Brief Report: Sleep Disturbances following Mild Traumatic Brain Injury in Childhood

G. Milroy,[1] D Clin Psy, L. Dorris,[2] D Clin Psy, and T. M. McMillan,[1] MAppSci PhD
[1]*Department of Psychological Medicine, University of Glasgow and* [2]*Fraser of Allander Neurosciences Unit, Royal Hospital for Sick Children*

Objective To examine objective and subjective reports of sleep disturbance in school-aged children who had sustained mild traumatic brain injury (TBI) at least 6 months prior to the study. **Methods** Eighteen children aged 7–12 years with a history of mild TBI (GCS 13–15. LOC < 15 min) were compared to 30 children with orthopedic injuries using actigraphy and parental and self-report sleep questionnaires. **Results** Parents reported greater sleep disturbance in the mild TBI group. No significant differences were found in parental ratings of daytime sleepiness, child-reported sleep difficulties, or objective (actigraph) sleep measures. **Conclusions** The finding of greater parental reports of sleep disturbance following mild TBI 6 months after injury requires greater exploration and future research with a larger sample followed from the point of injury would seem appropriate.

Key words brain injury; childhood; pediatrics; sleep.

Recent reviews (Carroll et al., 2004) conclude that there is little evidence from methodologically strong studies of persistent negative outcomes following mild traumatic brain injury (TBI) in childhood. However, parents and teachers repeatedly report cognitive behavioral somatic and emotional problems following mild TBI (Yeates & Taylor, 2005). Persistent symptoms reported include, poor concentration, personality changes, headaches, dizziness, fatigue, and attention and memory difficulties (Hawley, Ward, Magnay, & Long, 2002; Hooper et al., 2004; Overweg-Plandsoen et al., 1999)

Interestingly, this pattern of reported difficulties following mild TBI in children is similar to that associated with sleep disturbances in otherwise healthy children. A recent review indicated that problems with attention, memory, school performance, executive functioning, hyperactivity, aggression, and mood problems were reported for children with both respiratory and nonrespiratory sleep disorders (Blunden & Beebe, 2006).

Whilst sleep disturbances have been consistently reported following mild TBI in adults (Beetar, Guilmette, & Sparadeo, 1996), there have been few sleep studies following mild TBI in childhood. Two studies (Kaufman et al., 2001; Pillar et al., 2003) have found evidence from objective (actigraphy, polysomnography) and subjective measures of greater sleep disturbance in young people following mild TBI compared to noninjured controls. However, sleep disturbances may have been present prior to mild TBI and could increase the risk of sustaining such an injury. Additionally, trauma or pain may contribute to sleep disturbance. Use of a non-TBI injury group allows these factors to be taken into consideration.

Studies of sleep disturbance in children with attention deficit hyperactivity disorder (ADHD) indicate that subjective reports of sleep disturbance and objective measures such as actigraphy can provide different information (Corkum, Tannock, Moldofsky, Hogg-Johnson, & Humphries, 2001; Owens, Maxim, Nobile, McGuinn, & Msall, 2000a). Sleep patterns can be identified via actigraphy, whereas night-to-night variability in sleep patterns may not be apparent to parents or children (Gruber, Sadeh, & Raviv, 2000). Children may be more aware of their parents of certain sleep difficulties such as night waking, as they may not alert their parents to such events.

All correspondence concerning this article should be addressed to Prof. Tom McMillan, Psychological Medicine, University of Glasgow, Gartnavel Royal Hospital, 1055 Great Western Road, Glasgow, G12 OXH, UK. 0141-211-0694. E-mail: t.m.mcmillan@clinmed.gla.ac.uk

Journal of Pediatric Psychology 33(3) pp. 242–247, 2008
doi:10.1093/jpepsy/jsm099
Advance Access publication October 29, 2007

The current study compared sleep disturbances in the longer-term (6 months to 4 years postinjury) between a mild TBI and orthopedic injury group using parental and self-report questionnaires and actigraphy. This methodology was employed to address the issues raised earlier.

It was hypothesized that parents and children in the mild TBI group would report more sleep disturbance and fatigue than orthopedic controls on questionnaire measures and would demonstrate poorer sleep efficiency and greater wake time as measured by actigraphy.

Method

Sample Recruitment and Procedure

Participants were identified from databases of children admitted to the Royal Hospital for Sick Children in Glasgow, UK, between January 2002 and July 2005. Inclusion criteria for both groups were (a) aged 7–12 years at the time of recruitment; (b) at least 6 months from last hospital attendance related to their injury; and (c) duration of hospital admission for <48 hr. Exclusion criteria were evidenced in hospital records of the child (a) having a developmental disability, diagnosis of epilepsy, history of psychiatric disorder, or preexisting sleep disorder; (b) not attending mainstream school; (c) being admitted to hospital in the last 6 months due to another injury or illness; or (d) history of nonaccidental injury. Children in the mild TBI group met the British Society for Rehabilitation Medicine (1998) criteria for mild head injury [GCS score on admission between 13 and 15 and loss of conscious (LOC), if present for <15 min]. Orthopedic controls had sustained fractures to the arm or wrist and were excluded if they had any history of head injury requiring hospitalization. An attempt was made to exclude children with multiple injuries but this information was not always available in hospital records. Forty-three percent of the mild TBI admissions and 61% of orthopedic admissions met the criteria.

All those meeting criteria were sent an invite letter, information sheet, and consent form. Children were asked to give written assent. Parents who returned signed consent forms were contacted by telephone to arrange participation in the study and were issued with an actiwatch, instructions for its use, questionnaire measures, and a sleep diary. A contact telephone number was provided for the researcher if the parents or children had any queries. Participants returned measures after five nights of actigraph monitoring. Ethical approval for the study was obtained from the local Research Ethics Committee. The response rate was 13% for both groups, resulting in 18 participants in the mild TBI group and 30 orthopedic controls.

Measures

Actigraphy

Children wore an Actiwatch AW4 (Cambridge Neurotechnology) on their nondominant hand for a 5-night period. This is similar to a wrist watch but monitors movement. Raw data were downloaded using Actiwatch Sleep Analysis 2001 software. Children completed a sleep diary over the same period and the actigraph data were compared to this to screen for potential artifacts e.g., removal of the watch.

Actigraphy data was averaged over the 5-night period for each participant; research indicates that reliability estimates for children are acceptable for most parameters when averaged over 5 nights (Acebo et al., 1999). Night-to-night variability was assessed using the standard deviation of scores on each parameter (Gruber et al., 2000).

Children's Sleep Habits Questionnaire (CSHQ)

This 45 item Children's Sleep Habits Questionnaire (CSHQ; Owens, Spirito & MgGuinn, 2000b) was completed by parents. It screens for the most common sleep problems in school aged children and yields a total score (''total sleep disturbance'') and eight subscale scores including a ''daytime sleepiness'' subscale.

Self-Report Sleep Scale (SSR)

Children completed this 18 item retrospective questionnaire that has been validated for use with children aged 7–12 years (Owens et al., 2000a). Scoring procedures are outlined by Owens et al. (2000a)

Strengths and Difficulties Questionnaire (SDQ)

Parents completed the SDQ (Goodman, 1997) and the ''total difficulties score'' was used as an indicator of psychological adjustment. The likelihood of a child having emotional, behavioral, or concentration problems severe enough to warrant diagnosis using DSM-IV (APA, 1994) was predicted from SDQ scores and participants were categorized as ''low,'' ''medium,'' or ''high'' risk. The SDQ has good validity and reliability (Goodman & Scott, 1999).

Demographic and Injury-related Data

This was obtained from hospital records. Parents were asked to report any recent life events, other injuries, or illnesses affecting their child. Carstairs Index scores (Carstairs & Morris, 1991) were used to indicate

deprivation levels. These are based on four variables (overcrowding, male unemployment, low social class, and no car).

Results

Sample Characteristics

The mild TBI group consisted of 18 children (44% males) with an average age of 9.7 years (*SD* 1.5). Causes of injury were falls (67%), collisions such as bumping into a wall (28%), and being struck with an object (5%). Sixty-one percent had only one recorded mild head injury and 39% had two recorded mild head injuries. Seventy-eight percent of the mild TBI group had no recorded orthopedic injuries. Sixteen of the samples had a GCS of 15 with only one child having a GCS of 13 and one a GCS of 14. Ninety-four percent had no loss of consciousness. Twenty-two percent had a recorded episode of posttraumatic amnesia. The orthopedic control group was comprised of 30 children (60% males) also with an average age of 9.7 years (*SD* 1.5) all of whom sustained their injuries in falls. Seventy-eight percent had one recorded orthopedic injury and 22% had two. The average age at injury was 7 years 8 months for the mild TBI group and 7years 7 months for the orthopedic group. The average time since injury in the mild TBI group was 23.9 months compared to 25 months in the orthopedic group. There were no significant differences between the groups in terms of age, gender distribution, deprivation levels, and age at injury or time since injury.

Psychological Adjustment

No significant difference in total stress scores was found between groups [$t\,(44) = 0.174$; $p = 0.863$], or if categorizing scores as low-medium or high risk for diagnosis of an emotional, behavioral, or attentional disorder [$\chi^2(1) = 0.027$, $p = 0.87$].

Subjective Reports of Sleep Disturbances

Parents of children with mild TBI reported greater sleep disturbance than parents in the orthopedic control group [Mean and *SD*, 46.6 (6.48) vs. 42.5 (6.37); $t(42) = 2.08$, $p = .044$], with a medium effect size ($d = 0.64$) (See Table I). A cut-off score of 41 on the CSHQ indicates sleep disturbances with a sensitivity of 0.80 and specificity of 0.72 (Owens et al., 2000b). More (76.5%) of the mild TBI group had a total CSHQ above this cut-off point than the orthopedic controls (51.9%), however this difference did not reach significance [$\chi^2(1) = 2.67$, $p = .10$].

There was no significant difference between the groups on the Daytime Sleepiness subscale score [11.5 (2.40) vs. 10.6 (3.09), $t(42) = 1.09$, $p = .283$].[1]

Children's subjective reports of sleep disturbance on the Sleep Self Report scale (SSR) did not differ between groups [17.76 (4.21) vs. 17.82 (3.40); $t(43) = -0.102$, $p = .919$].[2]

Objective Measures of Sleep Disturbance[3]

Groups did not differ on actigraph measures for sleep efficiency [81.3% (±6.13) vs. 82.14% (±3.79), $t(42) = -.560$, $p = .579$] or actual wake time [$t(42) = 1.10$, $p = .278$]. (See Table I)

There was no significant difference between the groups on the average standard deviation for sleep efficiency [$t(42) = -0.438$, $p = .664$][4] or actual wake time [$t(42) = 1.73$, $p = .091$].[5]

Relationship between Subjective and Objective Measures

There was no significant correlation between total CSHQ scores and actigraph measures of sleep efficiency or total SSR scores and sleep efficiency (Spearman's, $\rho < 1.44$, $p > .05$).

Discussion

In the current study, parents of children with mild TBI tended to report greater sleep disturbance than parents of orthopedic controls. A higher percentage of children in the mild TBI group scored above the cut-off on the CSHQ but this difference did not reach statistical significance. Children in the mild TBI group did not self-report greater sleep problems. No group effect was found for objective measures of sleep. These results are in contrast to the findings of Kaufman and colleagues (2001) in which mild TBI participants showed greater sleep disturbance via actigraphy than noninjured controls. Differences in the current study include the use of an orthopedic control

[1] Original data was not normally distributed therefore the analysis was conducted on transformed data (Square root of Daytime Sleepiness subscale score), means and standard deviations are given for original scores.

[2] Data were transformed using the square root function.

[3] There were three instances of failure of the actiwatch to record data (one in the mild TBI group and 2 in the orthopaedic group. One participant in the orthopaedic group also did not wear the actiwatch).

[4] Analysis conducted on transformed data (square root).

[5] Analysis conducted on transformed data (logarithm).

Table I. Means and Standard Deviations on SDQ, CSHQ, SSR, and Actigraphy and Results of Statistical Analysis

Variable	Mild TBI Mean (*SD*)	Orthopedic Mean (*SD*)	95% CI (for difference in means)	df	Statistic *t*	Sig. (*P*)	Effect size
Strengths and difficulties questionnaire							
N	18	28					
Total difficulties score	10.56 (5.66)	10.25 (5.92)	−3.24, 3.85	44	0.174	.863	0.05
Children's Sleep Habits Questionnaire							
N	17	27					
CSHQ total	46.65 (6.48)	42.52 (6.37)	0.12, 8.13	42	2.08*	.044	0.64
Daytime sleepiness[a]	11.5(2.40)	10.6 (3.09)	−0.12, 0.40	42	1.09	.283	0.33
Sleep Self Report Scale							
N	17	28					
Total score[a]	17.76 (4.21)	17.82 (3.40)	−0.28, 0.25	43	−0.10	.919	0.02
Averaged actigraph measures							
N	17	27					
Sleep efficiency	81.30 (6.13)	82.14 (3.79)	−3.85, 2.18	42	−0.56	.579	0.16
Night waking time	79.87 (33.40)	70.60 (22.64)	−7.75, 26.3	42	1.10	.278	0.32
Standard deviation of actigraph measures							
Sleep efficiency[a]	4.07(2.68)	4.30 (2.39)	−0.42, 0.27	42	−0.44	.664	0.09
Night waking timea	22.44 (21.22)	13.04 (7.08)	−0.03, 0.35	42	1.73	.091	0.59

CI, confidence interval.

[a]Variables transformed for the purposes of statistical analysis.

*$p < .05$.

group and a sample that was not selected on the basis of reported sleep disturbances.

The difference in findings between parental measures and actigraphy is of interest. These measures serve different purposes and may identify different types of sleep difficulties. Corkum and colleagues (2001) found that parents of children with ADHD reported higher rates of sleep disturbance, which were generally not verified by actigraphy. The ADHD group had particular problems with bedtime resistance. Perhaps parents report on sleep problems related to behavior that are not detected via actigraphy. The small sample size in the current study limited its ability to detect which items on the CSHQ contributed to the overall score being significantly higher in the mild TBI group and this would be of interest in future research.

Recent research with children with moderate or severe TBI indicated that children in the moderate TBI group did not differ from orthopedic controls on parental reports of sleep disturbance but the severely injured group did (Beebe et al., 2007). This contrasts with findings related to parental reports in the current study, perhaps due to differences in methodology as Beebe and colleagues did not employ the CSHQ. It may also be important to consider the role of parental expectations following mild TBI. In the current study, parents were provided with an information sheet to allow informed consent to be given. This indicated that the study aimed to investigate potential long-term effects of mild head injuries and particularly the effects on sleep.

Studies on knowledge and expectation about mild TBI in adults supports a role for ''symptom'' guessing in questionnaire responses that seems independent of actual experience of TBI (Mulhern & McMillan, 2006) and it may therefore be useful to investigate the role of parental expectations following mild TBI in childhood.

Interestingly, comparison to other studies employing the CSHQ suggested that both groups in the current study had elevated levels of reported sleep disturbances. In a study by Couturier and colleagues (2005), only 26% of controls scored above the CSHQ cut-off compared to 77% in the mild TBI group and 52% in the orthopedic controls in the current study. Thus both groups appear to have greater difficulties and this requires further exploration. It is also noted that approximately one third of the children in each group were classified as being at medium to high risk on the SDQ, suggesting that a higher than expected proportion of both groups may meet criteria for an emotional, behavioral, or attentional disorder.

Limitations

The ability to generalize from the findings of this study is limited by the low response rate, the majority of participants having a GCS of 15 and underrepresentation of males in the TBI group. Although the sample size was based on a power calculation, the study used to inform

the calculation had selected participants on the basis of reported sleep disturbances and thus the estimate of power may have been inflated reducing the ability of the current design to detect significant differences of more moderate effect sizes. As the study was retrospective information on the sleep patterns prior to injury was not available. This is important as sleep disturbance and associated daytime sleepiness may place children at greater risk of sustaining injuries (Fallone, Owens, & Deane, 2002). It was also not possible to consider the impact of age at injury, time since injury, and the child's current age within the current study on a relatively small sample.

Although these limitations affect the conclusions drawn from the current study it does appear to indicate that future research addressing these concerns would be useful. Strengths of the study include the use of an orthopedic control group and the inclusion of parental and child report measures alongside actigraphy. The use of such methodology within a larger scale study following children from the point of injury and obtaining retrospective information on sleep would appear appropriate given the findings of the current study and that in children with moderate to severe injuries (Beebe et al., 2007).

Acknowledgments

This research was in part fulfillment of a Doctorate in Clinical Psychology funded by NES. Thanks are due to Professor C. Espie and the Sleep Research Group at the Sackler Centre for Psychobiology, University of Glasgow for advice regarding objective measurement of sleep and to Mr George Bennet and Dr Fiona Russell, RHSC for their advice on recruitment.
Conflicts of interest: None declared.

Received March 31, 2007; revisions received September 13, 2007; accepted September 24, 2007

References

Acebo, C., Sadeh, A., Seifer, R., Tzischinsky, O., Wolfson, A. R., Hafer, A., et al. (1999). Estimating sleep patterns with activity monitoring in children and adolescents: How many nights are necessary for reliable measures? *Sleep, 22*, 95–103.

American Psychiatric Association. (1994). *Diagnostic and statistical manual of mental disorders* (4th ed.), Washington DC: Author.

Beebe, D. W., Krivtzky, L., Wells, C. T., Wade, S. L., Taylor, G., & Yeates, K. O. (2007). Brief report: Parental report of sleep behaviors following moderate or severe pediatric traumatic brain injury. *Journal of Pediatric Psychology, 32*, 845–850.

Beetar, J. T., Guilmette, T. J., & Sparadeo, F. R. (1996). Sleep and pain complaints in symptomatic traumatic brain injury and neurologic populations. *Archives of Physical Medicine & Rehabilitation, 77*, 1298–1302.

Blunden, S., & Beebe, D. W. (2006). The contribution of intermittent hypoxia, sleep debt and sleep disruption to daytime performance deficits in children: Consideration of respiratory and non-respiratory sleep disorders. *Sleep Medicine Reviews, 10*, 109–118.

Carroll, L. J., Cassidy, J. D., Peloso, P. M., Borg, J., von Holst, H., Holm, L., et al. (2004). Prognosis for mild traumatic brain injury: Results of the WHO collaborating centre task force on mild traumatic brain injury. *Journal of Rehabilitation Medicine, 43* (Suppl), 84–105.

Carstairs, V., & Morris, R. (1991). *Deprivation and health in Scotland*. Aberdeen: Aberdeen University Press.

Corkum, P., Tannock, R., Moldofsky, H., Hogg-Johnson, S., & Humphries, T. (2001). Actigraphy and parental ratings of sleep in children with attention deficit/hyperactivity disorder. *Sleep, 24*, 303–312.

Couturier, J. L., Speechley, K. N., Steele, M., Norman, R., Stringer, B., & Nicolson, R. (2005). Parental perception of sleep problems in children of normal intelligence with pervasive developmental disorders: Prevalence, severity, and pattern. *Journal of the American Academy of Child & Adolescent Psychiatry, 44*, 815–822.

Fallone, G., Owens, J. A., & Deane, J. (2002). Sleepiness in children and adolescents: Clinical implications. *Sleep Medicine Reviews, 6*, 287–306.

Goodman, R. (1997). The strengths and difficulties questionnaire: A research note. *Journal of Child Psychology & Psychiatry & Allied Disciplines, 38*, 581–586.

Goodman, R., & Scott, S. (1999). Comparing the strengths and difficulties questionnaire and the child behavior checklist: Is small beautiful? *Journal of Abnormal Child Psychology, 27*, 17–24.

Gruber, R., Sadeh, A., & Raviv, A. (2000). Instability of sleep patterns in children with attention-deficit/hyperactivity disorder. *Journal of the American Academy of Child & Adolescent Psychiatry, 39*, 495–501.

Hawley, C. A., Ward, A. B., Magnay, A. R., & Long, J. (2002). Children's brain injury: A postal follow-up of

525 children from one health region in the UK. *Brain Injury, 16*, 969–985.

Hooper, S. R., Alexander, J., Moore, D., Sasser, H. C., Laurent, S., King, J., et al. (2004). Caregiver reports of common symptoms in children following a traumatic brain injury. *Neurorehabilitation, 19*, 175–189.

Kaufman, Y., Tzischinsky, O., Epstein, R., Etzioni, A., Lavie, P., & Pillar, G. (2001). Long-term sleep disturbances in adolescents after minor head injury. *Pediatric Neurology, 24*, 129–134.

Mulhern, S., & McMillan, T. M. (2006). Knowledge and expectation of postconcussion symptoms in the general population. *Journal of Psychosomatic Research, 61*, 439–445.

Overweg-Plandsoen, W. C., Kodde, A., van Straaten, M., van der Linden, E. A., Neyens, L. G., Aldenkamp, A. P., et al. (1999). Mild closed head injury in children compared to traumatic fractured bone; neurobehavioural sequelae in daily life 2 years after the accident. *European Journal of Pediatrics, 158*(3), 249–252.

Owens, J. A., Maxim, R., Nobile, C., McGuinn, M., & Msall, M. (2000a). Parental and self-report of sleep in children with attention- deficit/hyperactivity disorder. *Archives of Pediatrics & Adolescent Medicine, 154*, 549–555.

Owens, J. A., Spirito, A., & McGuinn, M. (2000b). The children's sleep habits questionnaire (CSHQ): Psychometric properties of a survey instrument for school-aged children. *Sleep, 23*, 1043–1051.

Pillar, G., Averbooch, E., Katz, N., Peled, N., Kaufman, Y., & Shahar, E. (2003). Prevalence and risk of sleep disturbances in adolescents after minor head injury. *Pediatric Neurology, 29*, 131–135.

Yeates, K. O., & Taylor, H. G. (2005). Neurobehavioural outcomes of mild head injury in children and adolescents. *Pediatric Rehabilitation, 8*, 5–16.