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Objective: To investigate demographic and pre-injury factors in Finnish school-aged children admitted to pediatric neurology services after mild traumatic brain injury (mTBI). The relation of these factors to prolonged injury symptoms and later visits into psychiatric care was assessed.

Methods: Demographic information, pre-injury learning status, and neuropsychological test results of 120 patients aged 7-16 years were retrospectively collected from the hospital medical records. Data were compared with self- or parent-reported injury symptoms at 1-3 months post injury and visits to psychiatric care during the study period of seven years.

Results: According to medical records, 14.2% of the children with mTBI had a diagnosed neurobehavioral or psychiatric condition pre-injury. Additionally, 53.3% of the children had some neurobehavioral or psychiatric concerns or traits prior to the injury. Over half (56.7%) of the children studied were symptomatic at 1-3 months following the injury. Female gender and presence of prolonged symptoms were predictive for later visit into psychiatric care.

Conclusions: Pre-injury neurobehavioral or psychiatric problems may predict prolonged injury symptoms following pediatric mTBI. In this retrospective patient series, prolonged symptoms and female gender seem to predict the need for later psychiatric care. Monitoring the recovery of children with mTBI and pre-injury risk factors is important for timely interventions.

Keywords: mild traumatic brain injury; pediatric; pre-injury learning; psychiatric care

Introduction

Traumatic brain injury (TBI) is one of the leading causes of death and injury-related disability among children and adolescents worldwide (1,2). Globally, the rate of diagnosed TBIs is approximately 419:100 000 among children under 15 years of age (3). However, major differences exist between developing and high-income countries. According to a paper published in 2017, the incidence of pediatric TBI is increasing (4). In Finland the cumulative incidence for pediatric TBIs during years 1998-2012 has been

reported to be 99/100 000, with boys being approximately 50 percent more likely to sustain a TBI (5). When compared to other countries with corresponding population-based data, the rate in Finland seems to be slightly higher than in e.g. Australia (91/100 000) and the United States (73/100 000) (5).

It has been well established that majority of children suffering moderate or severe TBI experience at least transient impairment in cognitive and/or behavioral functioning (6, 7). Seventy to ninety percent of all hospital treated pediatric TBIs are classified as mild, therefore making mTBI as one of the most common injury in children and adolescents (8, 9). Despite its relatively high prevalence, even comprehensive literature reviews have come to different conclusions on outcomes from pediatric mTBI (9).

There is some agreement concerning the presence of acute physical, cognitive and behavioral symptoms. The most often reported symptoms include pain, nausea, dizziness, cognitive disturbances - such as poor attention and memory problems - as well as behavioral and emotional dysfunction (10, 11). Instead, controversy exists regarding the long-term cognitive and neurobehavioral outcome (9, 10, 11, 12, 13). When measured with objective psychometric tests only, the outcome following a single uncomplicated (= without brain imaging findings) mTBI, has been reported to be quite good at a group level, showing few if any impairments in neurocognitive outcomes compared to uninjured controls (14, 15). However, the inconsistency between the results from standardized cognitive testing and subjective symptom reporting has been well established (9, 10, 16). Recent longitudinal studies utilizing more sensitive measures and a trauma control group suggest that at least 5-20% of children with mTBI experience prolonged or persistent symptoms following even a single uncomplicated mTBI (13, 17, 18).

According to recent narrative review (19), variation in post-concussion symptom resolution seems to be higher in children and adolescents compared to adults.

Yeates and Taylor (10) concluded that prolonged symptoms following pediatric mTBI probably reflect multifactorial background, such as pre-injury learning capacity and psychologic functioning, family relationships, as well as organic changes in brain function. Additionally, they stated that the predictors of symptoms following mTBI vary as a function of time. Mc Nally et al. (20) showed that non-injury factors including low cognitive capacity and existence of psychological problems, female gender, younger age at injury, and poor family functioning play a major role as predictors for prolonged symptoms following pediatric mTBI.

According to Fay et al. (21) pre-injury cognitive ability is a significant moderator of the outcome from pediatric mTBI. Dicker (22) stated that the rate of pre-injury learning disabilities or otherwise poor academic performance in those suffering of mTBI, could be as high as 50%. Studies on TBI outcome usually exclude those patients, thereby omitting a considerable number of injured children. This might give somewhat biased results, as learning and other types of neurodevelopmental deficits are overrepresented in patients sustaining a pediatric TBI (23).

There is a growing body of literature associating childhood mTBI and long-term behavioral and psychiatric difficulties, even if according to a systematic review performed by Emery et al. (24), there is only little evidence for persistence of psychological or psychiatric problems beyond the acute and subacute phase following pediatric mTBI. According to Scott et al. (25), childhood TBI is associated with psychosocial problems in adulthood, with females with mTBI being at increased risk for

developing internalizing disorders, such as anxiety and depression. In a prospectively studied cohort Max et al. (26) found that even as much as 31% of the children with mTBI were experiencing psychiatric or neuropsychiatric symptoms at 24 months following the injury. Furthermore Sariaslan et al. (27) showed that even a single mTBI in childhood could be associated with several adverse long-term outcomes including psychiatric visits and inpatient hospitalization. Child- and parent-reported health-related quality of life (HRQOL) has been reported to be significantly worse in children with prolonged or persistent postconcussive symptoms compared to their peers with other kind of chronic medical conditions e.g. diabetes, cancer, obesity and psychiatric illnesses (28), possibly exposing them thus to develop more serious psychiatric symptoms. Paradoxically it has also been suggested that a person, whose cognition is more intact, may experience more psychological distress compared to their more severely injured peers following TBI. This might be due to their better insight into their problems (25, 29, 30), suggesting that persons suffering from milder forms of TBI could actually be at increased risk for developing psychiatric symptoms.

In this study, we wanted to explore demographic and pre-injury factors in school-aged children with mTBI and their relation to prolonged injury symptoms and later visits to psychiatric care. We hypothesized that:

(1) children with pre-injury learning difficulties or neuropsychiatric symptoms would be more prone to injury-related symptoms and

(2) these traits would be positively related to the presence of injury-related symptoms 1-3 months following mTBI, and

(3) children with prolonged injury symptoms would be at elevated risk for having later visits to psychiatric care following an mTBI.

Methods

This study was conducted at the Department of Pediatric Neurology at Turku University Hospital (TUH) Finland. Approval for the study was granted by the Ethics Committee of The Hospital District of Southwest Finland and TUH.

Participants

The study sample comprised 120 children treated at TUH due to mTBI during the years 2010-2016. The patients who had brain CT or MRI examination available, had their TBI classified as mild, and who had undergone neuropsychological examination within 3 months following injury, were included into the study. In order to make the neuropsychological results more comparable within the study population and the study group more homogenous, only patients aged 7-16 years at the time of injury were included in this study. Eligibility criteria for mTBI included the Glasgow Coma Score (GCS) (31) of no less than 13/15, loss of consciousness (LOC) of less than 30 minutes, and of post traumatic amnesia (PTA) no more than 24 hours. When the GCS score was not entered in the patient database, it was estimated retrospectively based on the documented clinical information

The data were collected retrospectively from the hospital records at least two years post injury for every patient. We identified all new pediatric visits with any head trauma at Turku University Hospital over the years 2010-2016 by a diagnosis-based registry search. We wanted to find all pediatric patients with any head trauma, which is why ICD-10 codes including: S06 (intracranial injuries), T90 (sequelae of intracranial injuries), F07 (personality and behavioral disorders due to brain disease, damage and dysfunction), and F04 (organic amnesic syndrome, not induced by alcohol and other psychoactive substances) were used. Search covered visits at The Department of Pediatrics and Adolescent Medicine, and Emergency Care at TUH. During this time

period, 1206 children had a diagnosis of any head trauma and subsequent brain imaging linked to that event. The number of patients with the first hospital-treated head trauma during the study period, who had a CT and/or MRI examination linked to the event, and had sufficient information in the patient records about the initial management, was 804, from which 41 patients were excluded due to reasons shown in Figure 1. Additionally, the patients whose TBI classified as moderate or severe were excluded from the study (n= 32). Number of patients excluded due to age < 7 or ≥16 years at the time of injury, was 316. Of the remaining 415 children, 120 (29%) were directed for neuropsychological examination carried out within 1-3 months after the injury according to the clinical judgement of the pediatric neurologist. The selection process is presented in Figure 1. [Figure 1 near here]

Measures

Demographic data and injury characteristics were retrieved from the medical records. Injury symptoms at 1-3 months following mTBI, as reported by the child or the parents were retrospectively gathered from the patient files. The information was originally registered in the context of semistructured interview carried out by a hospital psychologist during the neuropsychological evaluation. Children or adolescents as well as their parents were asked to describe emergence or worsening of symptoms (e.g fatigue, impulsivity) following injury. The Full-Scale Intelligence Quotient score (FSIQ) from the Wechsler Intelligence scale for children, WISC IV (32) was used to describe the child's overall neurocognitive ability at 1-3 months following mTBI.

Data concerning pre-injury learning or behavioral difficulties were retrospectively gathered from the medical records. Participants were grouped into three subgroups according to their pre-injury neurodevelopmental and behavioral functioning

as follows: a) no pre-injury concerns or behavioral tendencies mentioned, b) pre-injury concerns or behavioral tendencies mentioned in the medical records, but without a diagnosed condition, and c) a diagnosed neurobehavioral or psychiatric illness prior to mTBI. Additionally, the data concerning pre- and post-injury contact to psychiatric care were collected from the medical records.

Data analyses

Statistical analyses and descriptive statistics were done using the SPSS software (version 24.0, IBM Corp., Armonk, NY). Normality of continuous variables was checked using histograms. Binary logistic regression analysis was conducted to predict self- or parent-reported injury symptoms at 1-3 month following injury, as well as visits to psychiatric care following injury. Gender, age, pre-injury learning and behavior problems, and pre-injury visits to psychiatric care were used as predictors in both multivariable logistic models. Additionally, symptoms at 1-3 month following injury were used as a predictor for visits to psychiatric care. Results are expressed using odds ratios (OR) with 95% confidence intervals (CI). Data analyses were completed using all available data (i.e., including all the cases available at each occasion). P-values less than 0.05 were considered as statistically significant.

Results

Demographics

Children in the final study sample and those of 7-16 years old with mTBI diagnoses and CT/MRI examination but no neuropsychological examination carried out, did not differ according to gender (females 43.3% vs 41.9%, p=0.795), age (mean 11.9 v 12.2 years, p=0.298) or diagnoses before brain injury (24.2% vs 28.5%, p=0.366). The demographic characteristics of the final sample are presented in Table 1. [Table 1. near here]

External causes of brain injury

Falls accounted for most of the causes, with 29 (24.2%) being from height and 30 (20.5%) from ground-level. The number of traffic-related injuries was 38 (31.7%), of which 23 (19.2%) were from being hit by a car as a pedestrian or bicyclist, and 15 (12.5%) were caused from being as a passenger in a car or as a driver of a motor vehicle. (e.g. moped, tractor, snow-jet). Other causes for mTBI were sports-related accidents and hitting the head onto a solid object.

Injury symptoms

Presence of at least one injury symptom was reported by 56.7% of the children or their parents at 1-3 months following injury, based on the clinical interview carried out during the neuropsychological evaluation performed by the hospital psychologist. The most common symptom was fatigue, reported by 26.7 % of the children themselves or their parents. The next common symptoms reported were headache or dizziness, difficulties in emotional regulation, and memory problems.

Pre-injury learning and behavior

Children with pre-injury diagnosed learning or behavior disorder (14.2%) were diagnosed for ADHD or Tourette's syndrome (n=2), mental disability (n= 3), or learning/language development impairment (n=2). Nine of the children had a pre-injury diagnosis of a psychiatric disorder (conduct disorder, anxiety disorder, reactive attachment disorder). Learning or behavioral problems pre-injury were significantly related to child- or parent-reported post concussive symptoms at 1-3 months (Table 2). The overall intelligence score (FSIQ) was not a significant predictor for post-concussion symptoms. Due to the significant amount of missing FSIQ values (N=9) and its high negative correlation with pre-injury learning ability ($r = -0.384$, $p < 0.001$), it was left out from the analyses. [Table 2. near here]

Visits to psychiatric care

Earlier contact to psychiatric care, female gender, and occurrence of self- or parent-reported injury symptoms at 1-3 months following mTBI were significant predictors for later contact to psychiatric care. Age at injury and pre-injury learning or behavioral problems were not predictive for later visits to psychiatric care (Table 3.). [Table 3. near here]

Discussion

This retrospective study of children with mTBI identified demographic and pre-injury factors associated to prolonged injury symptoms as well as later visits to psychiatric care in TUH. Information concerning psychiatric care in other facilities except for TUH, was not available.

As we hypothesized, children with pre-injury learning or behavioral difficulties were overrepresented in our data. Of the children studied, 14% had diagnosed neurobehavioral or psychiatric illness before the injury. Even if we expected to find an overrepresentation of learning and behavioral difficulties in our study sample, the finding that approximately half (53.3 %) of the children showed some premorbid concerns or behavioral traits mentioned in medical records, was surprising. Together with diagnosed learning or behavioral disorders, the total number of these cases was 67.5% of the whole sample. Thus, only 32.5% of the children studied did not have any premorbid concerns or tendencies mentioned in the clinical records. This finding could be explained by the fact that children with neurobehavioral problems are more accident-prone compared to normative population, and therefore over-represented among children with mTBI. Another possibility is that children with lower premorbid cognitive reserve due to e.g. neurological or psychiatric vulnerability, experience more or stronger

symptoms, and are therefore guided into neuropsychological follow-up evaluation more often. This kind of selection bias is possible as our sample has been retrospectively gathered from clinical patient files.

As expected, the existence of pre-injury learning or behavioral difficulties (either diagnosed condition or concern mentioned in medical records) was a significant predictor of being symptomatic at 1-3 months following injury. This finding is in line with the conclusions from a recent systematic review (33). A slight majority (56.7%) of the children studied still reported being symptomatic at the time of the neuropsychological evaluation at 1-3 months following mTBI. In contrast to e.g. McNally's and Eving-Cobbs' work (20, 34), no gender difference in terms of prolonged symptoms was found in our sample.

Our finding that 56.7% of children and adolescents experienced some symptoms at 1-3 months following mTBI, is considerably higher compared to 13 % presented by Barlow et al. (35). However, as our study group consisted of those patients who had undergone neuropsychological evaluation based on clinical consideration, it is likely, that the number of symptomatic children in this group is somewhat bigger compared to all the children with mTBI treated in TUH during the study years. Unfortunately, information of self- or parent-reported injury symptoms at 1-3 months following injury was only available for those children who had undergone neuropsychological examination, so the comparison between the groups could not be done.

By the date of data gathering, 24.2% of children studied had visited psychiatric care following mTBI. This number is codirectional with 31% presented by Max et al. (26). Female gender, being symptomatic according to self or parental report at 1-3 months, as well as pre-injury psychiatric contact, were significant predictors for later visits into psychiatric care. The finding that prolonged injury symptoms were predictive

of later psychiatric contact might suggest that residual symptoms from mTBI are left misdiagnosed and been later interpreted as psychiatric problems. Another possible explanation could be that children who experience prolonged post-concussive symptoms may be at increased risk for developing secondary mental health problems due to not being able to meet the requirements and expectations of their surroundings. This phenomenon has already been described by Boll (29).

Consistently with previous studies, the most common cause of pediatric mTBI was a fall with boys being overrepresented. The M:F ratio found in this study was somewhat different from those found in two earlier Finnish population studies (5, 36). A slightly higher proportion of girls represented in our study could be explained by the fact reported by McNally et al. (20), that girls tend to be more sensitive in reporting post-concussive symptoms compared to boys, and therefore may have a higher probability to be guided into further examinations. As our sample was retrospectively collected from medical records, this kind of bias is possible. As our data had originally been gathered for clinical purposes, some variation existed regarding the data available and the methods being used. The presence of post-concussive symptoms was evaluated merely based on parent's and children's oral reports during the neuropsychological examination. No standardized rating scales were used. Additionally, the data was lacking information concerning the socioeconomic status of the children, which has been reported to be a predictive factor in recovering from TBI (11,12). Because the data had been generated during a daily clinical work, no systematic method for recording the data was used, why there were also some missing data.

Conclusion

The present study suggests that there is a predictive relationship between pre-injury learning or psychiatric problems and prolonged symptoms following pediatric mTBI,

and that prolonged mTBI symptoms together with female gender predict later visit into psychiatric care. As children with mTBI are overrepresented among the patients having later visits into psychiatric care, these results imply a need for more careful monitoring of possible residual injury symptoms, especially within those children who are known to have risk factors for prolonged symptoms and are discharged from the hospital without routine follow-up.

To validate these results, further research including an orthopedic control group and examining the neuropsychological functioning prospectively and more precisely is necessary. Additionally, a long-term follow-up of those with prolonged symptoms after a pediatric mTBI is needed in order to examine eventual changes and consequences over time.

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Declarations of interests

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

Due to the nature of this research, participants of this study did not agree for their data to be shared publicly, so supporting data is not available.

References:

1. Langlois JA, Rutland-Brown W, Wald MM. The epidemiology and impact of traumatic brain injury: a brief overview. J Head Trauma Rehabil. 2006 Sep-Oct;21(5):375-8. doi: 10.1097/00001199-200609000-00001. Cited in: PMID: 16983222.

2. Lloyd J, Wilson ML, Tenovuo O, Saarijärvi S. Outcomes from mild and moderate traumatic brain injuries among children and adolescents: A systematic review of studies from 2008-2013. Brain Inj. 2015;29(5):539-49. doi: 10.3109/02699052.2014.1002003. Epub 2015 Mar 19. Cited in: PMID: 25790086.

3. WHO Guidelines Approved by the Guidelines Review Committee. Geneva: World Health Organization; 2008-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK132015/

4. Maas AIR, Menon DK, Adelson PD, Andelic N, Bell MJ, Belli A, Bragge P, Brazinova A, Büki A, Chesnut RM, Citerio G, Coburn M, Cooper DJ, Crowder AT, Czeiter E, Czosnyka M, Diaz-Arrastia R, Dreier JP, Duhaime AC, Ercole A, van Essen TA, Feigin VL, Gao G, Giacino J, Gonzalez-Lara LE, Gruen RL, Gupta D, Hartings JA, Hill S, Jiang JY, Ketharanathan N, Kompanje EJO, Lanyon L, Laureys S, Lecky F, Levin H, Lingsma HF, Maegele M, Majdan M, Manley G, Marsteller J, Mascia L, McFadyen C, Mondello S, Newcombe V, Palotie A, Parizel PM, Peul W, Piercy J, Polinder S, Puybasset L, Rasmussen TE, Rossaint R, Smielewski P, Söderberg J, Stanworth SJ, Stein MB, von Steinbüchel N, Stewart W, Steyerberg EW, Stocchetti N, Synnot A, Te Ao B, Tenovuo O, Theadom A, Tibboel D, Videtta W, Wang KKW, Williams WH, Wilson L, Yaffe K; InTBIR Participants and Investigators. Traumatic brain injury: integrated approaches to improve prevention, clinical care, and research. Lancet Neurol. 2017 Dec;16(12):987-1048. doi: 10.1016/S1474-4422(17)30371-X. Cited in: PMID: 29122524.

5. L Wilson M, Tenovuo O, Mattila VM, Gissler M, Celedonia KL, Impinen A, Saarijärvi S. Pediatric TBI in Finland: An examination of hospital discharges (1998-2012). Eur J Paediatr Neurol. 2017 Mar;21(2):374-381. doi: 10.1016/j.ejpn.2016.10.008. Cited in: PMID: 27840023.

6. Anderson V, Catroppa C, Morse S, Haritou F, Rosenfeld J. Outcome from mild head injury in young children: a prospective study. J Clin Exp Neuropsychol. 2001 Dec;23(6):705-17. doi: 10.1076/jcen.23.6.705.1015. Cited in: PMID: 11910538.

7. Yeates, KO. Traumatic Brain Injury. In: Yeates, KO, Taylor HG, Pennington BF, editors. Pediatric Neuropsychology, Research, Theory and Practise 2nd ed. New York: The Guilford Press; 2010. p.112-146.

8. Cassidy JD, Carroll LJ, Peloso PM, Borg J, von Holst H, Holm L, Kraus J, Coronado VG; WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. Incidence, risk factors and prevention of mild traumatic brain injury: results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. J Rehabil Med. 2004 Feb;(43 Suppl):28-60. doi: 10.1080/16501960410023732. Cited in: PMID: 15083870.

9. McKinlay A. Controversies and outcomes associated with mild traumatic brain injury in childhood and adolescences. Child Care Health Dev. 2010 Jan;36(1):3-21. doi: 10.1111/j.1365-2214.2009.01006.x. Cited in: PMID: 19719771.

10. Yeates KO, Taylor HG. Neurobehavioural outcomes of mild head injury in children and adolescents. Pediatr Rehabil. 2005 Jan-Mar;8(1):5-16. doi: 10.1080/13638490400011199. Cited in: PMID: 15799131.

11. Yeates KO, Taylor G. Neurobehavioral outcomes. In: Kirkwood MJ, Yeates KO, editors. Mild Traumatic Brain Injury in Children and adolescents, from basic science to clinical management.New York: The Guilford Press; 2012. p. 124-141.

12. Taylor HG, Dietrich A, Nuss K, Wright M, Rusin J, Bangert B, Minich N, Yeates KO. Post-concussive symptoms in children with mild traumatic brain injury. Neuropsychology. 2010 Mar;24(2):148-59. doi: 10.1037/a0018112. Cited in: PMID: 20230109; PMCID: PMC2843004.

13. McInnes K, Friesen CL, MacKenzie DE, Westwood DA, Boe SG. Mild Traumatic Brain Injury (mTBI) and chronic cognitive impairment: A scoping review. PLoS One. 2017 Apr 11;12(4):e0174847. doi: 10.1371/journal.pone.0174847. Erratum in: PLoS One. 2019 Jun 11;14(6):e0218423. Cited in: PMID: 28399158; PMCID: PMC5388340.

14. Kirkwood MW, Yeates KO, Taylor HG, Randolph C, McCrea M, Anderson VA. Management of pediatric mild traumatic brain injury: a neuropsychological review from injury through recovery. Clin Neuropsychol. 2008 Sep;22(5):769-800. doi: 10.1080/13854040701543700. Cited in: PMID: 17896204; PMCID: PMC2847840.

15. Babikian T, Asarnow R. Neurocognitive outcomes and recovery after pediatric TBI: meta-analytic review of the literature. Neuropsychology. 2009 May;23(3):283-96. doi: 10.1037/a0015268. Cited in: PMID: 19413443; PMCID: PMC4064005.

16. Gioia GA, Isquith PK. Ecological assessment of executive function in traumatic brain injury. Dev Neuropsychol. 2004;25(1-2):135-58. doi: 10.1080/87565641.2004.9651925. Cited in: PMID: 14984332.

17. Karr JE, Areshenkoff CN, Garcia-Barrera MA. The neuropsychological outcomes of concussion: a systematic review of meta-analyses on the cognitive sequelae of mild traumatic brain injury. Neuropsychology. 2014 May;28(3):321-36. doi: 10.1037/neu0000037. Cited in: PMID: 24219611.

18. Bernard CO, Ponsford JL, McKinlay A, McKenzie D, Krieser D. Do Concussive Symptoms Really Resolve in Young Children? J Head Trauma Rehabil. 2017 Nov/Dec;32(6):413-424. doi: 10.1097/HTR.0000000000000298. Cited in: PMID: 28422893.

19. Manzanero S, Elkington LJ, Praet SF, Lovell G, Waddington G, Hughes DC. Concussion. 2017;1:1-8. doi:10.1177/2059700217726874.

20. McNally KA, Bangert B, Dietrich A, Nuss K, Rusin J, Wright M, Taylor HG, Yeates KO. Injury versus noninjury factors as predictors of postconcussive symptoms following mild traumatic brain injury in children. Neuropsychology. 2013 Jan;27(1):1-12. doi: 10.1037/a0031370. Cited in: PMID: 23356592; PMCID: PMC3760010.

21. Fay TB, Yeates KO, Taylor HG, Bangert B, Dietrich A, Nuss KE, Rusin J, Wright M. Cognitive reserve as a moderator of postconcussive symptoms in children with complicated and uncomplicated mild traumatic brain injury. J Int Neuropsychol Soc. 2010 Jan;16(1):94-105. doi: 10.1017/S1355617709991007. Cited in: PMID: 19835663; PMCID: PMC2835160.

22. Dicker BG. Profile of those at risk for minor head injury, J Head Trauma Rehabil.1992; 7:83-91.doi: 10.1097/00001199-199203000-00011.

23. Farmer JE, Kanne SM, Haut JS, Williams J, Johnstone B, Kirk K. Memory functioning following traumatic brain injury in children with premorbid learning problems. Dev Neuropsychol. 2002;22(2):455-69. doi: 10.1207/S15326942DN2202_2. Cited in: PMID: 12537333.

24. Emery CA, Barlow KM, Brooks BL, Max JE, Villavicencio-Requis A, Gnanakumar V, Robertson HL, Schneider K, Yeates KO. A Systematic Review of Psychiatric, Psychological, and Behavioural Outcomes following Mild Traumatic Brain Injury in Children and Adolescents. Can J Psychiatry. 2016 May;61(5):259-69. doi: 10.1177/0706743716643741. Cited in: PMID: 27254800; PMCID: PMC4841286.

25. Scott C, McKinlay A, McLellan T, Britt E, Grace R, MacFarlane R. A comparison of adult outcomes for males compared to females following pediatric traumatic brain injury. Neuropsychology. 2015 Jul;29(4):501-508. DOI: 10.1037/neu0000074.

26. Max JE, Friedman K, Wilde EA, Bigler ED, Hanten G, Schachar RJ, Saunders AE, Dennis M, Ewing-Cobbs L, Chapman SB, Yang TT, Levin HS. Psychiatric disorders in children and adolescents 24 months after mild traumatic brain injury. J Neuropsychiatry Clin Neurosci. 2015;27(2):112-20. doi:

10.1176/appi.neuropsych.13080190. Cited in: PMID: 25923850; PMCID: PMC5007244.

27. Sariaslan A, Sharp DJ, D'Onofrio BM, Larsson H, Fazel S. Long-Term Outcomes Associated with Traumatic Brain Injury in Childhood and Adolescence: A Nationwide Swedish Cohort Study of a Wide Range of Medical and Social Outcomes. PLoS Med. 2016 Aug 23;13(8):e1002103. doi: 10.1371/journal.pmed.1002103. Cited in: PMID: 27552147; PMCID: PMC4995002.

28. Simpson TS, Peterson RL, Mason DS, Connery AK, Baker DA, Kirkwood MD. Quality of Life for Youth with Persistent Postconcussive Symptoms Following Mild Traumatic Brain Injury, Clinical Practise in Pediatric Psychology, 2017;5(3):248-257. doi: 10.1037/cpp0000195.

29. Boll TJ. Minor Head Injury in Children –Out of Sight but Not Out of Mind, J Clin Child Psychology, 1983;12(1):74-80. doi:10.1080/15374418309533114.

30. Cooper-Evans S, Alderman N, Knight C, Oddy M. Self-esteem as a predictor of psychological distress after severe acquired brain injury: an exploratory study. Neuropsychol Rehabil. 2008 Oct-Dec;18(5-6):607-26. doi: 10.1080/09602010801948516. Cited in: PMID: 18609016.

31. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. Lancet. 1974 Jul 13;2(7872):81-4. doi: 10.1016/s0140-6736(74)91639-0. Cited in: PMID: 4136544.

32. Wechsler D, Wechsler Intelligence Scale for Children (WISC-IV) 4th Edition: Finnish translation, Handbook I (Administration and Scoring). Jyvaskyla, Finland: Psykologien kustannus; 2011.

33. Lumba-Brown A, Yeates KO, Sarmiento K, Breiding MJ, Haegerich TM, Gioia GA, Turner M, Benzel EC, Suskauer SJ, Giza CC, Joseph M, Broomand C, Weissman B, Gordon W, Wright DW, Moser RS, McAvoy K, Ewing-Cobbs L, Duhaime AC, Putukian M, Holshouser B, Paulk D, Wade SL, Herring SA, Halstead M, Keenan HT, Choe M, Christian CW, Guskiewicz K, Raksin PB, Gregory A, Mucha A, Taylor HG, Callahan JM, DeWitt J, Collins MW, Kirkwood MW, Ragheb J, Ellenbogen RG, Spinks TJ, Ganiats TG, Sabelhaus LJ, Altenhofen K, Hoffman R, Getchius T, Gronseth G, Donnell Z, O'Connor RE, Timmons SD. Diagnosis and Management of Mild Traumatic Brain Injury in Children: A Systematic Review. JAMA Pediatr. 2018 Nov 1;172(11):e182847. doi: 10.1001/jamapediatrics.2018.2847. Epub 2018 Nov 5. Erratum in: JAMA Pediatr. 2018 Nov 1;172(11):1104. Cited in: PMID: 30193325.

34. Ewing-Cobbs L, Cox CS Jr, Clark AE, Holubkov R, Keenan HT. Persistent Postconcussion Symptoms After Injury. Pediatrics. 2018 Nov;142(5):e20180939. doi: 10.1542/peds.2018-0939. Cited in: PMID: 30323108; PMCID: PMC6317768.

35. Barlow KM, Crawford S, Stevenson A, Sandhu SS, Belanger F, Dewey D. Epidemiology of postconcussion syndrome in pediatric mild traumatic brain injury. Pediatrics. 2010 Aug;126(2):e374-81. doi: 10.1542/peds.2009-0925. Cited in: PMID: 20660554.
36. Koskinen S, Alaranta H. Traumatic brain injury in Finland 1991-2005: a nationwide register study of hospitalized and fatal TBI. Brain Inj. 2008 Mar;22(3):205-14. doi: 10.1080/02699050801938975. Cited in: PMID: 18297592.