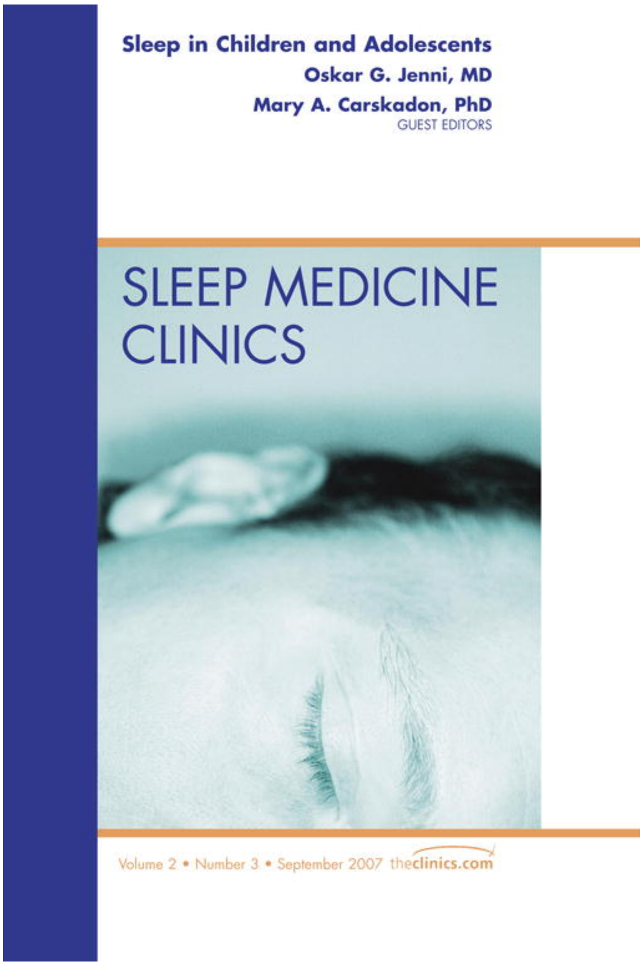
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Consequences of Sleep Loss or Sleep Disruption in Children

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The literature on the effects or consequences of sleep loss and sleep disruptions in children has dramatically increased over the last two decades [1–4]. In this article the term "consequences" relates to affected or associated domains and covers such areas as neurobehavioral functioning (NBF), academic achievements, behavior problems, and emotion regulation. Highly related topics, such as the consequences of sleep-disordered breathing, are reviewed in the article by Gozal and colleagues in this issue and the links to psychopathology are reviewed in the article by Dahl in this issue. This article is based only on papers published in peer-reviewed scientific journals [1–4]. Expanded review of additional work in this area can be found in the cited review papers.

When addressing the links between sleep and cognitive, emotional, and behavioral domains, it is very important to distinguish between correlative studies, which constitute most studies in this field and research based on experimental manipulations. Professionals from the sleep research or sleep medicine disciplines often tend to consider behavioral areas associated with insufficient or poor sleep as "consequences." It is crucial to realize that these links are often bidirectional, however, and although there is convincing theoretical framework for such interpretation, causal relationships cannot be inferred from such correlative studies. Experimental studies, which are still relatively rare in children, provide strong evidence regarding the consequences of poor or insufficient sleep with undisputable causal relationships.

There are two basic underlying mechanisms by which insufficient or disrupted sleep may adversely impact cognitive functioning and behavior in general. The first one relates to the active role of sleep in brain maturation, information processing, memory consolidation, learning, and other brain maintenance functions [5–9]. It is assumed that insufficient sleep, and particularly rapid eye movement sleep, prevents or reduces necessary brain activities required for brain maturation, affect regulation, memory consolidation, and learning. The second mechanism is related to the reinvigorating role of sleep and the fact that insufficient or disrupted sleep leads to increased daytime sleepiness and reduced alertness and possibly to compromised daytime functioning of specific brain areas (most commonly specified: the prefrontal cortex), which in turn leads to many areas of compromised cognitive function and behavior regulation [10–15].

The literature on the effects of sleep deprivation or sleep disruptions rarely addresses these underlying mechanisms and mostly focuses on demonstrating the links between sleep characteristics and the presumably affected (or at least associated) behavioral domains.

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Daytime sleepiness

Undoubtedly, the most common consequence of insufficient or disrupted sleep is daytime sleepiness and reduced alertness [16]. The definition of daytime sleepiness is problematic and various objective and subjective measures do not necessarily converge [17]. The most common methods to assess sleepiness are the Multiple Sleep Latency Test (MSLT) [18] and subjective reports [17].

Experimental studies on sleep deprivation or sleep restriction in children have indicated that increased daytime sleepiness is a direct and consistent result [19–24]. Using the MSLT, these studies have shown dramatic increase in daytime sleepiness (ie, decreased sleep latency) as a direct result of acute (ie, total sleep deprivation) or more moderate sleep restriction (ie, restricting sleep to 4 hours) [19–22]. For instance, Carskadon and colleagues [19] have shown that after 1 night of sleep deprivation, sleep latencies on the MSLT dropped from an average level above 15 minutes to an average below 5 minutes, which indicates severe sleepiness. Similarly, Randazzo and colleagues [21] have shown a dramatic drop in sleep latencies following sleep restriction to 4 hours. Similar findings were demonstrated in sleep restriction studies using subjective reports and teachers' ratings [19,22–24].

Field studies and surveys have repeatedly shown that increased sleepiness is associated with the maturational tendency to delay sleep onset and shorten sleep during the second decade of life [25–28]. Variations in school starting time also affect sleep duration and daytime sleepiness in children. Studies have shown that earlier school start time is associated with shorter sleep and increased daytime sleepiness and fatigue as measured by subjective reports and MSLT [29–31]. Furthermore, other correlative studies have shown association between sleep problems and insufficient sleep and daytime sleepiness [32–36].

The conclusion from these studies and others is that daytime sleepiness is a very prominent and consistent consequence of sleep problems and insufficient sleep. The behavioral manifestations of sleepiness in children and particularly young children are complex and sometimes misleading because children often become very agitated and hyperactive when they are overtired [16].

Neurobehavioral functioning, learning, and academic performance

For brevity, the term NBF is used to refer to all cognitive domains. There is a rapidly growing literature on the effects of sleep problems and insufficient sleep on NBF. Most of this literature is correlative in nature, particularly the literature on sleep disruptions, demonstrating associations between sleep problems and insufficient sleep and compromised NBF. The consequences of sleep loss or insufficient sleep have been demonstrated, however, in a small number of experimental studies on the effects of sleep deprivation or restriction [19–24]. The results of these studies are not always straightforward. Carskadon and colleagues [19] assessed the effects of a full-night sleep deprivation and a 4-hour sleep restriction [20] on NBF. They found compromised functioning on the Wilkinson Addition Test and the Williamson Word Memory Task following the full-night sleep deprivation. In the study on 4-hour sleep restriction, no significant effects were found on NBF and the authors concluded that partial sleep restriction may not be sufficient to produce significant consequences [20]. Recent studies challenge these findings, however, and suggest that sleep restriction does lead to detectable deficits in NBF, and that tracking these consequences may be dependent on the level of complexity of the tested domain. For example, Randazzo and colleagues [21] compared the performance of children following sleep restriction to 5 hours in bed with performance of a control group after 11 hours in bed. Performance of the sleep-restricted group was significantly poorer on measures of verbal creativity and on the Wisconsin Card Sorting Test. No differences were found on less complex memory tasks [21]. More conflicting results were obtained by Fallone and colleagues [22], who compared NBF in children and adolescents (8–15 years of age) after a night of optimized sleep (based on their normal sleep habits) with NBF in children after their sleep was restricted to 4 hours. The sleep-restricted children were more sleepy and inattentive as manifested by their behaviors. There were no significant group differences, however, on tests of response inhibition and sustained attention.

Sadeh and colleagues [23] explored the accumulative effects of minimal sleep restriction or extension for 3 consecutive nights on NBF in school children. The children were asked to sleep according to their regular schedule for 2 nights and their NBF was assessed in the morning of the first day. On the third afternoon they received a telephone call asking them to go to sleep either 1 hour earlier or later (according to random assignment) during the following 3 nights. After the third night of sleep restriction or extension, which was verified by actigraphy, their NBF was assessed again in the morning of the sixth day. The study revealed that the children in the sleep-restricted group shortened their sleep by an average of 41 minutes each night, and children in the sleep extension group extended their sleep by an average of 35 minutes. These accumulated variations in sleep time led to significant effects on their NBF as measured by simple reaction time task; the continuous performance test (assessing sustained attention); and working memory tasks. No significant effects were found on other less-demanding motor tasks [23].

The results of these studies show that experimental sleep loss does have significant effects on NBF in children. The findings of Sadeh and colleagues [23] suggest that even a very moderate (eg, "one more television show"), but accumulated, sleep loss may have significant effects on children's cognitive performance. The results also suggest that more complex neurobehavioral domains, particularly those related to executive functioning and associated with the prefrontal cortex, are more vulnerable to sleep loss. These results are consistent with the adult literature on the effects of sleep loss on NBF [11,12,37].

These causal links between sleep loss and compromised NBF gain additional support from correlative studies demonstrating the links between sleep duration or sleep quality and NBF [29,38–40]. For example, Steenari and colleagues [38] assessed sleep using actigraphy and memory function using the n-back task in 60 school-age children. They found that lower sleep efficiency and longer sleep latency were associated with more errors on the memory task. They also found that shorter sleep was correlated with poorer performance only at the highest load level. Sadeh and colleagues [39] performed a similar study in 135 school children, using actigraphy to assess naturalistic sleep patterns and a battery of computerized tests to assess NBF. Children with fragmented sleep (frequent night wakings, lower sleep efficiency) had compromised NBF on more complex tasks associated with executive functioning including the continuous performance test and a symbol-digit substitution test. The correlations between sleep and NBF were significantly higher in younger children (second grade in comparison with fourth and sixth grade), suggesting that younger children might be more vulnerable to sleep disruptions. No significant correlations were found between sleep duration and NBF in this study. More recently, Buckhalt and colleagues [40] have used actigraphy to assess sleep and a standard battery of cognitive tests (Woodcock-Johnson III) in a sample of 176 normal children (aged 7–11 years). Their findings included very modest correlations between sleep and cognitive measures. When race and socioeconomic status were controlled as moderating factors, stronger links were found between cognitive performance and the quality and quantity of sleep. The negative correlations between cognitive performance and shorter sleep and unstable sleep schedule were stronger in the children with African American origins compared with children with European-American origins.

A large number of studies have also shown that children who suffer from sleep-related breathing problems (eg, sleep apnea, snoring) are more likely to suffer from significant deficits in NBF. This topic is reviewed in the article by Gozal and colleagues in this issue.

Academic performance is the outcome of complex interplay between multiple factors including the child's intelligence; NBF; motivation for achievement; temperament; and external influences, such as socioeconomic status, parental education, and family atmosphere [4]. Perhaps the only published experimental study that assessed sleep restriction on direct teachers' ratings on academic performance was the one conducted by Fallone and colleagues [24]. Restricting sleep (8 hours of time in bed per night for second grade students and 6.5 hours for older students) during one school week led to a significant increase in academic problems. These academic problems were rated by the teachers and included quality of child's school work, percent of work completed, pace of learning, difficulty in recalling material, and carelessness and hastiness in school work.

A relatively large number of studies on sleep and academic performance in children and adolescents have been published over the last two decades [2–4]. These were mostly correlative studies linking academic performance and sleep patterns, insufficient sleep, sleep schedule, and sleep problems [29,33,41–47].

For example, Kahn and colleagues [41] surveyed sleep in 1000 elementary school children. In this study, school achievement difficulties were more likely to occur in poor sleepers. Wolfson and Carskadon [33] surveyed reported sleep and academic achievements in 3120 adolescents. Their results indicated that students with better academic record (mostly As and Bs) slept significantly longer than students with poorer academic performance (mostly Cs, Ds, and Fs). In a survey assessing the effects of early school start time on children's sleep and functioning, Epstein and colleagues [29] found that compared with children who started school at a regular time, "early risers" (who started school earlier) obtained significantly less sleep and they complained more about attention problems and difficulty concentrating. Other school surveys reflected associations between sleep problems and compromised school performance [43,44,46,47].

Although the links between sleep and academic performance have been repeatedly demonstrated, these links do not necessarily reflect causal relationships and additional evidence is still required to make a strong case that compromised school performance is a consequence of sleep loss or sleep disruptions. Other factors (eg, parental control or authority) could play a significant role in determining both sleep duration and academic performance [4,48].

Behavior, temperament, and mood

The effects of sleep loss and sleep disruptions on temperament, mood, and manifested behavior (as opposed to tested NBF) have rarely been studied with experimental designs. Most of the literature in this area is based on correlative studies with only a few exceptions.

Behavior

One of the most widely addressed consequence of sleep problems or insufficient sleep is related to attention regulation and attention problems [10,49]. Many of the findings described in the section on NBF are related to tests that measure attention regulation or are considered sensitive to attention problems (eg, continuous performance tests). The fact that sleep disruptions and insufficient sleep lead to attention-deficit–hyperactivity disorder–like symptoms has been systematically addressed in the literature [50–53]. The links between sleep disruptions and attention-deficit–hyperactivity disorder as a diagnostic entity are described in the article by Dahl in this issue. The links between sleep and attention regulation, however, have also been documented in normal, nondiagnosed children.

In their experimental studies on sleep restriction, Fallone and colleagues [22,24] described increased attention difficulties in response to both acute and moderate-accumulated sleep restriction. In the study on the effects of early school start time (described previously), higher level of attention and concentration problems were reported by the "early risers" who obtained less sleep [29]. Other studies documented associations between sleep problems and attention problems in normal children and adolescents [42,45,54,55].

Beyond the attention-regulation domain, behavior problems have often been associated with insufficient or disrupted sleep. This topic is related to the topic of sleep and psychopathology, covered in the article by Dahl in this issue, but it is important to emphasize that insufficient and disrupted sleep have consistently been associated with behavior problems in normal, undiagnosed children [36,39,42,56–63]. From a different angle, a unique study assessed the effects of behavioral intervention for sleep-disturbed toddlers on their interactive behavior following the intervention [64]. It was found that following the intervention and the improvement in sleep, the behavior of the toddlers significantly improved, although maternal behavior remained stable. A causal interpretation, however, is not straightforward. One tempting interpretation is that the improvement in sleep led to the improvement in child behavior. The alternative interpretation is that the acquired new training experiences of the parents that led to the improvement in sleep were also responsible for the changes in child interactive behaviors [64]. Regardless of the "true" interpretation, this study shows how the dynamics of sleep and behavior regulation are interwoven and interdependent.

Temperament

The concept of temperament in early childhood is a very problematic one [65]. In practice it is used as an organizing concept for behavior typology or traits mostly in infants and toddlers, but sometimes also with older children. The relationships between sleep and temperament have been a topic for many years of research without conclusive results. Most of the research conducted to date is correlative and based on parental ratings of child temperament. Most of these studies indicated that poor or insufficient sleep is associated with difficult temperament [66–72]. There are good reasons to assume that the relationships between sleep and temperament (as it is measured in most studies) are bidirectional. For instance, after finding low sensory threshold in sleep-disturbed infants Carey [66] proposed that perhaps sleep is more vulnerable in these babies because of their inability to block external and internal stimuli that disrupt sleep. The intuitive notion is that sleep-deprived babies become cranky, irritable, and difficult to manage, and it is easy to accept the idea that insufficient or disturbed sleep could lead to difficult temperament. The research in this area is insufficient, however, to postulate that difficult temperament is indeed a consequence of insufficient or disrupted sleep.

Mood and emotion regulation

In a comprehensive meta-analytic review on the effects of sleep-deprivation in adults, Pilcher and Huffcutt [73] concluded that the effects of sleep deprivation on mood were more profound than its effects on cognitive or motor performance. These studies in adults lay the groundwork for the hypothesis that insufficient or disrupted sleep could lead to a negative mood or difficulty in emotion regulation in children.

In contrast to the adult literature, there is a striking lack of experimental findings on the effects of sleep deprivation on mood and emotion regulation in children. There are multiple correlative studies demonstrating links between shorter or disrupted sleep and negative mood and poor emotion regulation [33,55,68,74–83]. These studies associate poor or insufficient sleep with negative mood and symptoms of depression, anxiety, and other signs of poor emotion regulation. The relative lack of strong experimental evidence does not permit any conclusion about the role of sleep in mood and emotion regulation in children at this time. Additional evidence for these links exist in the literature on sleep and psychopathology, covered in the article by Dahl in this issue.

Although sleep loss and sleep disruption may lead to negative mood in normal individuals, sleep deprivation or sleep restriction can lead to improvement in depressive symptoms in clinically depressed children [84,85]. The underlying mechanism for this clinical improvement (also seen in adults) is still unclear [86–88] but it does challenge the notion that more sleep is always beneficial. Furthermore, there is strong support to the conceptualization of sleep problems as a consequence of dysfunctional emotion regulation [10,89] or of stressful life events [90]. More experimental research is needed to establish the specific role of insufficient or disrupted sleep in the development of poor emotion regulation.

Summary

The literature on the consequences of sleep loss and sleep disruptions in children is significantly lagging behind the literature on adults. The number of experimental studies on sleep deprivation or sleep restriction in children is very small and they mostly cover the area of NBF or cognitive performance. The findings of these studies, however, are generally in line with those obtained in adults. There is converging evidence that daytime sleepiness and fatigue are a direct and consistent consequence of sleep loss and sleep disruptions. This conclusion is supported by experimental and correlative studies in children (and in adults). There is reasonable support for a conclusion that compromised NBF is a consequence of sleep loss. This seems to be particularly true for neurobehavioral tasks that challenge executive control, attention regulation, and working memory. This conclusion is also supported by experimental and correlative studies in children (and in adults). There is also substantial correlative data to support the hypothesis that sleep disruptions may also lead to compromised NBF.

In the behavior regulation domain there is reasonable support to consider difficulty in attention regulation as a consequence of sleep loss. There are many studies correlating sleep disruptions (very often breathing-related or periodic movement in sleep) with attention problems and attention-deficit–hyperactivity disorder. The etiologic mechanisms underlying these associations, however, do not necessarily justify considering these attention problems as a direct result of a sleep loss.

The evidence for consequences in the domains of mood and emotion regulation is very limited. There are numerous correlative studies demonstrating the links between sleep problems or insufficient sleep and behavior problems and emotion regulation. The lack of experimental studies in this area, however, is striking. This is probably the most needed and challenging area for future research in the exploration of the consequences of insufficient or disrupted sleep in children.

References

[1] O'Brien LM, Gozal D. Neurocognitive dysfunction and sleep in children: from human to rodent. Pediatr Clin North Am 2004;51(1): 187–202.

[2] Curcio G, Ferrara M, De Gennaro L. Sleep loss, learning capacity and academic performance. Sleep Med Rev 2006;10(5):323–37.

[3] Taras H, Potts-Datema W. Sleep and student performance at school. J Sch Health 2005;75(7): 248–54.

[4] Wolfson AR, Carskadon MA. Understanding adolescents' sleep patterns and school performance: a critical appraisal. Sleep Med Rev 2003;7(6):491–506.

[5] Stickgold R. Toward a cognitive neuroscience of sleep. Sleep Med Rev 2001;5(6):417–21.

[6] Stickgold R, Hobson JA, Fosse R, et al. Sleep, learning, and dreams: off-line memory reprocessing. Science 2001;294(5544):1052–7.

[7] Mirmiran M, Vansomeren E. The importance of REM-sleep for brain maturation. J Sleep Res 1993;2(4):188–92.

[8] Peigneux P, Laureys S, Delbeuck X, et al. Sleeping brain, learning brain: the role of sleep for memory systems. Neuroreport 2001;12(18):A111–24.

[9] Frank MG, Benington JH. The role of sleep in memory consolidation and brain plasticity: dream or reality? Neuroscientist 2006;12(6): 477–88.

[10] Dahl RE. The regulation of sleep and arousal: development and psychopathology. Dev Psychopathol 1996;8(1):3–27.

[11] Horne JA. Human sleep, sleep loss and behaviour: implications for the prefrontal cortex and psychiatric disorder. Br J Psychiatry 1993;162: 413–9.

[12] Drummond SPA, Brown GG. The effects of total sleep deprivation on cerebral responses to cognitive performance. Neuropsychopharmacology 2001;25:S68–73.

[13] Harrison Y, Horne JA, Rothwell A. Prefrontal neuropsychological effects of sleep deprivation in young adults: a model for healthy aging? Sleep 2000;23(8):1067–73.

[14] Harrison Y, Horne JA. The impact of sleep deprivation on decision making: a review. J Exp Psychol Appl 2000;6(3):236–49.
[15] Jones K, Harrison Y. Frontal lobe function, sleep loss and fragmented sleep. Sleep Med Rev 2001; 5(6):463–75.
[16] Fallone G, Owens JA, Deane J. Sleepiness in children and adolescents: clinical implications. Sleep Med Rev 2002;6(4):287–306.
[17] Pigeon WR, Sateia MJ, Ferguson RJ. Distinguishing between excessive daytime sleepiness and fatigue–toward improved detection and treatment. J Psychosom Res 2003;54(1):61–9.
[18] Carskadon MA, Dement WC, Mitler MM, et al. Guidelines for the multiple sleep latency test (MSLT): a standard measure of sleepiness. Sleep 1986;9(4):519–24.
[19] Carskadon MA, Harvey K, Dement WC. Sleep loss in young adolescents. Sleep 1981;4(3): 299–312.
[20] Carskadon MA, Harvey K, Dement WC. Acute restriction of nocturnal sleep in children. Percept Mot Skills 1981;53(1):103–12.
[21] Randazzo AC, Muehlbach MJ, Schweitzer PK, et al. Cognitive function following acute sleep restriction in children ages 10-14. Sleep 1998; 21(8):861–8.
[22] Fallone G, Acebo C, Arnedt JT, et al. Effects of acute sleep restriction on behavior, sustained attention, and response inhibition in children. Percept Mot Skills 2001;93(1):213–29.
[23] Sadeh A, Gruber R, Raviv A. The effects of sleep restriction and extension on school-age children: what a difference an hour makes. Child Dev 2003;74(2):444–55.
[24] Fallone G, Acebo C, Seifer R, et al. Experimental restriction of sleep opportunity in children: effects on teacher ratings. Sleep 2005;28(12): 1561–7.
[25] Sadeh A, Raviv A, Gruber R. Sleep patterns and sleep disruptions in school-age children. Dev Psychol 2000;36(3):291–301.
[26] Gau SF, Soong WT. Sleep problems of junior high school students in Taipei. Sleep 1995; 18(8):667–73.
[27] Carskadon MA. Patterns of sleep and sleepiness in adolescents. Pediatrician 1990;17(1):5–12.
[28] Carskadon MA, Harvey K, Duke P, et al. Pubertal changes in daytime sleepiness. Sleep 2002;25(6): 453–60.
[29] Epstein R, Chillag N, Lavie P. Starting times of school: effects on daytime functioning of fifth-grade children in Israel. Sleep 1998;21(3):250–6.
[30] Hansen M, Janssen I, Schiff A, et al. The impact of school daily schedule on adolescent sleep. Pediatrics 2005;115(6):1555–61.
[31] Carskadon MA, Wolfson AR, Acebo C, et al. Adolescent sleep patterns, circadian timing, and sleepiness at a transition to early school days. Sleep 1998;21(8):871–81.
[32] Archbold K, Pituch K, Panahi P, et al. Symptoms of sleep disturbances among children at two general pediatric clinics. J Pediatr 2002;140(1): 97–102.
[33] Wolfson AR, Carskadon MA. Sleep schedules and daytime functioning in adolescents. Child Dev 1998;69(4):875–87.
[34] Neveus T, Cnattingius S, Olsson U, et al. Sleep habits and sleep problems among a community sample of schoolchildren. Acta Paediatr 2001; 90(12):1450–5.
[35] Liu XC, Liu LQ, Owens JA, et al. Sleep patterns and sleep problems among schoolchildren in the United States and China. Pediatrics 2005; 115(1):241–9.
[36] Kirmil Gray K, Eagleston JR, Gibson E, et al. Sleep disturbance in adolescents: sleep quality, sleep habits, beliefs about sleep, and daytime functioning. J Youth Adolesc 1984;13(5):375–84.
[37] Harrison Y, Horne JA. Sleep loss impairs short and novel language tasks having a prefrontal focus. J Sleep Res 1998;7(2):95–100.
[38] Steenari MR, Vuontela V, Paavonen EJ, et al. Working memory and sleep in 6-to 13-year-old schoolchildren. J Am Acad Child Adolesc Psychiatry 2003;42(1):85–92.
[39] Sadeh A, Gruber R, Raviv A. Sleep, neurobehavioral functioning and behavior problems in school-age children. Child Dev 2002;73(2): 405–17.
[40] Buckhalt JA, El-Sheikh M, Keller P. Children's sleep and cognitive functioning: race and socioeconomic status as moderators of effects. Child Dev 2007;78(1):213–31.
[41] Kahn A, Van de Merckt C, Rebuffat E, et al. Sleep problems in healthy preadolescents. Pediatrics 1989;84(3):542–6.
[42] Liu XC, Sun ZX, Uchiyama M, et al. Prevalence and correlates of sleep problems in Chinese schoolchildren. Sleep 2000;23(8):1053–62.
[43] Lazaratou H, Dikeos DG, Anagnostopoulos DC, et al. Sleep problems in adolescence: a study of senior high school students in Greece. Eur Child Adolesc Psychiatry 2005;14(4):237–43.
[44] Meijer AM, van den Wittenboer GLH. The joint contribution of sleep, intelligence and motivation to school performance. Pers Individ Dif 2004;37(1):95–106.
[45] Giannotti F, Cortesi F, Sebastiani T, et al. Circadian preference, sleep and daytime behaviour in adolescence. J Sleep Res 2002;11(3): 191–9.
[46] Meijer AM, Habekothe HT, van den Wittenboer GLH. Time in bed, quality of sleep and school functioning of children. J Sleep Res 2000;9(2):145–53.
[47] Bruni O, Ferini-Strambi L, Russo PM, et al. Sleep disturbances and teacher ratings of school achievement and temperament in children. Sleep Med 2006;7(1):43–8.
[48] Owens-Stively J, Frank N, Smith A, et al. Child temperament, parenting discipline style, and daytime behavior in childhood sleep disorders. J Dev Behav Pediatr 1997;18(5):314–21.

[49] Dahl RE, Pelham WE, Wierson M. The role of sleep disturbances in attention deficit disorder symptoms: a case study. J Pediatr Psychol 1991; 16(2):229–39.
[50] Corkum P, Tannock R, Moldofsky H. Sleep disturbances in children with attention-deficit/hyperactivity disorder. J Am Acad Child Adolesc Psychiatry 1998;37(6):637–46.
[51] Sadeh A, Pergamin L, Bar-Haim Y. Sleep in children with attention-deficit hyperactivity disorder: a meta-analysis of polysomnographic studies. Sleep Med Rev 2006;10(6):381–98.
[52] Cohen-Zion M, Ancoli-Israel S. Sleep in children with attention-deficit hyperactivity disorder (ADHD): a review of naturalistic and stimulant intervention studies. Sleep Med Rev 2004;8(5): 379–402.
[53] Owens JA. The ADHD and sleep conundrum: a review. J Dev Behav Pediatr 2005;26(4): 312–22.
[54] Shang CY, Gau SSF, Soong WT. Association between childhood sleep problems and perinatal factors, parental mental distress and behavioral problems. J Sleep Res 2006;15(1):63–73.
[55] Gregory AM, Eley TC, O'Connor TG, et al. Etiologies of associations between childhood sleep and behavioral problems in a large twin sample. J Am Acad Child Adolesc Psychiatry 2004;43(6): 744–51.
[56] Bates JE, Viken RJ, Alexander DB, et al. Sleep and adjustment in preschool children: sleep diary reports by mothers relate to behavior reports by teachers. Child Dev 2002;73(1):62–75.
[57] Morrison DN, McGee R, Stanton WR. Sleep problems in adolescence. J Am Acad Child Adolesc Psychiatry 1992;31(1):94–9.
[58] Hiscock H, Canterford L, Ukoumunne OC, et al. Adverse associations of sleep problems in Australian preschoolers: national population study. Pediatrics 2007;119(1):86–93.
[59] Kataria S, Swanson MS, Trevathan GE. Persistence of sleep disturbances in preschool children. J Pediatr 1987;110(4):642–6.
[60] Richman N, Stevenson J, Graham PJ. Preschool to school: a behavioural study. Behavioural Development: A Series of Monographs 1982;228.
[61] Zuckerman B, Stevenson J, Bailey V. Sleep problems in early childhood: continuities, predictive factors, and behavioral correlates. Pediatrics 1987;80(5):664–71.
[62] Lavigne JV, Arend R, Rosenbaum D, et al. Sleep and behavior problems among preschoolers. J Dev Behav Pediatr 1999;20(3):164–9.
[63] Lam P, Hiscock H, Wake M. Outcomes of infant sleep problems: a longitudinal study of sleep, behavior, and maternal well-being. Pediatrics 2003; 111(3):e203–7.
[64] Minde K, Faucon A, Falkner S. Sleep problems in toddlers: effects of treatment on their daytime behavior. J Am Acad Child Adolesc Psychiatry 1994;33(8):1114–21.
[65] Rothbart MK, Ahadi SA, Evans DE. Temperament and personality: origins and outcomes. J Pers Soc Psychol 2000;78(1):122–35.
[66] Carey WB. Night waking and temperament in infancy. J Pediatr 1974;84(5):756–8.
[67] Scher A, Epstein R, Sadeh A, et al. Toddlers' sleep and temperament: reporting bias or a valid link? A research note. J Child Psychol Psychiatry 1992; 33(7):1249–54.
[68] Weissbluth M. Sleep duration, temperament, and Conners' ratings of three-year-old children. J Dev Behav Pediatr 1984;5(3):120–3.
[69] Sadeh A, Lavie P, Scher A. Maternal perceptions of temperament of sleep-disturbed toddlers. Early Educ Dev 1994;5:311–22.
[70] Weissbluth M, Liu K. Sleep patterns, attention span, and infant temperament. J Dev Behav Pediatr 1983;4(1):34–6.
[71] Novosad C, Freudigman K, Thoman EB. Sleep patterns in newborns and temperament at eight months: a preliminary study. J Dev Behav Pediatr 1999;20(2):99–105.
[72] Keener MA, Zeanah CH, Anders TF. Infant temperament, sleep organization, and nighttime parental interventions. Pediatrics 1988;81(6): 762–71.
[73] Pilcher JJ, Huffcutt AI. Effects of sleep deprivation on performance: a meta-analysis. Sleep 1996;19(4):318–26.
[74] Gau SSF, Soong WT, Merikangas KR. Correlates of sleep-wake patterns among children and young adolescents in Taiwan. Sleep 2004;27(3): 512–9.
[75] Johnson EO, Chilcoat HD, Breslau N. Trouble sleeping and anxiety/depression in childhood. Psychiatry Res 2000;94(2):93–102.
[76] Fredriksen K, Rhodes J, Reddy R, et al. Sleepless in Chicago: tracking the effects of adolescent sleep loss during the middle school years. Child Dev 2004;75(1):84–95.
[77] Gregory AM, Rijsdijk FV, Dahl RE, et al. Associations between sleep problems, anxiety, and depression in twins at 8 years of age. Pediatrics 2006;118(3):1124–32.
[78] Gregory AM, O'Connor TG. Sleep problems in childhood: a longitudinal study of developmental change and association with behavioral problems. J Am Acad Child Adolesc Psychiatry 2002; 41(8):964–71.
[79] Bertelson AD, Monroe LJ. Personality patterns of adolescent poor and good sleepers. J Abnorm Child Psychol 1979;7(2):191–7.
[80] Blader JC, Koplewicz HS, Abikoff H, et al. Sleep problems of elementary school children: a community survey. Arch Pediatr Adolesc Med 1997; 151(5):473–80.
[81] Paavonen EJ, Almqvist F, Tamminen T, et al. Poor sleep and psychiatric symptoms at school: an epidemiological study. Eur Child Adolesc Psychiatry 2002;11(1):10–7.
[82] Smedje H, Broman JE, Hetta J. Associations between disturbed sleep and behavioural

difficulties in 635 children aged six to eight years: a study based on parents' perceptions. Eur Child Adolesc Psychiatry 2001;10(1):1–9.

[83] Smaldone A, Honig JC, Byrne MW. Sleepless in America: inadequate sleep and relationships to health and well-being of Our nation's children. Pediatrics 2007;119(Suppl 1):S29–37.

[84] King BH, Baxter LR Jr, Stuber M, et al. Therapeutic sleep deprivation for depression in children. J Am Acad Child Adolesc Psychiatry 1987;26(6):928–31.

[85] Naylor MW, King CA, Lindsay KA, et al. Sleep deprivation in depressed adolescents and psychiatric controls. J Am Acad Child Adolesc Psychiatry 1993;32(4):753–9.

[86] Wirz-Justice A, Van den Hoofdakker RH. Sleep deprivation in depression: what do we know, where do we go? Biol Psychiatry 1999;46(4):445–53.

[87] Benedetti F, Bernasconi A, Blasi V, et al. Neural and genetic correlates of antidepressant response to sleep deprivation: a functional magnetic resonance imaging study of moral valence decision in bipolar depression. Arch Gen Psychiatry 2007;64(2):179–87.

[88] Ringel BL, Szuba MP. Potential mechanisms of the sleep therapies for depression. Depress Anxiety 2001;14(1):29–36.

[89] Dahl RE, Lewin DS. Pathways to adolescent health: sleep regulation and behavior. J Adolesc Health 2002;31(6):175–84.

[90] Sadeh A. Stress, trauma, and sleep in children. Child Adolesc Psychiatr Clin N Am 1996;5(3):685–700.