (%)*	*M* (SD)
Health condition	GCS:		
	13	8 (3.5)	
	14	37 (16.0)	
	15	186 (80.5)	
	PTA duration:		
	None	50 (21.6)	
	<1 h	120 (51.9)	
	1–2 h	18 (7.8)	
	2–6 h	30 (13.0)	
	6–12 h	5 (2.2)	
	12–18 h	1 (.4)	
	18–24 h	7 (3.0)	
	LOC duration:		
	None	117 (50.6)	
	<2 min	69 (29.9)	
	2–5 min	33 (14.3)	
	>5 min	12 (5.2)	
	Cause of injury:		
	Sports accident	72 (31.2)	
	Traffic accident	68 (29.4)	
	Outdoor play accident	48 (20.8)	
	Accident at school/work	22 (9.5)	
	Accident at home	13 (5.6)	
	Physical abuse	5 (2.2)	
	Other	2 (.9)	
Function	Fatigue[a]		63.8 (19.5)
	PCS[b]		94.0 (22.3)
	PTSS[c]		59.0 (14.5)
Activities	Engagement in Activity domain[d]:		
	Total		15.9 (5.4)
	Recreational		5.5 (2.3)
	Active physical		1.6 (1.3)
	Social		3.5 (1.7)
	Skill-based		1.0 (1.2)
	Self-improvement		3.2 (1.5)
Environmental Factors	SES:		
	Low	53 (22.9)	
	Average	41 (17.7)	
	High	137 (59.3)	
	Pre-injury family functioning[e]		1.5 (.4)
	Healthy score	200 (86.6)	
	Unhealthy score	31 (13.4)	
Personal Factors	Child sex: male	151 (65.4)	
	Child age at injury in years	231 (100)	11.4 (3.3)
	(Min – Max, Range)	(6–17)	
	Pre-injury Behavioral functioning[f]		50.0 (10.0)
	Normal score	192 (83.1)	
	Mild impaired	29 (12.6)	
	Severe impaired	10 (4.3)	

GCS = Glasgow Coma Scale score, PTA = Posttraumatic amnesia, LOC = Loss of Consciousness, SES = Caregiver's Socioeconomic State.
[a] Measured with the PedsQL-Fatigue.
[b] Post-concussive symptoms measured with the HBI.
[c] Posttraumatic Stress Symptoms measured with the IES.
[d] Measured with the CAPE.
[e] Measured with the FAD-GF.
[f] Measured with the CBCL.

children and adolescents after brain injury [33–35]. All measurements took place in the presence of the researcher, who gave instructions. The researcher could check the completed questionnaires, so preventing missing data as much as possible. The researcher ensured the child completed the self-report questionnaires and the caregiver completed the caregiver-report questionnaires, so preventing false respondent bias.

2.6. Outcome measure

Level of activities and participation were measured across different settings with the Child and Adolescent Scale of Participation (CASP). The CASP is a 20-item questionnaire designed specifically to measure participation across different activity settings in children with ABI, according to the components of the ICF-CY [9,23,33,34]. The CASP can be completed by caregivers for children aged 6–18 years old, and the self-report can be completed by children aged 10–18 years old. Since it was found that caregivers and children report differently on activities and participation outcome after TBI [9], we decided to use both reports completed at T1. The CASP items are categorized into the following settings: at home, in the community, at school, and in the environment, and can be scored on a four point scale (1) age appropriate, (2) slightly impaired, (3) heavily impaired, (4) not capable. Summary scores are

Table 2a
Univariate binomial logistic regression analyses ($N = 231$) − Perspective of Caregiver.

ICF-CY Category	Characteristics	CASP Setting											
		Home			Community			School			Environment		
		β	*p*	Odds (95% CI)	β	*p*	Odds (95% CI)	β	*p*	Odds (95% CI	β	*p*	Odds (95% CI)
Health condition	GCS:	.07	.863	1.08 (.47−2.44)	- .16	.654	.85 (.43−1.71)	.56	.264	1.76 (.65−4.72)	- .02	.944	.98 (.54−1.77)
	PTA duration:	.17	.218	1.18 (.91−1.55)	.09	.485	1.10 (.85−1.43)	.03	.840	1.03 (.77−1.37)	.01	.936	1.01 (.81−1.26)
	LOC duration:	.19	.355	1.22 (.80−1.84)	.26	.172	1.30 (.89−1.89)	.33	.100	1.39 (.94−2.05)	.14	.377	1.15 (.84−1.59)
	Cause of injury[h]:		.521			.672			.878			.870	
Function	Fatigue[a]	- .03	.017[g]	.98 (.96−1.00)	- .02	.063[g]	.98 (.96−1.00)	- .02	.050[g]	.98 (.96−1.00)	- .02	.038[g]	.98 (.97−1.00)
	PCS[b]	.03	.001[g]	1.03 (1.01−1.05)	.02	.020[g]	1.02 (1.00−1.04)	.02	.008[g]	1.02 (1.01−1.04)	.03	<.000[g]	1.03 (1.02−1.05)
	PTSS[c]	.03	.016[g]	1.03 (1.01−1.06)	.02	.088[g]	1.02 (1.00−1.05)	.03	.017[g]	1.03 (1.01−1.06)	.02	.030[g]	1.02 (1.00−1.04)
Activities[d]	Total	- .05	.236	.96 (.89−1.03)	- .10	.007[g]	.90 (.84−.97)	- .08	.046[g]	.93 (.86−1.00)	- .03	.323	.97 (.92−1.03)
	Recreational	- .01	.933	.99 (.83−1.18)	- .21	.020[g]	.81 (.68−.97)	.00	.996	1.00 (.84−1.18)	- .01	.902	.99 (.87−1.13)
	Active physical	- .27	.135	.77 (.54−1.09)	- .34	.046[g]	.71 (.51−.99)	- .20	.243	.82 (.59−1.14)	- .03	.791	.97 (.77−1.22)
	Social	- .07	.550	.93 (.74−1.18)	- .11	.316	.89 (.72−1.11)	- .17	.170	.85 (.67−1.07)	- .03	.700	.97 (.82−1.15)
	Skill-based	- .12	.539	.89 (.61−1.29)	.04	.798	1.04 (.77−1.42)	- .30	.153	.74 (.49−1.12)	- .11	.438	.90 (.69−1.18)
	Self-improvement	- .16	.259	.86 (.65−1.12)	- .20	.115	.82 (.64−1.05)	- .23	.095[g]	.80 (.61−1.04)	- .23	.031[g]	.80 (.65−.98)
Environmental Factors	SES	- .39	.085[g]	.67 (.43−1.06)	- .21	.331	.81 (.53−1.24)	- .10	.653	.90 (.57−1.742	- .19	.294	.83 (.59−1.18)
	Pre-injury family functioning[e]	1.07	.056[g]	2.90 (.97−8.65)	.84	.103	2.31 (.85−6.28)	.85	.115	2.34 (.81−6.72)	.26	.528	1.30 (.68−2.93)
Personal Factors	Child sex	.13	.768	1.14 (.49−2.64)	.12	.762	1.13 (.52−2.45)	- .58	.141	.56 (.26−1.21)	- 22	.484	.80 (.44−1.48)
	Child age at injury	.08	.208	1.08 (.96−1.22)	.09	.100	1.10 (.98−1.23)	.04	.513	1.04 (.93−1.17)	.03	.521	1.03 (.94−1.13)
	Pre-injury Behavioral functioning[f]	.08	<.000[g]	1.08 (1.04−1.12)	.05	.001[g]	1.06 (1.02−1.09)	.08	<.000[g]	1.08 (1.05−1.12)	.08	<.000[g]	1.08 (1.05−1.11)

CASP = Child and Adolescent Scale of Participation, measured at T1, GCS = Glasgow Coma Scale score, PTA = Posttraumatic amnesia, LOC = Loss of Consciousness, SES = Caregiver's Socioeconomic State.
[a] Measured with the PedsQL-Fatigue.
[b] Post-concussive symptoms measured with the HBI.
[c] Posttraumatic Stress Symptoms measured with the IES.
[d] Measured with the CAPE.
[e] Measured with the FAD-GF.
[f] Measured with the CBCL.
[g] Factor entered into multivariate binomial logistic regression analyses.
[h] For cause of injury, β and Odds (95% CI) could not be calculated.

Table 2b
Univariate binomial logistic regression analyses ($N = 156$) − Perspective of Child.

ICF-CY Category	Characteristics	CASP Setting											
		Home			Community			School			Environment		
		β	*p*	Odds (95% CI)	β	*p*	Odds (95% CI)	β	*p*	Odds (95% CI	β	*p*	Odds (95% CI)
Health condition	GCS:	- .37	.238	.69 (.38–1.27)	- .25	.432	.78 (.42–1.45)	.05	.892	1.06 (.49–2.28)	-.09	.752	.91 (.50–1.66)
	PTA duration:	- .02	.899	.98 (.77–1.26)	- .09	.507	.91 (.70–1.19)	-.10	.544	.90 (.65–1.25)	-.08	.509	.92 (.72–1.18)
	LOC duration:	.18	.302	1.19 (.85–1.67)	.15	.392	1.16 (.82–1.64)	.34	.090[g]	1.40 (.95–2.07)	.15	.371	1.16 (.83–1.62)
	Cause of injury[h]:		.656			.742			.986			.838	
Function	Fatigue[a]	- .02	.017[g]	.98 (.96–1.00)	-.02	.096[g]	.99 (.97–1.00)	-.02	.102	.98 (.96–1.00)	-.02	.060[g]	.98 (.97–1.00)
	PCS[b]	.03	<.000[g]	1.03 (1.02–1.05)	.02	.010[g]	1.02 (1.01–1.04)	.03	.007[g]	1.03 (1.01–1.04)	.02	.001[g]	1.03 (1.01–1.04)
	PTSS[c]	.04	.001[g]	1.04 (1.02–1.07)	.04	.006[g]	1.04 (1.01–1.06)	.02	.143	1.02 (.99–1.05)	.02	.106	1.02 (1.00–1.04)
Activities[d]	Total	.01	.656	1.01 (.96–1.07)	- .02	.434	.98 (.92–1.04)	-.10	.017[g]	.91 (.84–.98)	-.04	.137	.96 (.91–1.01)
	Recreational	.10	.235	1.10 (.93–1.30)	.01	.889	1.01 (.85–1.20)	-.10	.330	.90 (.73–1.11)	-.11	.190	.90 (.76–1.06)
	Active physical	.08	.500	1.08 (.86–1.37)	- .14	.286	.87 (.68–1.12)	-.16	.316	.86 (.63–1.16)	.10	.404	1.10 (.88–1.39)
	Social	- .01	.914	.99 (.82–1.19)	- .04	.687	.96 (.80–1.16)	-.34	.013[g]	.71 (.54–.93)	-.07	.455	.93 (.78–1.12)
	Skill-based	.07	.583	1.08 (.83–1.40)	- .07	.649	.94 (.71–1.24)	-.46	.046[g]	.63 (.40–.99)	-.23	.096	.80 (.61–1.04)
	Self-improvement	- .09	.431	.92 (.74–1.14)	- .05	.681	.96 (.77–1.19)	-.17	.205	.84 (.65–1.10)	-.24	.030[g]	.79 (.64–.98)
Environmental Factors	SES	- .19	.327	.82 (.56–1.21)	- .10	.628	.91 (.61–1.35)	-.52	.026[g]	.60 (.38–.94)	-.31	.112	.73 (.50–1.08)
	Pre-injury family functioning[e]	1.30	.006[g]	3.661 (1.44–9.29)	.57	.229	1.76 (.70–4.44)	.84	.133	2.31 (.78–6.90)	1.98	<.000[g]	7.23 (2.72–19.22)
Personal Factors	Child sex	.14	.691	1.15 (.58–2.26)	- .41	.242	.66 (.34–1.32)	-.19	.653	.83 (.37–1.87)	.25	.460	1.28 (.66–2.48)
	Child age at injury	- .01	.874	.99 (.86–1.14)	- .01	.889	.99 (.85–1.15)	.13	.148	1.14 (.96–1.36)	.12	.099[g]	1.13 (.98–1.30)
	Pre-injury Behavioral functioning[f]	.08	<.000[g]	1.08 (1.04–1.13)	.05	.008[g]	1.05 (1.01–1.08)	.02	.280	1.02 (.98–1.06)	.06	.003[g]	1.06 (1.02–1.10)

CASP: Child and Adolescent Scale of Participation, measured at T1. GCS = Glasgow Coma Scale score, PTA = Posttraumatic amnesia, LOC = Loss of Consciousness, SES = Caregiver's Socioeconomic State.
[a] Measured with the PedsQL-Fatigue.
[b] Post-concussive symptoms measured with the HBI.
[c] Posttraumatic Stress Symptoms measured with the IES.
[d] Measured with the CAPE.
[e] Measured with the FAD-GF.
[f] Measured with the CBCL.
[g] Factor entered into multivariate binomial logistic regression analyses.
[h] For cause of injury, β and Odds (95% CI) could not be calculated.

Table 3a
Multivariate binomial logistic regression analyses ($N = 231$) – Perspective of Caregiver.

ICF-CY Category	Characteristics	CASP Setting											
		Home			Community			School			Environment		
		β	*p*	Odds (95% CI)	β	*p*	Odds (95% CI)	β	*p*	Odds (95% CI	β	*p*	Odds (95% CI)
Health condition	GCS:												
	PTA duration:												
	LOC duration:												
	Cause of injury:												
Function	Fatigue[a]	N.I.	.096	N.I.	N.I.	.551	N.I.	N.I.	.541	N.I.	N.I.	.223	N.I.
	PCS[b]	N.I.	.291	N.I.	N.I.	.638	N.I.	N.I.	.645	N.I.	N.I.	.074	N.I.
	PTSS[c]	N.I.	.370	N.I.	N.I.	.499	N,I	N.I.	.640	N.I.	N.I.	.605	N.I.
Activities[d]	Total				N.I.	.227	N.I.	-.08	.045*	.92 (.85–1.00)			
	Recreational				-.26	.006*	.77 (.64–.93)						
	Active physical				N.I.	.073	N.I.						
	Social												
	Skill-based												
	Self-improvement							N.I.	.600	N.I.	N.I.	.126	N.I.
Environmental Factors	SES	N.I.	.247	N.I.									
	Pre-injury family functioning[e]	N.I.	.554	N.I.									
Personal Factors	Child sex												
	Child age at injury												
	Pre-injury Behavioral functioning[f]	.08	<.000*	1.08 (1.04–1.12)	.06	<.000*	1.07 (1.03–1.10)	.08	<.000*	1.08 (1.05–1.12)	.08	<.000*	1.08 (1.05–1.11)

CASP = Child and Adolescent Scale of Participation, measured at T1, GCS = Glasgow Coma Scale score, PTA = Posttraumatic amnesia, LOC = Loss of Consciousness, SES = Caregiver's Socioeconomic State.
* Significant in the final model ($p < .05$).
N.I. = Factor not included in the final model.
NB: No β and Odds (95% CI) could be calculated for the factors that were not included in the final model ($p > .05$).
[a] Measured with the PedsQL-Fatigue.
[b] Post-concussive symptoms measured with the HBI.
[c] Posttraumatic Stress Symptoms measured with the IES.
[d] Measured with the CAPE.
[e] Measured with the FAD-GF.
[f] Measured with the CBCL.

created by summing item responses, dividing this number by the maximum possible score and multiplying this number by 100 to conform to a 100-point scale. The total score range is therefore 25–100, with a higher score representing better outcomes. Missing and 'not applicable' scores are not included in scoring. In case of missing and not applicable scores, the sum of item responses are divided by the number of applicable scores. Since scores on the CASP are well-known for their ceiling effect we dichotomized the scores resulting in a full score of 100 being evaluated as full functioning and any score below 100 as deviant functioning [9,13,33,34].

2.7. Predictors

The predictors were categorized according to the ICF-CY [23] in health condition, function, activities, environmental and personal factors (see Fig. 1). These variables were identified and collected from patient files and at the initial assessment two weeks post-injury (T0) and are described in more detail below.

2.8. Health condition

With the health condition being mTBI, injury-related characteristics in this study include GCS (13–15), posttraumatic amnesia (PTA) (<24 h), loss of consciousness (LOC) (<30 min.) and cause of injury subdivided into traffic accident, sports accident, outdoor play accident, accident at school/work, accident at home, physical abuse, and other.

2.9. Function

Predictors of function level in this study are fatigue, measured with the Pediatric Quality of Life Inventory-fatigue scale (PedsQL-fatigue), post-concussive symptoms, measured with the Health and Behavior Inventory (HBI), and posttraumatic stress symptoms, measured with the Impact of Events Scale (IES). These questionnaires were completed by caregivers about their experience of symptoms at T0. The PedsQL-Fatigue is an 18-item questionnaire that measures overall fatigue, problems regarding sleep/rest, and cognitive fatigue. A higher score indicates fewer symptoms of fatigue [27]. The HBI is a 50-item questionnaire that measures physical, emotional, cognitive, and behavioral post-concussive symptoms. A lower total score represents fewer PCS [28]. The IES is a 34-item questionnaire measuring possible post-traumatic stress responses. A lower score represents less symptoms [29].

2.10. Activities

In this study, engagement across different domains of activities was measured with the Children's Assessment of Participation and Enjoyment (CAPE). The CAPE is a 55-item self-report questionnaire, whose items correspond to engagement in 55 different activities, completed by children aged 6–18 years old. It measures diversity in recreational, active physical, social, skill-based and self-improvement activity domains and can be scored binary; 0 if the activity was not performed, 1 if the activity was performed. The total score range is therefore 0–55, with higher scores indicating greater participation in activities [35,36]. In this study, the CAPE evaluated the performed activities from time since injury up to T0.

Table 3b
Multivariate binomial logistic regression analyses ($N = 156$) − Perspective of Child.

ICF-CY Category	Characteristics	CASP Setting											
		Home			Community			School			Environment		
		β	*p*	Odds (95% CI)	β	*p*	Odds (95% CI)	β	*p*	Odds (95% CI	β	*p*	Odds (95% CI)
Health condition	GCS:												
	PTA duration:												
	LOC duration:							N.I.	.278	N.I.			
	Cause of injury:												
Function	Fatigue[a]	N.I.	.656	N.I.	N.I.	.962	N.I.				N.I.	.775	N.I.
	PCS[b]	N.I.	.428	N.I.	N.I.	.953	N.I.	.02	.016*	1.02 (1.00−1.04)	.02	.028*	1.02 (1.00−1.03)
	PTSS[c]	.03	.017*	1.03 (1.01−1.06)	.03	.032*	1.03 (1.00−1.06)						
Activities[d]	Total							N.I.	.594	N.I.			
	Recreational												
	Active physical												
	Social							N.I.	.052	N.I.			
	Skill-based							N.I.	.401	N.I.			
	Self-improvement										N.I.	.053	N.I.
Environmental Factors	SES							-.51	.038*	.60 (.37−.97)			
	Pre-injury family functioning[e]	N.I.	.241	N.I.							1.83	.001*	6.25 (2.24−17.45)
Personal Factors	Child sex												
	Child age at injury										N.I.	.197	N.I.
	Pre-injury Behavioral functioning[f]	.07	.001*	1.07 (1.03−1.12)	.04	.038*	1.04 (1.00−1.08)				N.I.	.467	N.I.

CASP = Child and Adolescent Scale of Participation, measured at T1, GCS = Glasgow Coma Scale score, PTA= Posttraumatic amnesia, LOC = Loss of Consciousness, SES = Caregiver's Socioeconomic State.
* Significant in the final model ($p < .05$).
N.I. = Factor not included in the final model.
NB: No β and Odds (95% CI) could be calculated for the factors that were not included in the final model ($p > .05$).
[a] Measured with the PedsQL-Fatigue.
[b] Post-concussive symptoms measured with the HBI.
[c] Posttraumatic Stress Symptoms measured with the IES.
[d] Measured with the CAPE.
[e] Measured with the FAD-GF.
[f] Measured with the CBCL.

2.11. Environmental factors

Physical, social, and attitudinal environment was measured with parental Socioeconomic Status (SES). The Family Assessment Device (FAD) completed by caregivers at T0 measured pre-injury family functioning. The FAD-GF is a 12-item questionnaire to measure general family functioning, of which six items require reverse scoring to fit the four-point Likert scale (1) strongly disagree, (2) disagree, (3) agree, and (4) strongly agree. Item scores are averaged to yield a possible total score range from 1.00 (healthy family functioning) to 4.00 (unhealthy family functioning). The cut-off score for healthy family functioning is 2.00 [30,31].

2.12. Personal factors

Individual background characteristics in this study include sex, age at the time of injury, and pre-injury behavioral functioning, measured with the Child Behavior Checklist (CBCL), completed by caregivers at T0 on the child's pre-injury behavioral functioning. The CBCL is a 113-item questionnaire to measure skills, cognitive- and behavioral problems in children. The CBCL provides a Total Behavior Problem Score (T = 50, SD = 15). For the Total Scale, a score >60 can be considered impaired (61–69 mild impairment, >70 severe impairment) [32].

2.13. Statistical analysis

Descriptive statistics were used to describe baseline health condition, function, activities, environmental, and personal characteristics. Means (SD's) or medians (ranges) were reported depending on the distribution of data.

The predictive value of health condition, function, activities, environmental, and personal characteristics for the dichotomized (either full or deviant functioning) CASP outcome across different settings of activities and participation six months after mTBI was first investigated by univariate binomial logistic regression analyses for each factor. When statistical significance at an alpha level of .10 or less [37] was reached, the factor was entered into multivariate binomial logistic regression (backward LR) analyses per setting of activities and participation. The abovementioned analyses were performed both for the perspective of caregivers and of the children. The statistical significance for the multivariate binomial logistic regression analyses was set at an alpha level of 0.05. The regression models were checked for independence of error and absence of co-linearity (Box-Tidwell) and outliers. Nagelkerke R^2 was used to describe the proportion of variance of the CASP associated by the predictor(s) in the final multivariate model. Goodness of fit of the multivariate models were tested with the Hosmer-Lemeshow test, with *p*-values higher than .05 representing a good fit.

Statistical analyses were performed using IBM SPSS Statistics for Windows, version 25.0.

3. Results

3.1. Sample characteristics

In total 698 children with mTBI were considered for participation in the study, of whom 140 were excluded based on the exclusion criteria (see Fig. 2). Furthermore, a total of 257 persons did not participate in the study; the vast majority (168) could not be reached. Finally, 60 participants received the Brains Ahead! Intervention, and were, therefore, excluded from the analyses in this study. Since we decided to work with complete datasets, the incomplete datasets of 10 participants were left out of further analyses. In total 231 participants were included in the analyses for the perspective of caregivers. Since the CASP self-report could be completed by children aged 10–18 years only, data of 156 participants were included in the analyses for the perspective of the children.

Children's characteristics show that the sample consisted of more boys (65.4%); mean age at injury was 11.4 (*sd* 3.3) (Table 1). Many of the participants had a high parental SES (59.3%) and normal pre-injury behavioral functioning of the child (83.1%). Most children sustained mTBI due to sports (31.2%) or traffic accidents (29.4%), showed a GCS of 15 (80.5%) and a PTA of less than one hour (73.5%), and about half of the children experienced LOC (49.4%).

3.2. Activities and participation across different settings six months post-mTBI

With regard to the perspective of caregivers, 87.9% scored full functioning on activities and participation at home, 85.3% in the community, 87.0% at school, and 74.0% scored full functioning in the environment six months post-mTBI. With regard to the perspective of the children, 61.9% scored full functioning on activities and participation at home, 65.8% in the community, 80.0% at school, and 48.4% scored full functioning in the environment six months post-mTBI.

3.3. Univariate binomial logistic regression analyses

Results of the univariate binomial logistic regression analyses are shown in Tables 2a and 2b. It was found that more symptoms on the PedsQL-Fatigue, HBI and IES, lower scores on (all) CAPE activities, low SES, higher scores on the FAD, and higher scores on the CBCL significantly predicted outcome, and injury-related factors did not. Predictive factors differ across settings and perspectives.

3.4. Multivariate binomial logistic regression analyses

The results of the multivariate binomial logistic regression analyses are shown in Tables 3a and 3b. From the perspective of caregivers, higher scores on the CBCL significantly predicted a higher chance of deviant functioning on level of activities and participation in all settings ($p < .000$). For activities and participation in the community, lower scores on CAPE recreational activities ($p = .006$) significantly added to the model, as did lower scores on CAPE total activities ($p = .045$) for activities and participation at school.

From the perspective of the children, higher scores on the CBCL and higher scores on the IES significantly predicted a higher chance of deviant functioning on level of activities and participation at home (CBCL: $p = .001$; IES: $p = .017$) as well as in the community (CBCL: $p = .038$; IES: $p = .032$). Higher scores on the HBI significantly predicted a higher chance of deviant functioning on level of activities and participation at school ($p = .016$) and in the environment ($p = .028$). For activities and participation at school, lower SES ($p = .038$) significantly added to a higher chance of deviant functioning, as did higher scores on the FAD ($p = .001$) for activities and participation in the environment.

Nagelkerke R^2 and goodness of fit (Hosmer-Lemeshow) test results from the final models of the multivariate binomial logistic regression analyses are shown in Table 4. All Nagelkerke R^2 scores were <0.23 and all Hosmer Lemeshow tests showed a good final model fit, except for the caregivers' perspective at school.

4. Discussion

The results of this prospective cohort study indicate that predictors of long-term consequences for activities and participation in children with mild traumatic brain injury (mTBI) differ across settings and perspectives. Child function factors (pre-injury and post-injury), personal factors, and environmental factors play a role in predicting consequences for activities and participation.

The present study adds to the literature that injury-related factors do not play an important role in predicting long-term functioning for activities and participation in children with mTBI. This is in accordance with previous mixed sample studies [11,13,16,17] of the predictive value for cause of injury, but in contrast to previous studies [11–13,16,17] for the predictive value of GCS on the level of activities and participation in samples of children with mixed TBI-severity. A previous study on long-term functional outcomes post-TBI in adults found that GCS was significantly related to mobility, but not cognitive and physical independence or occupation and social integration [38]. Since mobility is more often affected in patients with lower GCS scores, the predictive value of GCS is possibly more prominent in more severe TBI's in comparison to mTBI. Furthermore, the results of our study add to the literature that psychosocial (personal and environmental) factors are predominant for the prediction of unfavorable outcome after pediatric mTBI. These findings are in agreement with findings in adult in mTBI, in which predictors were also found in psychosocial categories, but not injury-related [39,40].

More specifically, based on our findings, the child's pre-injury behavioral functioning should be taken into account when considering children at risk of unfavorable long-term outcomes for activities and participation. This finding is in accordance with the results of previous studies in children with mixed TBI-severity [14] and comparable to the predictive value of pre-injury mental health (e.g. physical, emotional and social-behavioral functioning) in outcome studies after adult mTBI [40]. Furthermore, we found that factors within the categories of activities, function, and the environment should also be considered. Children are expected to be at greater risk for decreased functioning in activities and participation

Table 4
Final model test results of the multivariate binomial logistic regression analyses.

CASP setting	Caregivers' perspective		Children's perspective	
	Nagelkerke R^2	Hosmer-Lemeshow[a]	Nagelkerke R^2	Hosmer-Lemeshow[a]
Home	.147	.311	.203	.657
Community	.138	.797	.105	.219
School	.190	.044	.166	.550
Environment	.150	.711	.221	.115

CASP = Child and Adolescent Scale of Participation, measured at T1.
[a] Hosmer-Lemeshow *p*-values.

when they experience an increased number of symptoms post injury (e.g. PTSS and PCS), low parental SES, less healthy pre-injury family functioning, and fewer participation in activities. These findings are in high accordance with results of previous pediatric mixed TBI-sample studies, in which it was indicated that levels of PTSS and PCS are important predictors for activities and participation [11]. A previous study emphasized that psychological resilience plays an important role in recovery from concussion in adolescents; this relationship may be negatively influenced by anxiety and depressive symptoms [22]. Therefore, emotional distress and maladaptive coping may be considered important predictors of outcome for activities and participation, as well as important components of interventions aiming to prevent long-term problems after pediatric mTBI. This was also previously proposed in an adult study on outcome after mTBI [40].

Furthermore, SES [11,13,16], and family functioning [11–13] were found to be predictors for activities and participation in earlier mixed sample studies, also in accordance with our current findings. For example, a positive relationship between participation in activities and high family SES was found in a study on extra-curricular physical activity in Italian adolescents [41]. Family relationship quality was found to indirectly affect activity involvement in a study predicting organized activity involvement in adolescents [42]. These studies also emphasize the importance of interplay between family- and individual factors in predicting activity involvement during high-school, regardless of the presence of an injury [41,42]. Factors within the category, activities, were not previously studied on their predictive value for activities and participation. In a previous study, in which the relation between children's self-efficacy and physical activity performance after mTBI were explored, it appeared that children lack confidence in their abilities to perform such activities as compared to before the injury [43]. The results of our study show that participating in fewer activities, in comparison to healthy peers, increases the risk for decreased activities and participation in several settings. Our finding supports the idea that resilience, individualized advice and information on returning to activities is a warranted element for early interventions after mTBI [43,44]. Furthermore, social support from caregivers, but also from peers may help children to regain their confidence in returning to activities [45]. Fatigue was not previously investigated as a predictor for activities and participation, despite its common occurrence in children after TBI and frequent obstruction for daily functioning. In this study, we did not find that fatigue adds to the prediction of outcome for activities and participation when combined with other predictive factors (such as pre-injury behavioral functioning) in one model. Possibly, children with mTBI suffer less from fatigue in comparison to children with more severe types of TBI, making its predictive value less prominent. From a methodological view, another explanation could be that in this study, fatigue was investigated as one overall concept. In an adult study, it was found that mental fatigue could last for several years after mTBI, profoundly affecting work capacity, as well as social activities [46]. Therefore, in order to obtain a more complete view of the possible predictive value, future studies focusing on prediction of activities and participation in pediatric mTBI should measure fatigue on specific domains, such as physical fatigue, problems regarding sleep/rest, and mental or cognitive fatigue.

This study has several strengths. First, this study had a large population of children with mTBI only, and assessed both children of all school ages (6–18) as well as their caregivers. Second, this study examined multiple injury-related, functional and psychosocial factors based largely on the relevant ICF-CY categories in one model on their predictive value for activities and participation in various settings and from different perspectives. This provides a more complete overview of predictors for children at risk of long-term problems in activities and participation after pediatric mTBI. Furthermore, this study used face-to-face assessments, preventing bias caused by missing values.

This study also has some limitations. First, admission to hospital emergency departments were part of the inclusion criteria. Consequently, the study sample may not be representative of the larger mTBI population since this excludes those who do not receive acute medical care. Second, concerning external validity, a relatively large number of children who were eligible for participation in the study could not be reached. However, from the number of reached eligible participants, almost 80% chose to participate. Finally, neuroimaging findings of our sample are not available because these data are not gathered systematically at the emergency departments. A direct comparison with other studies on the proportion of children with complicated/uncomplicated mTBI cannot be made. However, for the purpose of the present study these data are less relevant because they have not been found to predict outcome on the level of activities and participation in children with brain injury of mixed severity and etiology.

In conclusion, this study showed that decreased activity and participation after pediatric mTBI can be predicted by pre-injury factors (pre-injury behavioral and family functioning, parental SES), more symptoms two weeks post-injury (PTSS, PCS) and less resumption of activities, but not injury-related factors. This knowledge can be used to select those children at risk and who may benefit from interventions at an early stage after injury. Furthermore, researchers and professionals should be aware that this knowledge is to be shared with the family and teachers of children with mTBI, because their involvement and support has a positive influence on the outcome of the child. Although the results of our study are very useful for this purpose, our final model only declared a small proportion of variance in outcome for activities and participation after mTBI. There are more factors which may further add to the prediction and could be investigated in future studies. For example, resilience [22] and motivation for returning to activities and participation [43,44], coping styles of children and caregivers [40], the child's self-efficacy and emotion-regulation [39], the child's and caregivers personality traits [39], the level of social support from caregivers and peers [45], and other comorbid problems, such as chronic pain, substance abuse, life stress and protracted litigation [47].

Conflicts of interest

The authors declare that there are no conflicts of interests regarding financial, consultant, institutional or relationships.

Source of funding

The study was funded by the Johanna Kinderfonds (Award Number 2012/0040-1552) and the Revalidatiefonds (Award Number R2012175).

Acknowledgements

Brains Ahead! Research group: N. Bovens from Maastricht University and Revant Rehabilitation Centre, from Rijnstate

Hospital; K. van Dijk, H. Hendricks and D. Rijpsma, from Hospital Gelderse Vallei; T. Oosterveld-Bonsma and B. Kievit, E. Peeters from Medical Centre Haaglanden and Haga Hospital; J.F. de Rijk-van Andel from Amphia Hospital, S. te Winkel from Groot-Klimmendaal Rehabilitation Centre, F. van Markus-Doornbosch from Sophia Rehabilitation Centre, R. Pangalila from Rijndam Rehabilitation Centre, and C. Southcombe.

References

[1] J.F. Kraus, A. Rock, P. Hemyari, Brain injuries among infants, children, adolescents and young adults, AMA J. Dis. Child 144 (6) (1990) 684–691, https://doi.org/10.1001/archpedi.1990.02150300082022.
[2] H.G. Taylor, L.J. Orchinik, N. Minich, A. Dietrich, K. Nuss, M. Wright, et al., Symptoms of persistent behavior problems in children with mild traumatic brain injury, J. Head Trauma Rehabil. 30 (5) (2015) 302–310, https://doi.org/10.1097/htr.0000000000000106.
[3] T.A. Blinman, E. Houseknecht, C. Snyder, D.J. Wiebe, M.L. Nance, Post-concussive symptoms in hospitalized pediatric patients after mild traumatic brain injury, J. Pediatr. Surg. 44 (6) (2009) 1223–1228, https://doi.org/10.1016/j.jpedsurg.2009.02.027.
[4] C.A. Hawley, A.B. Ward, A.R. Magnay, J. Long, Outcomes following childhood head injury: a population study, J. Neurol. Neurosurg. Psychiatry 75 (5) (2004) 737–742, https://doi.org/10.1136/jnnp.2003.020651.
[5] K.M. Barlow, S. Crawford, A. Stevenson, S.S. Sandhu, F. Belanger, D. Dewey, Epidemiology of postconcussion syndrome in pediatric mild traumatic brain injury, Pediatrics 126 (2) (2010) e374–e381, https://doi.org/10.1542/peds.2009-0925.
[6] R. Ruff, Two decades of advances in understanding of mild traumatic brain injury, J. Head Trauma Rehabil. 20 (1) (2005) 5–18, https://doi.org/10.1097/00001199-200501000-00003.
[7] I. Renaud, S.A. Lambregts, A. de Kloet, C.E. Catsman-Berrevoets, I. van De Port, C.M. van Heugten, Activities and participation of children and adolescents after mild traumatic brain injury and the effectiveness of an early intervention: the Brains Ahead! study design, Trials 17 (1) (2016) 236, https://doi.org/10.1186/s13063-016-1357-6.
[8] C. van Heugten, I. Renaud, C. Resch, The role of early intervention in improving the level of activities and participation in youths after mild traumatic brain injury: a scoping review, Concussion 2 (3) (2017) CNC38, https://doi.org/10.2217/cnc-2016-0030.
[9] J. McDougall, G. Bedell, V. Wright, The youth report version of the Child and Adolescent Scale of Participation (CASP): assessment of psychometric properties and comparison with parent report, Child Care Health Dev. 39 (4) (2013) 512–522, https://doi.org/10.1111/cch.12050.
[10] A. Golos, G. Bedell, Responsiveness and discriminant validity of the Child and Adolescent Scale of Participation across three years for children and youth with traumatic brain injury, Dev. Neurorehabil. (2017) 1–8, https://doi.org/10.1080/17518423.2017.1342711.
[11] A.J. De Kloet, R. Gijzen, L.W. Braga, J.J. Meesters, J.W. Schoones, T.P. Vliet Vlieland, Determinants of participation of youth with acquired brain injury: a systematic review, Brain Inj. 29 (10) (2015) 1135–1145, https://doi.org/10.3109/02699052.2015.1034178.
[12] E. van Tol, J.W. Gorter, C. DeMatteo, A. Meester-Delver, Participation outcomes for children with acquired brain injury: a narrative review, Brain Inj. 25 (13–14) (2011) 1279–1287, https://doi.org/10.3109/02699052.2011.613089.
[13] W.S. Foo, J. Galvin, J. Olsen, Participation of children with ABI and the relationship with discharge functional status, Devl neurorehabil 15 (1) (2012) 1–12, https://doi.org/10.3109/17518423.2011.623142.
[14] C. Catroppa, L. Crossley, S.J.C. Hearps, K.O. Yeates, M. Beauchamp, K. Rogers, et al., Social and behavioral outcomes: pre-injury to six months following childhood traumatic brain injury, J. Neurotrauma 32 (2015) 109–115, https://doi.org/10.1089/neu.2013.3276.
[15] J. Galvin, E.H. Froude, J. McAleer, Children's participation in home, school and community life after acquired brain injury, Aust. Occup. Ther. J. 57 (2) (2010) 118–126, https://doi.org/10.1111/j.1440-1630.2009.00822.x.
[16] D. Anaby, M. Law, S. Hanna, C. DeMatteo, Predictors of change in participation rates following acquired brain injury: results of a longitudinal study, Dev. Med. Child Neurol. (2012 January) 339–346, https://doi.org/10.1111/j.1469-8749-2011.04204.x.
[17] G.L. Iverson, A.J. Gardner, D.P. Terry, J.L. Ponsford, A.K. Sills, D.K. Broshek, G.S. Solomon, Predictors of clinical recovery from concussion: a systematic review, Br. J. Sports Med. 51 (2017) 941–948, https://doi.org/10.1136/bjsports-2017-097729.
[18] C.D. Morgan, S.L. Zuckerman, Y.M. Lee, L. King, S. Beaird, A.K. Sills, G.S. Solomon, Predictors of postconcussion syndrome after sports-related concussion in young athletes: a matched case-control study, J. Neurosurg. Pediatr. 15 (66) (2015) 589–598, https://doi.org/10.3171/2014.10.PEDS14356.
[19] K. Smyth, S.S. Sandhu, S. Crawford, D. Dewey, J. Parboosingh, K.M. Barlow, The role of serotonin receptor alleles and environmental stressors in the development of post-concussive symptoms after pediatric mild traumatic brain injury, Dev. Med. Child Neurol. 56 (1) (2014) 73–77, https://doi.org/10.1111/dmcn.12263.
[20] L. Babcock, T. Byczkowski, S.L. Wade, M. Ho, J.J. Bazarian, Inability of S100B to predict postconcussion syndrome in children who present to the emergency department with mild traumatic brain injury: a brief report, Pediatr. Emerg. Care 29 (4) (2013) 458–461, https://doi.org/10.1097/PEC.0b013e31828a202d.
[21] H.G. Taylor, A. Dietrich, K. Nuss, M. Wright, J. Rusin, B. Bangert, N. Minich, K.O. Yeates, Post-concussive symptoms in children with mild traumatic brain injury, J. Neuropsychol. 24 (2) (2010) 148–159, https://doi.org/10.1037/a0018112.
[22] C.L. Durish, K.O. Yeates, B.L. Brooks, Psychological resilience as a predictor of symptom severity in adolescents with poor recovery following concussion, J. Int. Neuropsychol. Soc. 25 (4) (2019) 346–354, https://doi.org/10.1017/S1355617718001169.
[23] World Health Organization, International Classification of Functioning, Disability and Health, World Health Organization, Geneva, 2001.
[24] M. Renaud, I. van de Port, C. Catsman-Berrevoets, N. Bovens, S. Lambregts, C. van Heugten, The Brains Ahead! intervention for children and adolescents with mild traumatic brain injury and their caregivers: rationale and description of the treatment protocol, Clin. Rehabil. 32 (11) (2018) 1440–1448, https://doi.org/10.1177/0269215518785418.
[25] V.L. Kristman, J. Borg, A.K. Godbolt, L.R. Salmi, C. Cancelliere, L.J. Carroll, et al., Methodological issues and research recommendations for prognosis after mild traumatic brain injury: results of the International Collaboration on Mild Traumatic Brain Injury Prognosis, Arch. Phys. Med. Rehabil. 95 (3 Suppl) (2014) S265–S277, https://doi.org/10.1016/j.apmr.2013.04.026.
[26] S.R. McCauley, E.A. Wilde, V.A. Anderson, G. Bedell, S.R. Beers, T.F. Campbell, et al., Recommendations for the use of common outcome measures in pediatric traumatic brain injury research, J. Neurotrauma 29 (4) (2012) 355–362, https://doi.org/10.1089/neu.2011.1838.
[27] M. Gordijn, E.M. Cremers, G.J. Kaspers, R.J. Gemke, Fatigue in children: reliability and validity of the Dutch PedsQL multidimensional fatigue scale, Qual. Life Res. 20 (7) (2011) 1103–1108, https://doi.org/10.1007/s11136-010-9836-9.
[28] L.K. Ayr, K.O. Yeates, H.G. Taylor, M. Browne, Dimensions of postconcussive symptoms in children with mild traumatic brain injuries, J. Int. Neuropsychol. Soc. 15 (1) (2009) 19–30, https://doi.org/10.1017/S1355617708090188.
[29] E. van der Ploeg, T.T. Mooren, R.J. Kleber, P.G. van der Velden, D. Brom, Construct validation of the Dutch version of the impact of event scale, Psychol. Assess. 16 (1) (2004) 16–26, https://doi.org/10.1037/1040-3590.16.1.16.
[30] W.F. Maillette de Buy Wenniger, A.J.J.M. van Loon, R.H.I. Benoist, N. Moleman, The Dutch translation of the McMaster family assessment device, Tijdschr. Psychiatr. 37 (9) (1995).
[31] A.K. Mansfield, G.I. Keitner, J. Dealy, The family assessment device: an update, Fam. Process 54 (1) (2015) 82–93, https://doi.org/10.1111/famp.12080.
[32] T.M. Achenbach, A. Becker, M. Dopfner, E. Heiervang, V. Roessner, H.C. Steinhausen, et al., Multicultural assessment of child and adolescent psychopathology with ASEBA and SDQ instruments: research findings, applications, and future directions, J Child Psychol Psychiatry 49 (3) (2008) 251–275, https://doi.org/10.1111/j.1469-7610.2007.01867.x.
[33] G. Bedell, Further validation of the child and adolescent scale of participation (CASP), Dev. Neurorehabil. 12 (5) (2009) 342–351, https://doi.org/10.3109/17518420903087277.
[34] A.J. de Kloet, M.A. Berger, G.M. Bedell, C.E. Catsman-Berrevoets, F. van Markus-Doornbosch, T.P. Vliet Vlieland, Psychometric evaluation of the Dutch language version of the child and family follow-up survey, Dev. Neurorehabil. (2015) 1–8, https://doi.org/10.3109/17518423.2013.850749.
[35] C. Imms, Review of the children's assessment of participation and enjoyment and the preferences for activity of children, Phys. Occup. Ther. Pediatr. 28 (4) (2008) 389–404, https://doi.org/10.1080/01942630802307135.
[36] M.K. Bult, O. Verschuren, J.W. Gorter, M.J. Jongmans, B. Piskur, M. Ketelaar, Cross-cultural validation and psychometric evaluation of the Dutch language version of the Children's Assessment of Participation and Enjoyment (CAPE) in children with and without physical disabilities, Clin. Rehabil. 24 (9) (2010) 843–853, https://doi.org/10.1177/0269215510367545.
[37] V.R.M.P. Moulaert, E.M. Wachelder, J.A. Verbunt, T.W. Wade, C.M. van Heugten, Determinants of quality of life in survivors of cardiac arrest, J. Rehabil. Med. 42 (2010) 553–558.
[38] K.S. Seagly, R.L. O'Neil, R.A. Hanks, Pre-injury psychosocial and demographic predictors of long-term functional outcomes post-TBI, Brain Inj. 32 (1) (2018) 78–83, https://doi.org/10.1080/02699052.2017.1374467.
[39] H.J. van der Horn, M.L. Out, M.E. de Koning, A.R. Mayer, J.M. Spikman, I.E. Sommer, J. van der Naalt, An integrative perspective linking physiological and psychological consequences of mild traumatic brain injury, J. Neurol. (2019, Apr 27), https://doi.org/10.1007/s00415-019-09335-8 (Epub ahead of print).
[40] J. van der Naalt, M.E. Timmerman, M.E. de Koning, H.J. van der Ham, M.E. Scheenen, B. Jacobs, G. Hageman, T. Yilmaz, G. Roks, J.M. Spikman, Early predictors of outcome after mild traumatic brain injury (UPFRONT): an observational cohort study, Lancet Neurol. 16 (7) (2017) 532–540, https://doi.org/10.1016/S1474-4422(17)30117-5.
[41] G. La Torre, D. Masala, E. De Vito, E. Langiano, G. Capelli, W. Ricciardi, Extra-curricular physical activity and socioeconomic status in Italian adolescents, BMC Public Health 6 (1) (2016) 22, https://doi.org/10.1186/1471-2458-6-22.
[42] A.M. Bohnert, N.C. Martin, J. Garber, Predicting adolescents' organized activity involvement: the role of maternal depression history, family relationship quality, and adolescent cognitions, J. Res. Adolesc. 17 (1) (2007) 221–224,

https://doi.org/10.1111/j.1532-7795.2007.00520.x.

[43] I. Gagnon, B. Swaine, D. Friedman, R. Forget, Exploring children's self-efficacy related to physical activity performance after a mild traumatic brain injury, J. Head Trauma Rehabil. 20 (5) (2005) 436–449, https://doi.org/10.1097/00001199-200509000-00005.

[44] M. DiFazio, N.D. Silverberg, M.W. Kirkwood, R. Bernier, G.L. Iverson, Prolonged activity restriction after concussion; are we worsening outcomes? Clin Pediatr (Phila) 55 (5) (2016) 443–451, https://doi.org/10.1177/0009922815589914.

[45] B. Johansson, P. Berglund, L. Rönnbäck, Mental fatigue and impaired information processing after mild and moderate traumatic brain injury, Brain Inj. 23 (13–14) (2009) 1027–1040, https://doi.org/10.3109/02699050903421099.

[46] S.R. McCauley, C. Boake, H.S. Levin, C.F. Contant, J.X. Song, Postconcussional disorder following mild to moderate traumatic brain injury: anxiety, depression, and social support as risk factors and comorbidities, J. Clin. Exp. Neuropsychol. 23 (6) (2001) 792–808, https://doi.org/10.1076/jcen.23.6.792.1016.

[47] G.L. Iverson, Outcome from mild traumatic brain injury, Curr. Opin. Psychiatr. 18 (3) (2005) 301–317, https://doi.org/10.1097/01.yco.0000165601.29047.ae.