Article

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Sleep and quality of life in children with traumatic brain injury and ADHD: A comparison with primary ADHD

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Abstract

Objective: Attention problems are common in children who sustain a traumatic brain injury (TBI). The differential features of TBI-related Attention Deficit Hyperactivity Disorder (ADHD) and primary ADHD are largely unknown. This study aimed to compare sleep problems and quality of life between children with TBI and ADHD and children with primary ADHD.

Methods: Twenty children with TBI (mean age $= 12.7 \pm 3.1$ years) who had clinically significant ADHD symptoms according to the structured diagnostic interview and rating scales and a control group with primary ADHD ($n = 20$) were included. Parents completed Children's Sleep Habits Questionnaire (CSHQ) and Kinder Lebensqualitätsfragebogen: Children's Quality of Life Questionnaire-revised (KINDL-R). Neurology clinic charts were reviewed for TBI-related variables.

Results: When compared to children with primary ADHD, the Total Score and Sleep Onset Delay, Daytime Sleepiness, Parasomnias, and Sleep Disordered Breathing subscores of CSHQ were found to be higher in children with TBI and ADHD. The Total Score and Emotional Well-Being and Self-Esteem subscores of the

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KINDL-R were found to be low (poorer) in children with TBI and ADHD. The Total Score and certain subscores of KINDL-R were found to be lower in TBI patients with a CSHQ > 56 (corresponds to significant sleep problems) when compared to those with a CSHQ < 56. CSHQ Total Score was negatively correlated with age.
Conclusion: Children with TBI and ADHD symptoms were found to have a poorer sleep quality and quality of life than children with primary ADHD. ADHD in TBI may be considered as a highly impairing condition which must be early diagnosed and treated.

Keywords
traumatic brain injury, children, attention deficit hyperactivity disorder, sleep, quality of life

Introduction

Traumatic brain injury (TBI) is defined as an alteration in brain function, or other evidence of brain pathology, caused by an external force.[1] TBI is one of the main causes of morbidity and mortality of childhood. Children who sustained TBI are under the risk of psycho-social problems and impaired cognitive functioning.[2] Cognitive deficits may involve problems with information processing, attention, memory, and executive functions.[3–5] Numerous studies to date have shown that attention deficit hyperactivity disorder (ADHD) is a common comorbidity in children with TBI.[5] The frequency of ADHD for moderate and severe cases of TBI has been found as 19%–48%.[6–8]

Various factors including physiological effects of the damage inflicted on the brain by the injury, psycho-social difficulties, medication effects, and parenting practices may lead to sleep problems after TBI.[9] Although limited, research data indicate that sleep problems are highly frequent in children with TBI.[10,11] Among the sleep problems reported, excessive daytime sleepiness, insomnia, and parasomnias have been shown to be common.[11,12] Behavioral problems and psychiatric comorbidity may be related with an increased risk of sleep problems. In a recent review on the issue, Stores and Stores[9] have mentioned ADHD among the associated conditions of sleep problems in children with TBI.

There is evidence that TBI-related ADHD has some different features from primary ADHD; hyperactivity may be generally less pronounced, with the inattentive symptoms predominating in the first two years post-injury.[13–15] However, the differential features between the psycho-social aspects of TBI-related ADHD and primary ADHD are largely unknown. Although both types of ADHD may be expected to have a high frequency of sleep problems and a poor quality of life (QOF), there may also be differences in between.

The tools on investigation of ADHD symptoms in children with TBI have been studied limitedly. It has been suggested that behavioral questionnaires may be less sensitive at detecting ADHD than a standardized psychiatric interview.[16] In a previous effort by Wassenberg et al.,[17] the convergence between a psychiatric interview (Schedule for Affective Disorders and Schizophrenia for School-age Children-present and Lifetime version (K-SADS-PL)) and a behavioral questionnaire completed by a caretaker Child Behavior Checklist (CBCL) was examined. The results have shown that CBCL identified a lower comparable percentage of children as experiencing global psychiatric impairment, including ADHD, than the K-SADS.

This study aimed to compare sleep problems and QOL between children with TBI and ADHD and children with primary ADHD. We hypothesize that, with the more pronounced brain damage and a higher risk of psycho-social problems, children with TBI and ADHD may have a poorer sleep functioning and QOL than children with primary ADHD.

Methods

Sample

This study is the second part of a cross-sectional, case–control cohort survey of children and adolescents with TBI who were seen at the Pediatric Neurology Clinic of Mersin University Hospital. The first investigation on the sample has aimed to examine the short-term efficacy and tolerability of immediate-release methylphenidate in children with TBI and attention problems and has been titled as "Short-term efficacy and tolerability of methylphenidate in children with traumatic brain injury and attention problems" (under review elsewhere). The study protocol was approved by the Mersin University School of Medicine Ethics Committee.

The inclusion criteria for the patient group were as follows: (1) age of 6–18 years; (2) neurological diagnosis of moderate to severe TBI, with severity based on the initial Glasgow Coma Scale (GCS) Score at presentation to the study hospital. Moderate TBI was defined as the GCS Score of 9 to 12 or the presence of mechanical ventilation for less than 24 h; and severe TBI was defined as the GCS Score less than 9 or the presence of mechanical ventilation for 24 h or longer; (3) One to four years post-injury; (4) clinically significant attention problems and/or hyperactivity-impulsivity symptoms according to the K-SADS-PL interview; (5) Conners' Parent Rating Scale (CPRS) and Conners' Teacher Rating Scale (CTRS-R) scores suggestive of ADHD; (6) normal intelligence based on either a Wechsler Intelligence Scale for Children-Revised (WISC-R) full scale IQ score above 80 or the average/above average academic performance documented with the last year's final school grades. Normal intelligence was confirmed by at least one faculty member of child psychiatry. The children with developmental delay, motor and visual handicaps, uncontrolled seizure disorder, psychiatric disorder diagnoses, and other chronic diseases were excluded. At the time of the study, all in the TBI group were first-admission patients in child psychiatry. In addition, none of them were on medication treatment.

The study was conducted during May–July 2015 and the patient sample included children and adolescents who had TBI one to four years before the study (between May 2011 and May 2014). From the pediatric intensive care medical records, a total of 67 TBI patients who fulfilled the neurological and post-TBI duration inclusion criteria were detected. These eligible children and adolescents were then called for an evaluation by a child psychiatry faculty member of the same hospital. Appointments were given to 58 patients, and 51 of them underwent the psychiatric evaluation which included the K-SADS-PL interview. According to the K-SADS-PL, 22 children and adolescents with TBI met the psychiatric inclusion criteria and were recruited for the study. The parents of the sample were informed about the study procedure in detail, and informed consent was obtained for 20 patients. The final sample included 20 patients. Figure 1 illustrates the study processes in a flowchart.

During the K-SADS-PL interview of patients, the possible history of preinjury developmental ADHD was briefly questioned. However, most of the parents did not give a conclusive information (60% gave the answers of "I can't remember" or "My child has some behavioral problems and attention problems but not at an impairing level"). None of the patients was reported to have a preinjury ADHD diagnosis or a history of attendance at child psychiatry.

For the control group, the same number of children and adolescents were recruited from Mersin University Hospital child and adolescent psychiatry clinic. The following inclusion criteria was used: (1) Age of 6–18 years; (2) no known medical or neurological disease diagnosis; (3) diagnosis of primary ADHD with the K-SADS-PL interview; (4) CPRS and CTRS-R scores suggestive of ADHD; (5) no other psychiatric diagnosis on K-SADS-PL interview (only comorbid oppositional defiant disorder was allowed); (6) normal intelligence based on either a WISC-R full scale IQ score above 80 or the average/above average academic performance documented with the last year's final school grades. Normal intelligence was confirmed by at least one faculty member of child psychiatry. The children with developmental delay, motor and visual handicaps, uncontrolled seizure disorder, and other chronic diseases were excluded. At the time of the study, all of the control group patients were first-admission patients in child psychiatry. In addition, none of them were on medication treatment.

Instruments

The Children's Sleep Habits Questionnaire. The Children's Sleep Habits Questionnaire (CSHQ) is a retrospective, 45-item parent questionnaire that has been used in a number of studies to examine sleep behavior in young children.[18] The CSHQ includes items relating to a number of key sleep domains that

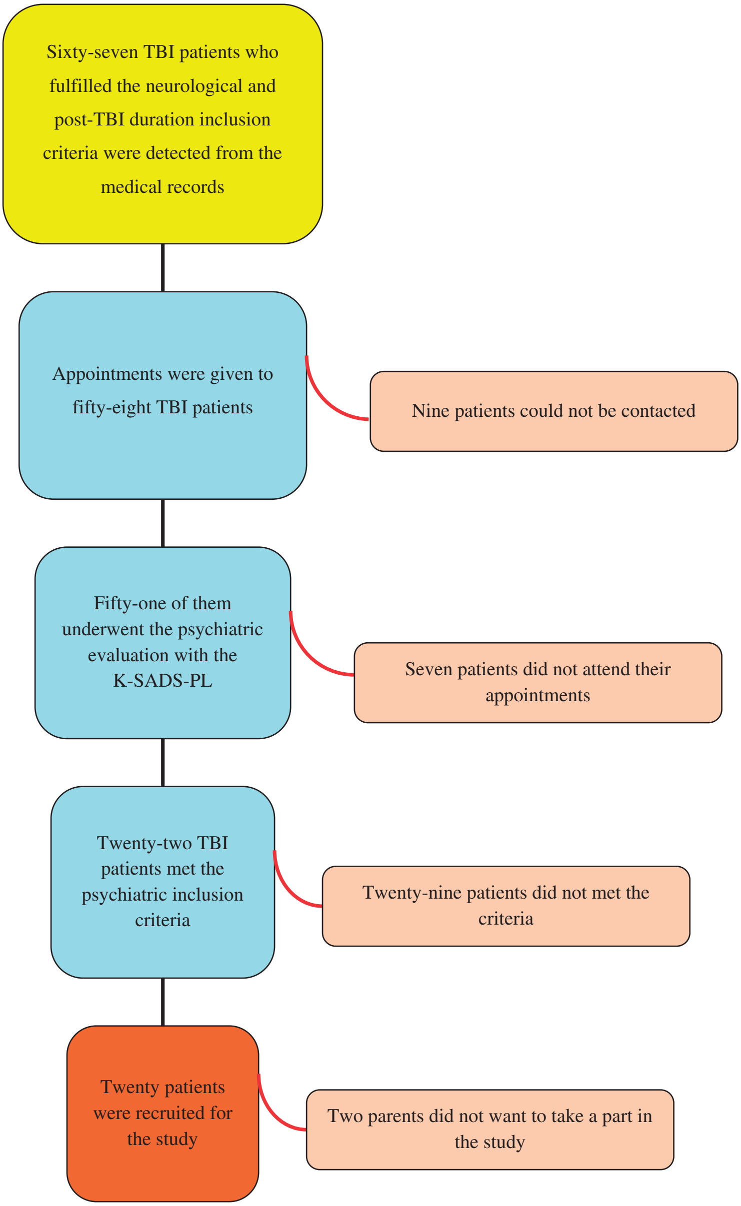

Figure 1. Flowchart illustrating the study processes.

encompass the major presenting clinical sleep complaints in this age group: bedtime behavior and sleep onset; sleep duration; anxiety around sleep; behavior occurring during sleep and night wakings; sleep disordered breathing; parasomnias; and morning waking/daytime sleepiness. Parents are asked to recall sleep behaviors occurring over a "typical" recent week. Items are rated on a three-point scale: "usually" if the sleep behavior occurred five to seven times/week; "sometimes" for two to four times/week; and "rarely" for zero to one time/week. Some items were reversed in order to consistently make a higher score indicative of more disturbed sleep. A total CSHQ score of 41 has been reported to be a sensitive cutoff for clinically significant sleep problems.[18] The Turkish translation of the scale was conducted by Perdahlı et al.[19] In the present study, based on the approach of a previous study using the scale,[20] CSHQ scores of 56 and above were defined as moderate to severe sleep problems.

Kinder Lebensqualitätsfragebogen: Children's QOL Questionnaire-revised

The Kinder Lebensqualitätsfragebogen: Children's QOL Questionnaire-revised (KINDL-R) assesses QOL of children and adolescents in six different domains: physical well-being, emotional well-being, self-esteem, family, friends, and everyday functioning (school).[21] The KINDL-R offers 24 items referring to the past week with five-point Likert-scales ("Never" to "All the time"), with 11 items being reverse-coded. The scores range from 0 to 100, where higher scores indicate higher levels of HRQOL. In the present study, KINDL-R parent questionnaire for 8–16 years was used. The validity and reliability of the Turkish version of the KINDL-R was demonstrated by Eser et al.[22]

Conners' Parent Rating Scale

CPRS is a 48-item Likert-type scale used to assess problematic behaviors in children.[23] In addition to a Total Score, there are five subscale scores: Conduct problems, Impulsivity and Hyperactivity, Learning problems, Anxiety, and Psychosomatic problems. Dereboy et al.[24] reported that the CPRS-Turkish Version is valid and reliable for use in the Turkish population. In the present study, The Total, Hyperactivity, and Learning problems scores of the scale were used.

Conners' Teacher Rating Scale-Revised

CTRS-R is a commonly used teacher rating scale for diagnosing behavioral problems in children.[23] The 28-item CTRS-R provides a Total Score and three subscale scores: Cognitive Problems/Inattention, Hyperactivity, and Conduct problems. Şener et al.[25] reported that the CTRS-R-Turkish Version is valid and reliable for use in the Turkish population. In the present study, The Total, Hyperactivity, and Cognitive Problems/Inattention scores of the scale were used.

Statistical analysis

The collected data were analyzed by using the SPSS version 21.0. Demographic variables were presented by using descriptive statistics. χ^2 and likelihood ratio tests were used for the comparison of normally distributed categorical variables. For the comparison of categorical variables which were not normally distributed, Fisher's exact probability test was used. Normally distributed parametric variables were compared between groups by using Independent Samples t test. The Mann–Whitney U test was used for the comparison of continuous variables which were not normally distributed. Pearson correlation test was used to examine the associations between study variables. The p value <0.05 was accepted to be statistically significant.

Sample size

A priori power calculation analysis was conducted. For the power calculation, the mean difference on the CSHQ Total Scores of the TBI and control groups was considered a relevant difference. This estimate, which was used as an effect-size parameter, was based on a result obtained in a previous study on children with TBI.[26] In the mentioned study by Sumpter et al.,[26] the mean CSHQ Total Scores of the TBI and control groups were 52.07 and 42.60, respectively, and the mean difference between groups was 9.47. In the present study, it was estimated that at least seven subjects in each group would be required to detect a significant mean difference of 9.47 (effect size) between TBI and control groups at the 90% power level with a type 1 error of 5%.

Results

Mean age of the TBI and ADHD (patient) group was 12.7 ± 3.1 years, and 75% ($N = 15$) were males. Primary ADHD (control) group had a mean age of 12.3 ± 3.05 years and 60% ($N = 12$) were males. The mean CPRS Total Scores of the patient and control groups were 31.3 ± 17.1 and 36.9 ± 14.2, respectively ($p = 0.287$). Learning problems score of CPRS was 4.7 ± 3.3 in the patient group while it was 6.1 ± 2.8 in the control group ($p = 0.164$). CPRS Hyperactivity score was 4.3 ± 2.4 and 5.4 ± 2.2 in the patient and control groups, respectively ($p = 0.131$). The CTRS-R Total Scores of children with TBI and those with primary ADHD were 24.15 ± 11.03 and 27.30 ± 8.9, respectively ($p = 0.328$). Cognitive Problems/Inattention score of CTRS-R was 7.35 ± 3.3 in the patient group while it was 8.65 ± 2.9 in the control group ($p = 0.202$). CTRS-R

Table 1. The comparison of CSHQ scores between study groups.

CSHQ scores	TBI and ADHD, N = 20 Mean (SD)	Primary ADHD, N = 20 Mean (SD)	p
Total	52.15 (6.50)	44.45 (3.91)	0.000
Bedtime resistance	10.00 (2.63)	9.15 (1.26)	0.202
Sleep onset delay	8.05 (1.14)	6.55 (1.23)	0.000
Sleep anxiety	5.55 (1.79)	4.75 (0.91)	0.083
Night wakings	4.00 (1.12)	3.45 (0.51)	0.054
Daytime sleepiness	14.30 (3.54)	9.50 (0.88)	0.000
Parasomnias	8.80 (2.04)	6.60 (0.75)	0.000
Sleep disordered breathing	3.55 (1.39)	2.90 (0.30)	0.049

Note: CSHQ: Children's Sleep Habits Questionnaire; TBI: traumatic brain injury; ADHD: attention deficit hyperactivity disorder.

Hyperactivity score was 7.65 ± 4.2 and 8.75 ± 3.4 in the patient and control groups, respectively ($p = 0.371$).

The majority of the patient sample had severe TBI (N = 11, 55%), while nine children had moderate TBI (45%). At the time of the injury, the mean GCS Score of the patient sample was 8.6 ± 2.7 (ranges between 5 and 12) and the mean duration of mechanical ventilation was 4.7 ± 5.7 days (0–18 days). Fourteen patients had injury on multiple cranial locations, while four had frontal (20%), one had temporal (5%), and one had occipital injuries (5%).

The comparison of CSHQ scores between patient and control groups is shown in Table 1. As seen in the table, Total Score ($p = 0.000$) and Sleep Onset Delay ($p = 0.000$), Daytime Sleepiness ($p = 0.000$), Parasomnias, and Sleep Disordered Breathing ($p = 0.049$) subscores of CSHQ were found to be higher in children with TBI and ADHD.

Table 2 shows the comparison of KINDL-R scores between patient and control groups. Total Score ($p = 0.021$) and the Emotional Well-Being ($p = 0.024$) and Self-Esteem ($p = 0.030$) subscores of the scale were found to be lower (poorer) in children with TBI and ADHD.

The comparison of KINDL-R scores between patients with CSHQ < 56 (N = 13) and CSHQ > 56 (N = 7) is shown in Table 3. As seen in the table, Total Score ($p = 0.000$) and the Emotional Well-Being ($p = 0.000$), Physical Well-Being ($p = 0.001$), Family ($p = 0.020$), and School ($p = 0.015$) subscores were significantly lower (poorer) in those with a CSHQ > 56. In addition to the table, CPRS Total Score was found to be higher in those with a CSHQ > 56 (mean: 40.85, SD: 20.45) when compared with those CSHQ < 56 (Mean: 26.15, SD: 13.1) ($p = 0.05$). CPRS Total Score was also found to be correlated with CSHQ Total Score ($r = 0.635$, $p = 0.003$).

Table 2. The comparison of KINDL-R scores between study groups.

KINDL-R scores	TBI and ADHD, N = 20 Mean (SD)	Primary ADHD, N = 20 Mean (SD)	p
Total	83.35 (9.27)	88.90 (4.57)	0.021
Physical well-being	15.40 (3.92)	15.25 (2.75)	0.889
Emotional well-being	13.95 (3.37)	16.10 (2.29)	0.024
Self-esteem	13.05 (3.23)	15.20 (2.78)	0.030
Family	16.35 (3.01)	17.05 (1.09)	0.335
Social	14.10 (2.42)	12.65 (4.20)	0.190
School	11.36 (1.94)	12.10 (1.71)	0.220

Note: KINDL-R: Kinder Lebensqualitätsfragebogen: Children's Quality of Life Questionnaire-revised; TBI: traumatic brain injury; ADHD: attention deficit hyperactivity disorder.

Table 3. The comparison of KINDL-R scores between patients with CSHQ $<$ 56 and CSHQ $>$ 56.

KINDL-R Scores	CSHQ $<$ 56 N: 13 Mean (SD)	CSHQ $>$ 56 N: 7 Mean (SD)	*p*
Total	89.00 (5.14)	72.85 (4.67)	0.000
Physical Well-Being	17.30 (3.35)	11.85 (1.95)	0.001
Emotional Well-Being	15.69 (2.68)	10.71 (1.70)	0.000
Self-esteem	13.46 (3.77)	12.28 (1.88)	0.453
Family	17.46 (2.98)	14.28 (1.79)	0.020
Social	13.23 (4.34)	14.28 (2.49)	0.564
School	12.16 (1.40)	10.00 (2.08)	0.015

Note: CSHQ: Children's Sleep Habits Questionnaire; KINDL-R: Kinder Lebensqualitätsfragebogen: Children's Quality of Life Questionnaire-revised.

Table 4 shows the Pearson correlations between CSHQ and KINDL-R scores in the patient group. As seen in the table, the Total Score ($p < 0.005$) and the Emotional Well-Being ($p < 0.05$), Physical Well-Being ($p < 0.05$), and Family subscores ($p < 0.05$) of KINDL-R were found to be negatively correlated with CSHQ Total Score.

Table 5 shows the comparison of CSHQ scores between patients with severe and moderate TBI. As seen in the table, no significant difference was found between the groups ($p = >0.05$). A Pearson correlation analysis was also performed to investigate the association between TBI-related variables and CSHQ

Table 4. The Pearson correlations between CSHQ and KINDL-R in the TBI patient group.

KINDL-R CSHQ	Total score	Physical well-being	Emotional well-being	Self-esteem	Family	Social	School
Total score	−0.702[b]	−0.573[a]	−0.591[a]	−0.118	−0.572[a]	0.018	−0.446
Bedtime resistance	−0.351	−0.254	−0.183	0.136	−0.119	−0.515[a]	−0.419
Sleep onset delay	−0.188	0.039	−0.309	−0.192	0.059	−0.154	−0.083
Sleep anxiety	−0.548[a]	−0.385	−0.378	−0.132	−0.369	−0.333	−0.639[b]
Night wakings	−0.560[a]	−0.656[b]	−0.471[a]	0.087	−0.202	−0.025	−0.296
Daytime sleepiness	−0.356	−0.282	−0.188	−0.052	−0.627[b]	0.128	−0.168
Parasomnias	−0.391	−0.489[a]	−0.360	−0.229	−0.133	0.195	−0.295
Sleep disordered breathing	0.025	−0.081	−0.061	−0.181	0.152	0.124	0.139

Note: CSHQ: Children's Sleep Habits Questionnaire; KINDL-R: Kinder Lebensqualitätsfragebogen: Children's Quality of Life Questionnaire-revised; TBI: traumatic brain injury.
[a]$p<0.05$.
[b]$p<0.005$.

Table 5. The comparison of CSHQ scores between patients with moderate and severe TBI.

CSHQ scores	Moderate N: 9 Mean (SD)	Severe N: 11 Mean (SD)	*p*
Total	51.22 (5.93)	52.90 (7.13)	0.578
Bedtime resistance	10.33 (3.27)	9.72 (2.10)	0.622
Sleep onset delay	6.11 (1.45)	6.90 (0.94)	0.155
Sleep anxiety	5.55 (2.35)	5.54 (1.29)	0.990
Night wakings	4.33 (1.22)	3.72 (1.00)	0.240
Daytime sleepiness	14.44 (3.64)	14.18 (3.62)	0.874
Parasomnias	8.33 (1.65)	9.18 (2.31)	0.369
Sleep disordered breathing	3.00 (0.00)	4.00 (1.78)	0.112

Note: CSHQ: Children's Sleep Habits Questionnaire; TBI: traumatic brain injury.

Total Score. There was no significant correlation between CSHQ Total Score and TBI duration ($r = -0.66$, $p = 0.781$) and GCS Score ($r = -0.06$, $p = 0.802$). Age was found to be negatively correlated with CSHQ Total Score ($r = -0.488$, $p = 0.029$). In addition, those with a CSHQ>56 were found to be younger than those with a CSHQ<56 (mean ages = 11.08 ± 2.8 vs. 14 ± 3.03 years, $p = 0.049$).

Discussion

The relationship among TBI, ADHD, and sleep problems must be conceptualized as a complex and multidirectional relationship. Children with TBI have a tendency to have both ADHD symptoms and sleep problems. On the other hand, the relationship between sleep problems and ADHD, which is already shown in primary ADHD, is a bilateral relationship.[27,28] In the present study, as we hypothesized, children with TBI and ADHD symptoms had a higher frequency of sleep problems than children with primary ADHD. According to our findings, a higher frequency of sleep problems may be considered as one differential feature of TBI-related ADHD from primary ADHD. Since both TBI and ADHD lead to an increased risk of sleep problems, the coexistence of both conditions in children may bring a double risk of sleep problems.

The studies on sleep problems in children with TBI are largely limited. Beebe et al.[12] used retrospective parental reports for preinjury sleep and repeated prospective post-injury assessments up to two years and found that severe TBI had a higher risk for post-injury sleep problems compared with those with moderate TBI and children with only an orthopedic injury. Kaufman et al.[29] found that adolescents who had suffered a minor head injury complained of severe sleep disturbances and showed polysomnographic and actometry abnormalities after three years. A prospective study over two years of children who had experienced TBI confirmed a higher rate of sleep disturbance than children who had experienced an orthopedic injury.[11] In a more recent study, where children with moderate–severe TBI were compared with healthy siblings, sleep difficulties occurred more often in the TBI group than in sibling controls, both for subjective report (self/parent) and actigraphy.[26] The mean CSHQ Total Score of 52 in our sample with TBI and ADHD symptoms was comparable to this study. Of note, none of the above-mentioned studies investigated the coexistence of ADHD symptoms in their sample. Moreover, in the majority of these studies, children with a psychiatric disorder diagnosis were excluded. It should be kept in mind that ADHD symptoms are commonly missed and underdiagnosed in children with TBI.

It is well known that children with primary ADHD are under the risk of poor QOL. Studies have shown that multiple domains of QOL including school, peer-relations, family relations, and daily functioning are impaired in children with ADHD.[30–32] Given the psycho-social and cognitive difficulties of TBI, TBI-related ADHD may be expected to be associated with a poorer QOL than primary ADHD. In accordance with this assumption, children with TBI and ADHD symptoms had a poorer QOL than children with primary ADHD in the present study. The Total Score and the Emotional Well-Being and Self-Esteem subscores of KINDL-R were found to be lower in children with TBI. A poorer QOL than primary ADHD may be considered as a differential feature of TBI-related ADHD.

In this study, CSHQ Total Score of children with TBI and ADHD was found to be negatively correlated with the Total Score and certain subscores of

KINDL-R. Moreover, the Total Score and the Emotional Well-Being, Physical Well-Being, and Family and School subscores of KINDL-R were significantly poorer in those with a CSHQ>56. It is not surprising that sleep problems are an additional burden in the QOL of children with TBI and ADHD. On the other hand, our findings indicate that the severity of sleep problems is also associated with the overall QOL. For those with ADHD and sleeping difficulties, sleep quality must be assessed regularly with parent- and clinician-rated tools. Those children with severe sleep problems may need more comprehensive and multimodal interventions for an improved QOL.

A number of studies in adults with TBI and sleep disorders have shown worse performance on cognitive functions including attention and memory.[33,34] Studies in children and adolescents are more limited. Sumpter et al.[26] indicated that the impact of sleep problems on a child with TBI may not present in an obvious way (such as expected daytime sleepiness), but instead as reduced attention, high activity, and irritability. A previous study, which used Parent-report Sleepiness Scale and Behavior Rating Inventory of Executive Function, investigated the association of somnolence and executive function problems in adolescents with TBI.[35] The results have shown that parent-rated daytime somnolence was associated with executive dysfunction on both the Behavior Rating Inventory of Executive Function self-report. Tham et al.[11] used Pediatric Symptom Checklist-17, which assess internalizing, externalizing, and attentional symptoms, and found a higher Pediatric Symptom Checklist-17 score as a risk factor for sleep problems. However, ADHD symptoms were not specifically mentioned in this study. In the present study, CPRS Total Score was found to be correlated with CSHQ scores. Our findings may also be considered as an addition to the limited literature which links sleep problems and ADHD symptoms in children with TBI.

Risk factors of sleep problems among children with TBI have not been extensively studied. There is limited evidence that female gender, psycho-social problems, and pain symptoms are related with sleep problems.[36] Parenting factors (e.g., absence of a routine or poor limit setting) have also been mentioned to contribute to sleep-wake disturbances.[9] In this study, age was found to be negatively correlated with sleep problems. A higher frequency of sleep problems in younger ages may be related with several factors. First, parental worries and resulting co-sleeping may disrupt the sleep hygiene and sleep quality. Overprotective parental attitudes may also affect the parental limits negatively. These may all lead to a resistance to sleep in the night, sleep onset delay, and daytime sleepiness. Second, the damage of TBI in the immature brain may result in a higher disruption on systems responsible for sleep-wake regulation.

Severe TBI, as being related with more severe brain pathology, may be expected to interrupt the brain systems implicated in sleep-wake regulation. On the other hand, greater behavioral problems after more severe pediatric TBI[37] may also result in an increased risk of sleep problems. The research literature on the relationship between TBI severity and sleep problems is mixed. In the study by Osorio et al.,[35] 51% of adolescents with moderate-to-severe TBI showed significant daytime somnolence compared with 22% of those with complicated mild TBI. In contrast, a prospective study of children with TBI found mild TBI as a risk factor for sleep problems.[11] To explain this finding, it has been proposed that persons with mild TBI may have increased recognition of post-injury impairments, and therefore may be more likely to report sleep disturbances as an injury complication.[36,38] In the present study, children with severe and moderate TBI severity did not differ regarding CSHQ scores. More studies are needed to clarify the relationship between TBI severity and sleep problems.

The relationship between TBI and ADHD must be conceptualized as a bilateral relationship. There is substantial evidence that preexisting ADHD may predispose children to traumatic injuries including TBI.[39] Especially, hyperactivity and impulsivity symptoms are associated with a higher risk.[39] Therefore, it should be kept in mind that ADHD symptoms after TBI may reflect both the preexisting ADHD diagnosis and ADHD symptoms which developed and/or worsened after TBI.

It has been shown that sustained attention is particularly vulnerable following TBI.[40] There is also a link between sleep disturbances after TBI and sustained attention deficits. A previous adult study has found that patients with poor sleep quality had significantly more problems on sustained attention.[41] Since no significant relationship was found between poor sleep and other domains of attention, it has been suggested that sleep problems after TBI may be specifically associated with sustained attention deficits.[41] More research is needed to draw a conclusion on such an association, both in adults and children with TBI.

This study has some noteworthy limitations, mainly the small sample size, wide age range of participants, cross-sectional design, and use of subjective sleep measures. To overcome the limitation of wide age range, both a diagnostic interview and rating scales were used for the inclusion of participants. The use of polysomnography, an objective and reliable way of sleep investigation, may reveal more valid findings on sleep problems. The lack of screening for organic sleep disorders such as obstructive sleep apnea and periodic limb movements during sleep is a major limitation, as these are treatable conditions. The investigation of sleep problems a minimum of one year after TBI is also a limitation, since some of the sleep problems could have gone into remission. A third group of patients which may include children with TBI without ADHD symptoms may also be interesting. However, it should be kept in mind that children with moderate–severe TBI frequently have ADHD symptoms. Therefore, most of the previous research on sleep problems in children with TBI, where ADHD was not mentioned, might have also included a significant number of those with ADHD symptoms.

In conclusion, it is important to investigate sleep after TBI, especially as children with TBI are already at increased risk of poorer cognition and behavioral problems. According to our findings, ADHD may be considered as an associated factor of sleep problems. When evaluating children with TBI, both the ADHD and sleep problems must be questioned in detail. Parent- and clinician-rated screening tools may be helpful.[42] For those having one of these conditions, the possible coexistence of the other condition must be investigated. Since both ADHD and sleep problems lead to a poor QOL, early diagnosis and treatment are of vital importance.

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