HHS Public Access

Author manuscript

Curr Opin Psychiatry. Author manuscript; available in PMC 2016 November 01.

Published in final edited form as:

Curr Opin Psychiatry. 2015 November ; 28(6): 483–489. doi:10.1097/YCO.0000000000000204.

Sleep and Anxiety in Late Childhood and Early Adolescence

Dana L. McMakin[a] and **Candice A. Alfano**[b]

[a]University of Pittsburgh

[b]University of Houston

Abstract

Purpose of review—Adolescence is a period of dynamic change in both sleep and emotional systems, with related increases in problems controlling emotion and behavior. Youth with anxiety enter adolescence with pre-existing vulnerabilities in systems of sleep and emotion that may place them at heightened risk. This review summarizes recent research on sleep and anxiety during the transition to adolescence, and highlights emerging themes.

Recent findings—Prospective studies support that sleep predicts anxiety symptoms in early adolescence. Notably, robust evidence for subjective sleep problems in anxious youth is not well-corroborated by objective assessments. Longitudinal designs and methodology that carefully examine dimensions of anxiety and sleep may clarify inconsistencies. Preliminary evidence suggests that late childhood to early adolescence may be a sensitive period for escalating problems with sleep and anxiety. Recent advances in the neuroscience of sleep can further refine integrative mechanistic models of developmental psychopathology—the role of sleep in emotional learning and memory is provided as an example.

Summary—Sleep problems are common and prospectively predict escalating anxiety symptoms. Precision is needed regarding the nature of sleep disruption, and how and when sleep impacts various aspects of developmental trajectories. This precision, along with advances in the neuroscience of sleep, may lead to developmentally-informed translational interventions.

Keywords

Sleep; Emotion; Anxiety; Adolescence; Neuroscience

Introduction

Sleep problems are ubiquitous to psychiatric disorders not just as a symptom but as a precursor of emotional and behavioral problems across the lifespan. Increasingly, it is evident that these linkages begin to take root early in life. In their review of a recent SRCD-sponsored forum on sleep and child development, El-Sheikh and Buckhalt [1++] describe an agenda for fully explicating the role of sleep in developmental trajectories of health that calls for integrative models across developmental psychology, neuroscience, anthropology

Correspondence should be addressed to Dana L. McMakin, 3811 O'Hara Street, Pittsburgh, PA 15213. mcmakind@upmc.edu.

Conflict of Interest

The authors do not have any conflicts of interest to report.

and public health. Though admittedly challenging, the products of such work stand to not only inform models of developmental psychopathology, but also identify opportunities for high impact and enduring intervention.

Guided by this broad framework, our review focuses on sleep in anxious youth during the transition from late childhood to early adolescence (approximately ages 10–13). We choose this population for several reasons. First, this unique transitional period of peri-puberty includes significant neurobiological, hormonal, and socio-contextual changes relevant to both affect and sleep-wake regulation [2+, 3]. Consequences of these developmental shifts, and their reciprocal impacts, include insufficient sleep among more than 70% of U.S. teens between 12 and 14 years[4], as well as escalating rates of emotional and behavioral problems (e.g. depression, anxiety, substance abuse, risky behavior) [5]. Second, anxious youth enter adolescence with pre-existing vulnerabilities that could amplify the causes and consequences of insufficient or poor sleep during this developmental stage. At the same time, modifying aspects of sleep in anxious youth during this sensitive period of neuro-maturation could powerfully impact emotional and behavioral health.

Our review is organized around three broad themes emerging in recent literature: 1) clarifying the precise nature of sleep disturbance in anxious youth, 2) prospective impacts of sleep disturbance on anxiety during the transition to adolescence, and 3) emerging integrative models of development that may explain associations between sleep and anxiety. We focus this review on Generalized Anxiety Disorder (GAD), Separation Anxiety Disorder (SAD), and Social Anxiety Disorder (SOC), given substantial similarities in phenotypes.

Characterizing the nature of sleep disturbance in youth with anxiety

A number of studies document robust and consistent subjective sleep complaints in as many as 90% of youth with anxiety, particularly as reported by parents [for recent reviews, 6+, 7]. These complaints include bedtime resistance, problems initiating/maintaining sleep, and feeling rested upon waking. However, more recent investigations utilizing objective sleep measures, including polysomnography (PSG) or actigraphy, have largely failed to demonstrate the presence of sleep alterations/disturbance. Regarding PSG, greater sleep onset latency as well as more rapid entry into rapid eye movement (REM) sleep was found among youth with generalized anxiety disorder (GAD) compared to controls assessed in the sleep lab [8]. A previous study also found greater sleep onset latency, but no differences in time to entry into REM [9]. Finally, a recent investigation of PSG in the home did not replicate results for sleep onset or REM latency [10+]. Regarding actigraphy, results from a recently published comparison study of children with GAD versus controls are consistent with previous findings [11] showing no robust sleep differences between these groups [12++]. Adolescents with SOC also did not differ from controls in terms of actigraphy-based sleep patterns [13]. Taken together, these studies suggest weak alignment in subjective and objective evidence for sleep disturbance in anxious youth.

Several conceptual and methodological issues may obscure the precise nature of sleep problems experienced by anxious youth. Some of these issues are reviewed below, but it is essential to first emphasize that subjective sleep complaints, whether or not corroborated by

objective evidence, are clinically meaningful if they are associated with psychological distress or daytime impairments in functioning. This is similar to criteria for other psychological symptoms for which objective markers do not exist (e.g., dysphoria, intrusive thoughts). Nevertheless, pursuing clarity regarding the precise nature and form of sleep disturbances may deepen understanding of which aspects of sleep contribute to the course of anxiety, and point to the most efficient intervention strategies.

The multi-dimensional and developmental nature of sleep

Various aspects of sleep may be relevant to clinical levels of anxiety. Problems with sleep duration (total minutes of sleep), quality (sleep efficiency, feeling subjectively "rested"), patterns (bedtime variability, sleep timing), and transitions (difficulty getting to bed, daytime sleepiness) have been implicated in different studies [6+]. Fewer studies have focused on sleep architecture (% sleep stages) and physiology (neural activity, heart rate variability) [8–10] and, rarer still, is consideration of the immediate sleep context. Sleeping outside of the bedroom, moving to different beds during the night, and co-sleeping are not uncommon even in early adolescents. Objective sleep patterns may differ considerably when youth are asked to sleep independently in their own bed. Understanding the contextual landscape of these sleep problems necessarily relies on questionnaires or structured interviews that inquire about sleep-wake transitions (e.g. difficulty getting to bed) and/or sleep-avoidant behaviors. Moreover, since sleep behavior and physiology changes dramatically across development [2+], including reliable circadian shifts with entry into adolescence, the relative salience of different aspects of sleep health shifts over time. Studies collapsing across dynamic developmental periods may therefore obscure important information.

Methodological limitations

Even when sleep constructs are clear, methodological limitations (for recent review, [14+]) may contribute to apparent discrepancies in sleep findings in anxious youth. First, self-report of sleep is inherently retrospective and subject to perceptual biases—a significant issue in the context of disorders of emotion where perception is often biased in negative ways. This point is illustrated by a recent study comparing retrospective and prospective reports of nightmares among clinically-anxious children [15]. Anxious youth were significantly more likely to report the presence of frequent nightmares based on retrospective reports, yet prospective assessment across 7 nights did not reveal a group difference. As highlighted by the authors, the symptoms and everyday experiences of anxious youth may indeed give rise to dreams including more negative/threatening content that are recalled as more distressing and intense over time.

Second, actigraphy is not a direct measure of sleep, but rather relies on an accelerometer to measure movement as a proxy for sleep-wake periods. Because it cannot easily distinguish lack of movement from actual sleep, actigraphy has been shown to identify sleep onset sooner than PSG when utilized concurrently [16]. This is particularly problematic for sleep measurement in a population prone to worrying/ruminating in bed. For this reason, evidence of mildly prolonged (e.g., 5–7 minutes based on actigraphy) sleep latency found in previous

studies [11, 12++] may be a conservative or inaccurate estimate of arousal prior to sleep initiation.

Polysomnography is a more labor intensive and expensive procedure typically used for limited timeframes and in lab-based settings. Inconsistencies across lab-based and home-based PSG suggest possible first night lab effects [17] and/or high variability in sleep patterns. Longer assessment periods in the home environment may clarify discrepancies. Advances in neuroscience models [18, 19++] and methodology [high density quantitative EEG assessments of neural activity; 20] can inform assessments of more 'micro' aspects of sleep architecture and physiology that may prove more relevant than the quantity of sleep in explaining why anxious youth commonly report poorer sleep quality and higher levels of daytime sleepiness than other children.

The multidimensional and developmental nature of anxiety

Finally, similar to sleep, anxiety is heterogeneous and multidimensional. Accordingly, although several recent studies have taken care to examine sleep among youth falling into different diagnostic categories[7, 21–23], it may be even more critical to focus on discrete dimensions of anxiety that relate to particular forms of sleep disruption. There were several examples in the literature this year [24–26]. One example by Weiner et al. [27+] examined anxiety sensitivity as a predictor of sleep-related problems in youth with various anxiety disorders (6–17 years). Anxiety sensitivity refers to the perception that physiological sensations associated with anxiety are uncontrollable and threatening, which several researchers have proposed may interfere with sleep due to heightened attention toward arousal. Child reported anxiety sensitivity predicted longer sleep latency onset based on subjective reports, above and beyond the effects of anxiety severity, depression, and age.

In sum, research focused on the sleep of anxious youth has reached an important juncture. On the one hand, there is consistent and copious evidence of subjective sleep problems among a majority of anxious youth, particularly those with a GAD diagnosis, as well as complaints of daytime sleepiness. Yet objective sleep data have generally failed to corroborate these reports. The extent to which these discrepancies relate to methodological, developmental, nosological, phenomenological, or contextual issues (or some combination of these) is unknown but merits further research that can inform a developmentally-sensitive conceptual model of sleep in early-onset anxiety.

Prospective associations between sleep and anxiety in youth

Prospective studies that examine the developmental impact of sleep on anxiety (and vice versa) during the transition from childhood to adolescence are growing in number and specificity. In general, recent reviews suggest that evidence is mixed for a bidirectional association between sleep and anxiety, with more robust evidence supporting early sleep problems as a precursor to anxiety in childhood and adolescence [6+, 7, 28++, 29++]. Key issues that may ultimately resolve inconsistencies are reflected in recent studies. First, multi-method assessment and analytics that are ideally suited to developmental models are essential to scientific progress. One exemplary study by Kelly and El-Sheikh [28++] examined 3 waves of youth (ages 8 to 13) over a period of five years using both subjective

(self-report) and objective (actigraphy) assessments of sleep. A cross-lagged panel model was used in order to examine reciprocal relations of sleep and symptoms, and their relative contributions, over time. Reduced sleep duration and worse sleep quality predicted greater anxiety, depression, and externalizing symptoms (while accounting for prior mental health and sleep problems), with a less robust effect found in the opposite direction. Notably, self-reported sleep predicted anxiety and depression, but not externalizing symptoms, whereas actigraphy-derived sleep estimates predicted changes across both internalizing and externalizing symptoms. This subjective-objective discrepancy again highlights the possible role of perceptual, sleep-distress-related, or methodological differences, as discussed above. This study underscores the value of using multi-method assessments in longitudinal studies with analytic techniques optimized to developmental questions.

A second issue raised in recent longitudinal literature is the potential for identifying sensitive developmental periods when aspects of sleep and anxiety interact most strongly to impact long-term health. In a 4 decade-long study following individuals from ages 5 to 38 years, familial or individual history of anxiety and depression early in life predicted a higher incidence of insomnia onset in adulthood [30]. This effect was more powerful if symptoms were present in adolescence (ages 11–15). Similarly, in their cross lagged model, Kelly and El Shiekh [28++] showed that sleep actigraphy predicted anxiety and depression from the second to third time-point (ages 10–13), but not the first to the second (ages 8–10). They concluded that the developmental period of early adolescence may be a sensitive period for the effects of sleep quantity and quality on emotional health. Notably, this age range coincides with the onset of puberty for most youth, which is associated with substantial developmental changes in both sleep (e.g. circadian advance) and affective processing (e.g. reactivity, regulation)[31]. Finally, in a large study of youth ages 9–16, sleep complaints predicted GAD, but they only predicted depression when GAD was also present. When considered in the developmental context of a 3-fold rise in depressive disorders in mid-adolescence, this finding raises a testable hypothesis that interactions between anxiety and sleep problems around the onset of puberty contribute to trajectories of risk for depression. Moreover, developmental considerations may help to explain some exceptions in the literature, including one study with older adolescents (ages 12–18) in which sleep problems predicted depression, but *not* anxiety [23]. These studies are not conclusive, but do provide early hints that it may be possible to identify sensitive periods when sleep and symptoms interact powerfully to impact development.

In sum, there is significant evidence that sleep is prospectively linked to anxiety in late childhood and early adolescence, and slightly weaker evidence for the opposite direction. Emerging issues in the field include examining how discrete dimensions of sleep and anxiety interact, as well as *when* these synergistic effects most powerfully influence developmental trajectories of emotional and behavioral health.

Mechanistic links of sleep and anxiety: Insights from translational neuroscience

Robust cross-sectional and prospective associations between sleep and anxiety motivate the question of which pathways link these broad associations. A number of theories and data

suggest links between sleep and emotional processing, cognitive processing, hormonal factors, and regulatory systems [for recent review, 6+]. Multi-level models that integrate bio-behavioral and socio-contextual factors will be essential for a comprehensive understanding of pathways of risk [1++]. Dahl's model describing the cascading effects of regulatory systems (sleep, arousal, affect) during sensitive windows of adolescent development was an early example of such an integrative model that continues to gain empirical support [32].

The recent explosion of knowledge regarding the neuroscience of sleep may further refine integrative models. Key neural regions and circuitry involved in emotional processing and regulation are highly active during sleep. As reviewed by Goldstein et al., the specific purpose of this neural activity during sleep is under critical investigation [19++]. One rapidly growing area of research highlights the role of sleep in memory and learning—including fear conditioning and extinction, as well as the consolidation of episodic emotional memories[for comprehensive review, 33]. During sleep, synaptic pruning and reorganization supports a process of memory consolidation, for which evidence suggests the following general stages: 1) salient information encountered during waking hours is "tagged" by the limbic system (e.g. amygdala), 2) tagged memories are subsequently reactivated during sleep, and 3) information is moved from short term hippocampal-based storage, to long-term integration into neocortical associative networks. Memory consolidation occurs over weeks and years [34], allowing for updating or strengthening of memories based on experience.

As part of this consolidation process, memories evolve and qualitatively change as sleep promotes the extraction of bottom-line meaning, or a "gist" from a stimulus or set of stimuli[35, 36+, 37]. *Gist memory* is exemplified by a false memory paradigm[38] in which participants are asked to remember a series of words: medicine, illness, insurance, tests. Many participants falsely recall that doctor was in this list—particularly following sleep[39]. The gist (ideas related to going to the doctor) is retained, while less meaningful details may be discarded. The liability of inaccuracies in gist memory is balanced by efficient and experience-based navigation of a complex environment. Indeed, the extraction of gist, and its integration with prior memories, allows for complex cognitive abilities such as insight, abstraction, intuition, and generalization of experience—all of which have been shown to be enhanced following sleep, relative to wake[for reviews; 35, 36+]. This process is suggested to occur during the transfer of memory from hippocampus to neocortical associative networks, with recent evidence supporting a time-dependent neural reorganization of memories that is stronger when sleep closely follows learning [40, 41].

Innumerable daily experiences make it critical that the brain select the most pertinent information to retain— emotion aids this selection[42, 43]. Emotional memories are preferentially retained relative to neutral memories, and especially following sleep (relative to wake)[34, 44–48]. Specifically, emotion reactivity to stimuli during encoding helps to tag memories for selective consolidation[49–52]. These processes appear mediated, in part, by amygdala activation and its coupling with hippocampus[e.g. 53, 54, 55]. As recently proposed by Bennion et al.[18], this emotion tagging may also interact with hormones, such as cortisol, during the period of encoding to aid selective consolidation.

These memory and learning processes occur across all developmental phases, but are likely to be uniquely influential during periods of high synaptic plasticity and learning. Growing evidence indicates that slow wave sleep and delta activity reflect synaptic reorganization and pruning related to experience-dependent learning [e.g., 56+]. Recent work has supported a role for slow wave sleep (in addition to REM sleep[57]) in at least some aspects of emotional memory consolidation [58+, 59, 60]. In adolescence, there is a greater than 60% decrease in slow wave sleep and delta activity, with a sharp decline beginning roughly with the onset of puberty (between ages 9 and 11 years) and flattening out around the age of 17 [61–63]. In support of a maturational effect, Wilhelm et al. recently showed that local changes in slow wave activity following experience-dependent learning were stronger in 8–11 years old youth, relative to 12–17 year old youth and adults[64++]. Notably, the only study of gist memory during sleep in youth (ages 8–11) showed greater gist-extraction in youth relative to adults[65].

There have been no studies of emotional memory consolidation and sleep in anxious adolescents. Memory and learning during sleep is relevant to models of anxiety not only because altered sleep or sleep physiology could interfere with memory and learning [for models relevant to adults clinical populations, 57, 66, 67], but also because of the emotional response tendencies of anxious youth. Anxious youth tend to evidence high emotion reactivity to perceived cues of threat which could negatively bias the selection of memories for consolidation. Moreover, anxious youth tend to [re]activate memories in a heightened negative emotional context at bedtime via rumination/worry [32, 68], which could be problematic given evidence that encoding of emotional memories that is followed closely by sleep (relative to wake) is enhanced even 6 months later[34, 40]. Heightened emotion reactivity and subsequent consolidation of negative memories during sleep may drive a quantitative and qualitative shift in gist representations (i.e. the world is a threatening place) in anxious youth. This is important in adolescence when sleep and emotion systems are developing [32], gist-based representations are strengthening [69, 70], and risk for disorders of emotion (e.g. depression) is on the rise [71].

The potential of neuroscience to inform translational interventions is high, with several groundbreaking examples published in the last year. A recent study published in Science showed that when counter-stereotype information was learned and then reactivated during slow wave sleep (via audio cueing), a reduced implicit social bias was observed 1 day and 1 week later, and the magnitude of the bias reduction was associated with post-training slow wave sleep and rapid eye movement sleep [72++] . In a study of youth with ADHD (ages 10–14), transcranial direct current stimulation during slow wave sleep improved declarative memory consolidation to the level of controls[73++] . More immediately relevant to anxiety, a study with healthy adults who napped following fear conditioning and extinction promoted generalization of fear extinction cues [74]. Finally, Kleim and colleagues [75+] showed that adult spider-phobics who napped after a one-session virtual reality exposure treatment showed greater reductions in self-reported fear and catastrophic cognitions during a behavioral approach task involving a live spider one week later compared to a group that did not nap. The latter set of findings is particularly exciting in suggesting the ability to augment already established efficacious treatments for anxiety disorders. Similar paradigms to these reviewed studies could be used to probe and identify sensitive periods when interventions

targeting memory and learning processes during sleep have greatest potential to influence emotional health and development among in anxious youth.

Conclusion

Broad cross-sectional and prospective associations between sleep and anxiety in late childhood and early adolescence are clearly established. However, deeper specificity regarding the precise nature of sleep disturbances (both subjective an objective) as they relate to dimensions of anxiety over the course of development can clarify contributions to psychopathology. Integrative models delineating biological and socio-contextual pathways through which sleep and anxiety are linked may lead to refined understanding and opportunities for intervention. The neuroscience of memory and learning during sleep is one such nascent area of research at the interface of sleep and developmental psychopathology. There are exciting opportunities for team-based interdisciplinary science to bridge basic science with applied research in clinical practice, with an eye toward opportunities for interventions with high impact and enduring effects on health and development.

Acknowledgments

Thanks and gratitude to the Jacobs Foundation for hosting the interdisciplinary Marbach Conference in 2012 on the topic of sleep, brain development and adolescence (led by Ronald E. Dahl). The conference was attended by the first author and inspired several ideas included in this manuscript.

Financial Support or Sponsorship

Support for this article was provided by the following career development grants from the National Institute of Mental Health: K23 MH092400 awarded to Dana L. McMakin, and K23 MH081188 awarded to Candice A. Alfano.

References

1++. El-Sheikh M, Buckhalt JA. Moving Sleep and child development research forward: Priorities and recommendations from the SRCD-sponsored forum on sleep and child development. Monographs of the Society for Research in Child Development. 2015; 80(1):15–32. This is a highly recommended article that is based on an SRCD-sponsored forum that aimed to provide a research agenda for the field of sleep and child devleopment. [PubMed: 25704733]

2+. Darchia N, Cervena K. The journey through the world of adolescent sleep. Reviews in the Neurosciences. 2014; 25(4):585–604. A useful review of changes in sleep across adolescent development. [PubMed: 24717334]

3. Crone EA, Dahl RE. Understanding adolescence as a period of social–affective engagement and goal flexibility. Nature Reviews Neuroscience. 2012; 13(9):636–650.

4. National_Sleep_Foundation. Sleep in the modern family. Sleep poll in America. 2014. [cited 2015 July 9]; http://sleepfoundation.org/sites/default/files/2014-NSF-Sleep-in-America-poll-summary-of-findings—FINAL-Updated-3–26–14-.pdf]

5. Ozer, EM.; Macdonald, T.; Irwin, CE, Jr. Adolescent health care in the United States: Implications and projections for the new millennium. In: Mortimer, JT.; Larson, RW., editors. The changing adolescent experience: Societal trends and the transition to adulthood. Cambridge University Press; New York: 2002. p. 129-174.

6+. Willis TA, Gregory AM. Anxiety disorders and sleep in children and adolescents. Sleep Medicine Clinics. 2015; 10(2):125–131. A clear review summarizing subjective and objective evidence for sleep problems across different diagnostic categories of anxiety, and a brief discussion of possible mechanistic underpinnings. [PubMed: 26055860]

7. Cowie J, et al. Addressing sleep in children with anxiety disorders. Sleep Medicine Clinics. 2014; 9(2):137–148.

8. Alfano CA, et al. Polysomnographic sleep patterns of non-depressed, non-medicated children with generalized anxiety disorder. Journal of Affective Disorders. 2013; 147(1–3):379–384. [PubMed: 23026127]

9. Forbes EE, et al. Objective sleep in pediatric anxiety disorders and major depressive disorder. Journal of the American Academy of Child & Adolescent Psychiatry. 2008; 47(2):148–155. [PubMed: 18176336]

10+. Patriquin MA, et al. Polysomnographic sleep characteristics of generally-anxious and healthy children assessed in the home environment. Journal of Affective Disorders. 2014; 161:79–83. A study showing null effects for Polysomnograhy in anxious youth when measured in the home environment. This calls into question prior studies conducted in a lab setting. [PubMed: 24751311]

11. Cousins JC, et al. The bidirectional association between daytime affect and nighttime sleep in youth with anxiety and depression. Journal of Pediatric Psychology. 2011; 36(9):969–979. [PubMed: 21795377]

12++. Alfano CA, Patriquin MA, De Los Reyes A. Subjective–objective sleep comparisons and discrepancies among clinically-anxious and healthy children. Journal of Abnormal Child Psychology. 2015:1–11. A key study that directly compares subjective and objective assessments of sleep in youth with generalized anxiety versus controls. [PubMed: 25212231]

13. Mesa F, Beidel DC, Bunnell BE. An examination of psychopathology and daily impairment in adolescents with social anxiety disorder. PLoS One. 2014; 9(4)

14+. Sadeh A. Sleep assessment methods. Monographs of the Society for Research in Child Development. 2015; 80(1):33–48. Excellent review of sleep assessment methods and their relative strengths and limitations for child research. [PubMed: 25704734]

15. Reynolds K, Alfano C. Things that go bump in the night: Frequency and predictors of nightmares in anxious and non-anxious children. Behavioral Sleep Medicine. In press.

16. Schwarz N. Self-reports: How the questions shape the answers. American Psychologist. 1999; 54(2):93.

17. Kis A, et al. Objective and subjective components of the first-night effect in young nightmare sufferers and healthy participants. Behavioral Sleep Medicine. 2014; 12(6):469–480. [PubMed: 24294972]

18. Bennion KA, Payne JD, Kensinger EA. Selective effects of sleep on emotional memory: What mechanisms are responsible? Translational Issues in Psychological Science. 2015; 1(1):79.

19++. Goldstein AN, Walker MP. The role of sleep in emotional brain function. Annual Review of Clinical Psychology. 2014; 10:679–708. An excellent review and presentation of conceptual model for the role of sleep in emotional brain function, and the relation to depression and PTSD in adults.

20. Pisarenco I, et al. High-density electroencephalography as an innovative tool to explore sleep physiology and sleep related disorders. International Journal of Psychophysiology. 2014; 92(1):8–15.

21. Shanahan L, et al. Sleep problems predict and are predicted by generalized anxiety/depression and oppositional defiant disorder. Journal of the American Academy of Child & Adolescent Psychiatry. 2014; 53(5):550–558. [PubMed: 24745954]

22. Lycett K, et al. Behavioral sleep problems and internalizing and externalizing comorbidities in children with attention-deficit/hyperactivity disorder. European child & adolescent psychiatry. 2014; 24(1):31–40. [PubMed: 24633694]

23. Alvaro PK, Roberts RM, Harris JK. The independent relationships between insomnia, depression, subtypes of anxiety, and chronotype during adolescence. Sleep Medicine. 2014; 15(8):934–941. [PubMed: 24958244]

24. Pieters S, et al. Prospective relationships between sleep problems and substance use, internalizing and externalizing problems. Journal of Youth and Adolescence. 2015; 44(2):379–388. [PubMed: 25385390]

25. Yan Y, et al. The relationship between worry tendency and sleep quality in Chinese adolescents and young adults: The mediating role of state–trait anxiety. Journal of health psychology. 2014; 19(6):778–788. [PubMed: 23520344]
26. Iwadare Y, et al. Relationshipbetween behavioral symptoms and sleepproblemsin children with anxiety disorders. Pediatrics International. 2015
27+. Weiner CL, et al. Anxiety sensitivity and sleep-related problems in anxious youth. Journal of Anxiety Disorders. 2015; 32:66–72. A nice example of studying a dimension of anxiety (anxiety sensitivity) as related to specific aspects of sleep (sleep latency onset). [PubMed: 25863826]
28++. Kelly RJ, El-Sheikh M. Reciprocal relations between children's sleep and their adjustment over time. Developmental Psychology. 2014; 50(4):1137. An exemplary study examining the longitudinal course of sleep and anxiety across 5 years of development (ages 8 to 13) using both subjective and objective assessments, and analytic approaches that could disentangle reciprocal effects. This study documented an effect that may suggest a period of developmental sensitivity for the influence of sleep on symptoms during late childhood/early adolescence (ages 10–13). [PubMed: 24188035]
29. Sadeh A, Tikotzky L, Kahn M. Sleep in infancy and childhood: implications for emotional and behavioral difficulties in adolescence and beyond. Current Opinion in Psychiatry. 2014; 27(6): 453–459. [PubMed: 25247458]
30. Goldman-Mellor S, et al. Mental health antecedents of early midlife insomnia: evidence from a four-decade longitudinal study. Sleep. 2014; 37(11):1767. [PubMed: 25364072]
31. Sadeh A, et al. Sleep and the transition to adolescence: a longitudinal study. Sleep. 2009; 32(12): 1602. [PubMed: 20041596]
32. Dahl, RE. Adolescent sleep patterns: Biological, social, and psychological influences. New York, NY: Cambridge University Press; 2002. The regulation of sleep-arousal, affect, and attention in adolescence: Some questions and speculations; p. 269-284.p. xviip. 297(2002)
33. Rasch B, Born J. About sleep's role in memory. Physiological reviews. 2013; 93(2):681–766. [PubMed: 23589831]
34. Wagner U, et al. Brief sleep after learning keeps emotional memories alive for years. Biological Psychiatry. 2006; 60:788–790. [PubMed: 16806090]
35. Stickgold R, Walker MP. Sleep-dependent memory triage: evolving generalization through selective processing. Nature Neuroscience. 2013; 16(2):139–145. [PubMed: 23354387]
36+. Payne JD. Seeing the forest through the trees. Sleep. 2014; 37(6):1029. A review of sleep and gist-based memory. [PubMed: 24882895]
37. Landmann N, et al. The reorganisation of memory during sleep. Sleep Medicine Reviews. 2014
38. Roediger HL Iii, McDermott KB. Creating False Memories: Remembering Words Not Presented in Lists. Journal of Experimental Psychology: Learning, Memory, and Cognition. 1995; 21(4):803–814.
39. Payne JD, et al. The role of sleep in false memory formation. Neurobiology of Learning and Memory. 2009; 92(3):327–334. [PubMed: 19348959]
40. Sterpenich V, Albouy G, Darsaud A, Schmidt C, Vandewalle G, Dang-Vu TT, et al. Sleep promotes the neural reorganization of remote emotional memory. The Journal of Neuroscience. 2009; 29(16):5143–5152. [PubMed: 19386910]
41. Spencer R. Neurophysiological basis of sleep's function on memory and cognition. ISRN Physiology. 2013; 2013
42. Cahill L, McGaugh JL. Mechanisms of emotional arousal and lasting declarative memory. Trends in Neurosciences. 1998; 21(7):294–299. [PubMed: 9683321]
43. McGaugh JL. Memory—a century of consolidation. Science. 2000; 287(5451):248–251. [PubMed: 10634773]
44. Nishida M, et al. REM Sleep, Prefrontal Theta, and the Consolidation of Human Emotional Memory. Cerebral Cortex. 2009; 19(5):1158–1166. [PubMed: 18832332]
45. Payne JD, Stickgold R, Swanberg K, Kensinger EA. Sleep preferentially enhances memory for emotional components of scenes. Psychological Science. 2008; 19(8):781–788. [PubMed: 18816285]

46. Payne JD, Chambers AM, Kensinger EA. Sleep promotes lasting changes in selective memory for emotional scenes. Frontiers in integrative neuroscience. 2012; 6
47. Sterpenich V, et al. Sleep-related hippocampo-cortical interplay during emotional memory recollection. Public Library of Science Biology. 2007; 5(11):e282.
48. Sterpenich V, et al. Sleep promotes the neural reorganization of remote emotional memory. The Journal of Neuroscience. 2009; 29(16):5143–5152. [PubMed: 19386910]
49. Bergado JA, Lucas M, Richter-Levin G. Emotional tagging—a simple hypothesis in a complex reality. Progress in Neurobiology. 2011; 94(1):64–76. [PubMed: 21435370]
50. Burke A, Heuer F, Reisberg D. Remembering emotional events. Mem Cognit. 1992; 20(3):277–90.
51. Christianson S-Å, Loftus EF. Remembering emotional events: The fate of detailed information. Cognition and Emotion. 1991; 5(2):81–108.
52. Cahill L. Neurobiological mechanisms of emotionally influenced, long-term memory. Progress in Brain Research. 2000; 126:29–37. [PubMed: 11105637]
53. Cahill L, et al. Amygdala activity at encoding correlated with long-term, free recall of emotional information. Proceedings of the National Academy of Sciences. 1996; 93(15):8016–8021.
54. McGaugh J. The amygdala modulates the consolidation of memories of emotionally arousing experiences. Annual Review of Neuroscience. 2004; 27(1):1–28.
55. Nili U, et al. Fear thou not: Activity of frontal and temporal circuits in moments of real-life courage. Neuron. 2010; 66(6):949–962. [PubMed: 20620879]
56+. Barnes DC, Wilson DA. Slow-wave sleep-imposed replay modulates both strength and precision of memory. The Journal of Neuroscience. 2014; 34(15):5134–5142. Documenting the role of slow wave sleep in memory consolidation. [PubMed: 24719093]
57. Walker MP. The role of REM sleep in emotional brain processing. Rapid Eye Movement Sleep: Regulation and Function. 2011:339.
58+. Cairney SA, et al. Complementary roles of slow-wave sleep and rapid eye movement sleep in emotional memory consolidation. Cerebral Cortex. 2014:bht349. Clarifying roles for different sleep stages on emotional memory consolidation.
59. Groch S, et al. Dissociating the contributions of slow-wave sleep and rapid eye movement sleep to emotional item and source memory. Neurobiology of Learning and Memory. 2014
60. Cairney SA, et al. Targeted memory reactivation during slow wave sleep facilitates emotional memory consolidation. Sleep. 2014; 37(4):701. [PubMed: 24688163]
61. Feinberg I, Campbell IG. Sleep EEG changes during adolescence: an index of a fundamental brain reorganization. Brain and Cognition. 2010; 72(1):56–65. [PubMed: 19883968]
62. Colrain IM, Baker FC. Changes in sleep as a function of adolescent development. Neuropsychology Review. 2011; 21(1):5–21. [PubMed: 21225346]
63. Jenni OG, Carskadon MA. Spectral analysis of the sleep electroencephalogram during adolescence. SLEEP-NEW YORK THEN WESTCHESTER. 2004; 27:774–783.
64++. Wilhelm I, et al. Sleep slow-wave activity reveals developmental changes in experience-dependent plasticity. The Journal of Neuroscience. 2014; 34(37):12568–12575. A key study using slow wave activity following learning to document the maturational effects of experience-dependent plasticity, with evidence that youth ages 9–11 show superior plasticity. [PubMed: 25209294]
65. Wilhelm I, et al. The sleeping child outplays the adult's capacity to convert implicit into explicit knowledge. Nature Neuroscience. 2013; 16(4):391–393. [PubMed: 23434910]
66. Landmann N, et al. REM sleep and memory reorganization: Potential relevance for psychiatry and psychotherapy. Neurobiology of Learning and Memory. 2015
67. Riemann D, et al. REM sleep instability—a new pathway for insomnia? Pharmacopsychiatry. 2012; 45(5):167–76. [PubMed: 22290199]
68. Dahl RE, Harvey AG. Sleep in Children and Adolescents with Behavioral and Emotional Disorders. Sleep Medicine Clinics. 2007; 2(3):501–511.
69. Reyna VF, Farley F. Risk and Rationality in Adolescent Decision Making. Psychological Science in the Public Interest. 2006; 7(1):1–44. [PubMed: 26158695]

70. McGuire K, London K, Wright DB. Developmental Trends in False Memory Across Adolescence and Young Adulthood: A Comparison of DRM and Memory Conformity Paradigms. Applied Cognitive Psychology. 2015; 29(3):334–344.

71. Kovacs M. Presentation and course of major depressive disorder during childhood and later years of the life span. Journal of the American Academy of Child & Adolescent Psychiatry. 1996; 35(6): 705–715. [PubMed: 8682751]

72++. Hu X, et al. Unlearning implicit social biases during sleep. Science. 2015; 348(6238):1013–1015. An important study documenting the possibility to reactivate memories of counterstereotype information during slow wave sleep to reduce implicit social biases during wake. The study included a control condition, and also showed an association between the magnitude of changes in implicit biases to slow wave sleep and REM sleep. [PubMed: 26023137]

73++. Prehn-Kristensen A, et al. Transcranial oscillatory direct current stimulation during sleep improves declarative memory consolidation in children with attention-deficit/hyperactivity disorder to a level comparable to healthy controls. Brain stimulation. 2014; 7(6):793–799. A first examination of altering memory consolidation during sleep in a child clinical population. [PubMed: 25153776]

74. Pace-Schott EF, Milad MR, Orr SP, Rauch SL, Stickgold R, Pitman RK. Sleep promotes generalization of extinction of conditioned fear. Sleep. 2009; 32(1):19–26. [PubMed: 19189775]

75+. Kleim B, et al. Sleep enhances exposure therapy. Psychological Medicine. 2014; 44(07):1511–1519. A first examination of using sleep to enhance existing therapeutic approaches. [PubMed: 23842278]

Key Points

1. Findings for subjective and objective assessments of sleep in youth anxiety are weakly aligned
2. Prospective data mostly supports associations between sleep and anxiety in early adolescence, but there is less support for the other direction.
3. Emerging data suggest that early adolescence may be a sensitive developmental period for interactions between sleep and anxiety. More research is needed.
4. Integrative models of devleopmental psychopathology are needed to identify mechanistic targets for intervention at the interface of sleep and anxiety.
5. The recent explosion of research focused on the neuroscience of sleep can inform integrative developmental models and point to novel treatment opportunities. An example focused on the role of sleep in learning and memory is provided.