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Review Article

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Adolescent Sleep: Review of Characteristics, Consequences, and Intervention

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Abstract

Inadequate sleep is a pervasive problem among adolescents. This paper reviews the characteristics of adolescent sleep patterns, the negative consequences of poor sleep, and the interventions that target disrupted sleep among adolescents. Review of the literature suggests that systematic assessment and implementation of outpatient and school-based interventions are infrequent for this population, and in general provide mixed findings with regard to improvement of overall sleep quality. Existing barriers for implementation of intervention are discussed, and suggestions for improving interventions via inclusion of motivational interviewing techniques, skills building, and "hands-on" approaches through group activities are provided.

Review of Adolescent Sleep Characteristics

Research suggests that adolescent sleep lacks duration, quality and consistency. There is a general consensus among sleep researchers that adolescents require approximately 9 to 10 hours of sleep per night for optimal functioning in a number of domains including school performance, mood regulation, cognitive processes including reaction speed and attention, and overall health [1-6]. According to a national survey on sleep patterns in U.S. adolescents between ages 11 and 17, only 20% get the recommended nine hours of sleep on school nights and 45% get less than eight hours on school nights [7]. Interestingly, 90% of parents believe their adolescent is getting enough sleep "most nights" [7,8].

Although parents may be unaware of their adolescent's poor sleep, adolescents themselves acknowledge inadequate sleep. In one survey, over 60% of high school students reported that they were "too sleepy to get out of bed in the morning", consistent with findings that 63% of adolescents aged 15-17 were very tired upon waking in the morning [3,9]. Over 70% of students require a parent to wake them up on school mornings and 15% had been late for school due to waking up late in the past two weeks, additional indicators that sleep duration was not adequate [8]. Another study reported that 85% of high school students needed their parent or an alarm to wake up on school days [10].

Subjectively, it is not uncommon for adolescents to report symptoms of insomnia or poor sleep quality. A large-scale epidemiological study published in 2000 examined older adolescents aged 15-18 in four western European countries, and found that over 30% had at least one sleep complaint. Nearly 20% complained of daytime sleepiness, while 13.8% reported nonrestorative sleep, 12.4% reported difficulty falling asleep, and 9.2% reported difficulty maintaining sleep [11]. Despite acknowledging these complaints, 60% of adolescents reported that they "enjoy staying up late" [12]. Perhaps this is because adolescents (and adults) commonly assume that sleep loss has little or no effect on waking brain function, that sleep loss primarily affects motivation, and that the amount of sleep needed for work performance is less than what is actually obtained [13].

Adolescents often attempt to compensate for missed sleep during the week by sleeping in on weekends. The difference between weekend and school-night bedtimes averages between 1 and 2 hours, and is usually greater in older than younger adolescents [6,7]. Even more drastic of a difference is the 3-4 hour discrepancy between weekday and weekend rise time in 13-19 year old adolescents, with girls rising earlier than boys [14].

Due to developmental changes related to puberty and environmental influences, many adolescents find it progressively difficult to fall asleep early and awake as early as they had when they were younger. Researchers argue that the number of hours of sleep needed does not change from ages 10 to 17, but rather there is a shift in sleep, or phase delay, linked to melatonin levels that peak later in the evening for adolescents in comparison to younger children and adults [10,15].

Correlates and Consequences of Poor Sleep in Adolescents

Adolescence is a time period of increased independence and responsibility involving a number of environmental pressures that interfere with adequate sleep. These environmental pressures range from decreased parental control to part time jobs. As high school students age, parental influence on a bed time greatly decreases (72% of 9th graders have a bed time and 39% of 12th graders), and adolescents are progressively allowed more independence in determining when to go to bed [8]. However, according to this poll, over 70% of the set bedtimes are for 10:00 PM or later, which typically is not sufficient for the recommended 9-10 hours of sleep due to time it takes to fall asleep (74% of students take >30 minutes to fall asleep) and an average wake time between 6:23 and 6:42. Furthermore, adolescents reported getting into bed on average 30 minutes after their set bedtime.

Additionally, student responsibilities and opportunities increase as independence increases. High school students often have more homework than they did in middle school, an opportunity for more extracurricular activities, and part time jobs with late hours [2,7,8]. In a recent study surveying 384 high school students, students identified homework (46%), too much time hanging out with friends (30%), too much TV (39%), and stress (42%) as the four main reasons why they got inadequate sleep [16]. Part time jobs (21%) and extracurricular activities (24%) also fell among the top reasons for inadequate sleep.

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Wolfson and Carskadon examined the sleep schedules of over 3000 high school students, and found significant differences among those students who held a part time job and those that did not. Students who worked 20 or more hours per week reported going to bed later at night, sleeping fewer hours per night, oversleeping more in the morning, and falling asleep more in class than those who did not work or worked less than 20 hours per week [6]. In this particular sample, high school students in rural, urban, and suburban communities of Rhode Island, 60% of the students held a job, and 30% of those employed worked more than 20 hours each week. In terms of extracurricular activities, those students who engaged in 5 or more hours per day of activities obtained significantly less sleep than those students that did not participate in extracurricular activities or work [17].

The Sleep in America poll also revealed that many high school students play video games, instant message or surf the web, exercise or talk on the phone the hour prior to going to bed. Due to the light that disrupts melatonin production, and the physical and emotional intensity of these activities, delayed sleep onset is expected. Furthermore, it is speculated that some adolescents experience frequent waking from text messaging and instant messaging noises and lights. Many of these environmental factors can be changed with relatively simple behaviors, such as turning off a phone before going to bed and rearranging the after school schedule. However, research would suggest education about these behaviors would be inadequate for promoting change. For example, a sample of adolescents completed a sleep hygiene intervention improving knowledge regarding good sleep behavior, supported by high scores on a sleep hygiene quiz, but many students also indicated that they did not want to change their current habits [18].

There are other less controllable environmental factors that contribute to poor sleep in adolescents and children. In an Australian study of 133 13-17 year olds, those adolescents who had no telephone, moved two or more times, and held a part time job were less likely to obtain adequate sleep [17]. The authors operationalized these findings as indicators of low socioeconomic status (SES), but discussed the limitations of that application. Surprisingly, there was no significant relationship between overcrowding and sleep duration. Crabtree et al. examined sleep in 2-7 year olds of differing socioeconomic status (SES). Not only did those children from low SES families obtain significantly less sleep than their middle class counterparts, they also were significantly more likely to display negative bedtime behavior and report excessive daytime sleepiness [19]. After controlling for SES, African American children were less likely to obtain adequate sleep than Caucasian children, although naps were not measured for total sleep time. Similar results were found when comparing Caucasian and minority 8 to 11 year olds on duration of sleep [20]. Minority males slept significantly less than nonminority boys and all girls. These authors emphasize the need for further understanding of the social and emotional influences that may differ among ethnicities. Most data suggesting a relationship between SES, ethnicity, and poor sleep is limited to research on pre-school and school aged children. The impact of SES and ethnicity on sleep in older adolescents is not clear.

There are other environmental variables that may or may not be related to SES that are related to shortened sleep time. In a sample of almost 400 adolescents, 29% identified the temperature of their sleeping environment as problematic, 25% stated there was too much outside noise, 23% indicated they had too many chores to do before sleep, and 15% reported that their care of siblings interfered with obtaining enough sleep [16].

In addition to the environmental and behavioral factors influencing sleep patterns in adolescents, there are significant developmental and biological changes that take place in adolescence. Due to these changes, sleep problems typically peak in late adolescence, during the high school years [17]. Circadian mechanisms are thought to slowly change across adolescent development, including a change toward evening circadian phase preference and later circadian phase. Also, a slower accumulation of homeostatic sleep pressure during puberty delays the sleep/wake cycle [3]. In other words, adolescents' sleep/wake schedule naturally becomes delayed as adolescents become tired and go to sleep later, but are not able to obtain enough sleep due to early awakening for school. As mentioned previously, these individuals often compensate for missed sleep by sleeping later on weekends and vacation days.

When this inconsistent and restricted pattern of sleep causes distress or impairs social, occupational, or other areas of functioning, a diagnosis of delayed sleep phase syndrome (DSPS) may be appropriate. The 2005 International Classification of Sleep Disorder (ICSD-Revised) lists DSPS within the set of Circadian Rhythm Sleep Disorders and state that it must be due to a persistent or recurrent pattern of sleep disturbances resulting from a misalignment of endogenous rhythm and external factors that affect timing/duration of sleep, and that there must be sleep disruption that lead to insomnia and/or excessive daytime sleepiness. The incidence of DSPS is somewhat unclear, but estimates of adolescent DSPS are as low as 1.6% in Japan to 7% or more in the US, while only an estimated 0.7% of adults suffer from this same disorder [21-23].

DSPS is not the only sleep disorder of concern among adolescents. In a sample of 330 adolescents (15-18 years old), 4% met criteria for insomnia [11]. An additional 2% of adolescents are thought to suffer from sleep disordered breathing, and somewhere between 13 and 66% of overweight adolescents have obstructive sleep apnea [24]. Although rare, narcolepsy, periodic limb movement, and restless leg syndrome are all disorders that can affect children and adolescents [5]. Diagnosable sleep disorders and subclinical sleep patterns that resemble DSPS and insomnia are a serious public health concern due to the serious consequences of chronic sleep restriction and poor quality of sleep.

Consequences of inadequate and poor sleep range from subjective sleepiness to increased risk of accidents and poor school performance. Excessive daytime sleepiness, which involves deficits in alertness and vigilance, is a primary complaint of reduced duration and/or quality of sleep. In addition to subjective difficulty in focusing and sustaining attention, laboratory findings suggest slowed cognitive capabilities, especially in complex tasks. Individuals often begin tasks well, but neglect details, make mental mistakes, and have slowed reaction time across time [25,26]. Complex mental tasks, involving abstract reasoning, problem solving, and cognitive flexibility seem to be impaired as a result of sleepiness, although most studies utilized school-aged children and young adolescents [27]. In a recent study that was carefully controlled for extraneous variables, deficits in executive functioning were related to higher levels of subjective sleepiness in adolescents, but not to duration of sleep [1]. This relationship was strongest among those with caregivers who had lower levels of education.

Other basic aspects of neurocognitive performance, including fine motor skills, attention and response inhibition, and memory have yielded inconsistent evidence of impairment as a direct consequence of sleepiness in adolescents [27]. When examining school-aged children there is some evidence that there is a relationship between poor sleep (sleep deprivation, sleep restriction, sleepiness) and these neurocognitive domains [28,29]. However, there are few studies utilizing older adolescent samples. One challenge when conducting this type of research is the issue of confounding demographic variables, such as race, ethnicity, education, and SES when examining cognitive functioning, as performance on neurocognitive measures can differ regardless of sleep. Furthermore, many of these studies measure executive functioning only after acute sleep restriction rather than chronic sleep loss [27]. Those researchers that have failed to find a strong relationship between sleep deprivation and cognitive performance in adolescents have offered the explanation of interindividual difference in tolerance for sleep deprivation [1,4]. Rather, measures of subjective sleepiness may be a better predictor of cognitive deficits.

Although the evidence utilizing standardized measures to examine executive functioning secondary to excessive daytime sleepiness is relatively weak, there is ample evidence that everyday activities involving executive functioning skills suffer. One such activity that involves sustained and reliable attention and vigilance is operating a motor vehicle. Motor vehicle crashes are the leading cause of death in adolescents, and people between the age of 16 and 29 years of age are the most likely to be involved in crashes caused by the driver falling asleep [30,31]. When alcohol is not involved, a majority of sleep related accidents are caused by two age groups, 16-25 years old and 65 and older. Young boys appear to be at a slightly higher risk than young girls, and those young persons who get only 6-7 hours of sleep per night are 1.8 times more likely to be involved in a sleep-related crash while those sleeping 5 hours or less per night are 4.5 times more likely to crash after falling asleep at the wheel than those getting more than 7 hours of sleep per night [32,33]. Stutz et al. interviewed drivers from North Carolina who were classified in their police reports as having a sleep or fatigue related crash. They found that 40% of drivers had been awake for 15 hours or more and 20% had been awake for 20 hours or more before falling asleep at the wheel [32].

School performance is another vital component of an adolescent's life that is threatened by poor sleep quality and duration. Wolfson and Carskadon carefully reviewed the large body of literature pertaining to adolescent sleep patterns and school performance [34]. In summary they concluded shortened total sleep time, irregular sleep schedules, and poor sleep quality are highly associated with poor school performance for adolescents. Those adolescents with self-reported higher grades reported significantly longer sleep times. Those students that slept greater than nine hours were more likely to earn B's or better, while those with less than 8 hours of sleep were more likely to earn C's or worse. Those students with better grades also reported a more regular sleep/wake schedule with fewer weekends sleep delays. However, Wolfson et al. discuss the weakness in utilizing grade point averages, as schools differ on difficulty, classes offered, and rating systems.

Meijer et al. and colleagues examined the relationships between time in bed, sleep quality, and various measures of school functioning among younger adolescents. They found that adolescents who reported having difficulty getting up were less motivated to do their best at school, while adolescents with high quality sleep were more receptive to teacher influence, had more positive images as themselves as students, and reported more motivation to do their best in school [35]. In summary, adolescents who obtained adequate sleep were more likely to earn higher grades and have a more positive attitude towards school than those adolescents with inadequate sleep.

The positive attitude and feelings associated with restorative sleep are not limited to the school environment. According to a large scale longitudinal study utilizing the Diagnostic Interview Schedule for Children (DISC-C), those adolescents with no sleep complaints had lower anxiety, depression, conduct disorder, and attention deficit disorder scores than those with sleep problems [36]. In a sample of over 4,500 adolescents, those who had reported sleeping issues were 22.7 times more likely to report anxiety and depression, 10.9 times more likely to report attention problems, and 6.2 times more likely to report social problems [37]. Despite the strength of the relationship between psychosocial problems and sleep problems, in is unclear if the relationship is bidirectional due to the correlational research design of these studies.

There are few longitudinal studies that explore poor sleep as a predictor for later mental health issues. Utilizing a sample of 257 boys from high-risk families, those who had reported difficulties sleeping at ages 3-5 were significantly more likely to have attention problems, anxiety, and depression at ages 12-14 [38]. In a short 1-year study of 11-17 year old adolescents, sleep disturbances predicted development of poor self esteem and depression one year later [39]. Gregory et al. identified greater risk for adult-onset anxiety disorders in adolescents that report sleep problems [40].

There is substantial research that suggests adolescents with clinical mood disorders report high rates of sleep disturbances, while there is also data indicating that adolescents with sleep problems report increased negative mood and difficulty regulating their mood [36,41]. In one of the first studies examining the effects of poor sleep in adolescents, participants who were classified as poor sleepers were more likely to report feeling "tired", "tense", "grumpy", and "down in the dumps" most of the time [42]. Interestingly, clinicians often report irritability and mood lability as an indicator of adolescent depression. Although the relationship between sleep and mood is not clear, it is obvious there is a strong connection between the two. In summary, problematic sleep is a marker for psychopathology in children and adolescents, and poor sleep puts one at risk for developing a psychiatric disorder. Furthermore, a study comparing adolescent suicide completers to a control group found higher rates of sleep disturbances in the completers, even after controlling for depression [43].

There is a similarly complex bidirectional relationship between sleep parameters and substance use and abuse in adolescents. Poor sleep or sleep disturbance may create a pathway for substance abuse as excessive daytime sleepiness and the resulting poor academic and social outcomes can lead to self medication [44]. For example, an adolescent may believe alcohol will facilitate sleep, but does not consider the impact of alcohol on sleep architecture and the rebound affect that leads to acute rebound insomnia [5]. The result is likely increased daytime sleepiness and negative outcomes, which sets the stage for a perpetuating cycle of sleep disturbance, daytime sleepiness, and self-medication with alcohol.

Findings pertaining to an increased risk of substance use in poor adolescent sleepers are not limited to alcohol use. According to the 1996 National Household Survey on Drug Abuse, adolescents who had trouble sleeping often were more likely than those who had no trouble sleeping to report past-year use of inhalants (odds ratio 6.5), and more than twice as likely to use marijuana and cigarettes [37]. This was the same sample that identified strong associations between psychopathology and poor sleep. It appears that psychopathology, predominantly anxiety and depression, poor sleep and sleepiness, and substance use are interconnected, and can contribute to a cycle of maladaptive feelings and behavior in adolescents.

The impact of chronic sleep deprivation is evident when examining physical health in addition to mental health. One consequence of inadequate sleep is a greater risk of obesity in adolescents. Being overweight is significantly associated with shorter sleep duration, and for each hour of lost sleep an adolescent's odds of developing obesity increases by 80% [45]. Longitudinal studies have strengthened the support for a causal relationship between poor sleep and development of obesity. In a study of 785 children, shorter sleep duration in 3rd grade was associated with a greater likelihood of being overweight in 6th grade. The analysis adjusted for gender, race, maternal education, and child's BMI score in 3rd grade [46]. A prospective study examined 150 children from birth until 9.5 years of age and identified shortened sleep time at ages 2 to 5 as a significant predictor for being overweight at the end of the study when children were 9.5 years old [47]. There is no evidence quality of sleep or daytime sleepiness is related to child or adolescent weight. However, researchers have hypothesized that excessive daytime sleepiness from shortened sleep duration leads to caffeine consumption. However, many drinks preferred by adolescents with high caffeine content, such as soft drinks and coffee drinks, are loaded with sugar and high in calories and sometimes fat [16].

Weight gain and obesity can be partially explained by the hormonal changes associated with greater caloric intake that result from inadequate sleep. The production of leptin, a hormone that reduces hunger and peaks during sleep, is decreased when sleep is decreased [48]. While leptin decreases hunger, a hormone called ghrelin increases hunger. Sleep time reduction increases ghrelin release, and is linked to cravings of sweet, salty, and typically calorically dense foods [49,50].

Chronic sleep loss has also been associated with higher cortisol levels and poorer glucose tolerance, which results in poorer insulin responses to hyperglycemia. This hormone profile is characteristic of one who is prediabetic, and eventually leads to insulin resistance and diabetes [51]. Furthermore, as summarized above, those adolescents who have sleep problems are more likely to struggle with cognitive deficits, mental health issues, poor school performance, and other stressors that are likely to increase cortisol levels even more.

Sleep disturbances may impact physical activity levels as well. Shorter sleep time results in less energy, resulting in lower interest in exercise and lower caloric expenditures [16]. In a large group of 11-16 year olds, for every hour that a sleep disturbance was experienced the adolescent's physical activity decreased by 3% [45]. The physical and mental health outcomes of inadequate sleep examined as a whole is alarming. From short-term moodiness and cognitive slowing to serious health risks associated with chronic poor sleep in childhood and adolescence, researchers regard this problem as a major public health concern that is in need of interventions.

Although researchers acknowledge the need for assessment of sleep problems and interventions for adolescents, screening for sleep problems is very rare in the primary care setting, and not typical in school either [52].

Review of Current Interventions to Improve Sleep in Adolescents

Due to the numerous consequences of poor sleep researchers have developed a small variety of interventions, many focused on a combination of cognitive and behavioral strategies, and many that have been modeled after successful adult sleep interventions [44,53]. Although cognitive behavioral therapy for insomnia is effective in 70-80% of adults, including young adults, support for the application to adolescent sleep problems is limited [54,55]. There are few studies that utilized a predominantly cognitive-behavioral framework as an intervention. A randomized controlled trial conducted with 81 Australian high school aged adolescents found that a school-based cognitive-behavioral intervention reduced the discrepancy between school week and weekend bedtimes in those adolescents with delayed sleep timing, and increased sleep hygiene knowledge [18]. However, there were no significant changes in sleep or daytime parameters such as total sleep time, daytime sleepiness, and depressed mood. Furthermore, the behavior change seen after the intervention disappeared after 6 weeks. One strength of this study was the short duration of 4 weeks at 50 minutes per week, and a high retention rate (83%) in the program. The researchers identified lack of motivation as a major contributor to poor outcomes. These researchers recently adapted their intervention to a motivational interviewing framework, and compared two classes 11th grade classes [56]. Students' motivation to regularize their out-of-bed times improved and there was a trend towards improved motivation to increase sleep time. Also, adolescents reported improvements in sleep and daytime functioning, but these changes were no different than the control group.

The other study to date that utilized CBT framework was an outpatient based intervention rather than school-based, and had a poor retention rate (42%) [44]. However, it must be noted that this study recruited a high-risk population, 55 adolescents with a history of substance abuse who were completing a substance abuse treatment program. Noncompleters of this program dropped out due to incarceration, work commitments, unwillingness to complete the assessments necessary for research, and travel burdens. The criteria for participating were having a "sleep disturbance" or "daytime sleepiness". Those that did complete the program showed a significant increase in total sleep time and also reported significant improvement in reductions of sleepiness, worry, and mental health distress. Completion was defined as attending 4 out of the 6 weekly sessions, and no long term followup was collected.

Despite both working within a cognitive behavioral framework, these two programs differed on sample population, content, delivery, and design. The sleep related components of the randomized school-based intervention included sleep hygiene, stimulus control, cognitive strategies for sleep, consequences of poor sleep practices, and education of sleep needs of adolescents. The outpatient group also utilized stimulus control, sleep hygiene education, and cognitive strategies for sleep. In addition, with the outpatient group, bright

light component was added in order to change circadian rhythms, as well as a mindfulness-based stress reduction component. The initial CBT school-based intervention identified only those students who had delayed sleep phase and imbedded the sleep content into a well-being program to reduce selection bias and demand effects [18]. In contrast, the outpatient participants had subjective complaints of sleep, and were aware that the intervention was specifically targeting sleep, which can create demand effects [44]. Finally, the Bootzin et al study was a smaller study that lacked a control group. Given the vast differences in these studies, it is difficult to summarize the overall utility of cognitive-behavioral approaches for adolescents with sleep problems.

The research examining less complex education based programs in the adolescent population is almost as scarce as the cognitive-behavioral focused programs [57]. Sleep-hygiene education programs have been applied to both middle school and high school students. Knowledge of sleep hygiene was weakly associated with good sleep hygiene practices in university students [58]. Researchers in other fields have noted that acquisition of knowledge is rarely enough in itself to change behavior as well [57]. These programs are also subject to low response rate, lack of controls, small sample sizes, compliance issues, and lack of follow-up data [16]. One such program was a sleep hygiene education program that was developed and implemented in four classes of adolescents in Brazil [53]. The objectives taught in this program included sleep physiology, causes and consequences of short sleep and sleep hygiene procedures. Sessions were 50 minutes and took place across 5 days in the same school week. After the program the adolescents' irregularity index of sleep onset decreased, they napped earlier in the day, and sleep latency diminished. There was no impact on daytime sleepiness or measures of sleep quality. All students were eligible to participate, regardless of delayed sleep phase behaviors or subjective sleep quality. This study was limited due to selection bias, self report data, limited time after follow up, and demand characteristics. A more recent randomized controlled sleep hygiene intervention study in adolescents utilized high school students as sleep educators for their peers [59]. Researchers identified 125 students who met criteria for being an "evening type" on the Morning & Eveningness Questionnaire (MEQ). Peer educators used baseline data to create individual sleep improvement plans. Mean bedtimes were earlier and sleep quality was significantly improved in the experimental group. Researchers attribute the success of this study to the unique peer component as well as the individualized treatment. It is unclear if this was a school-based intervention, or took place on an outpatient basis.

In summary, interventions for adolescent sleep problems are limited and have widely varied on content and quality. Due to vast differences in sample selection (all students, students with excessive daytime sleepiness, delayed sleep phase individuals, and evening type individuals) it is difficult to make comparisons among varying treatment programs and approaches. However, all interventions identified desire to participate and/or motivation as factors limiting effectiveness of treatment. Although behavior-focused programs and cognitive behavioral programs have been implemented, only one intervention has integrated aspects of motivational interviewing into treatment.

Motivational interviewing (MI) has been found to be effective in both altering adolescent health behaviors and areas of behavioral sleep medicine [60,61]. MI is a client-centered, directive method for enhancing intrinsic motivation to change by exploring and resolving ambivalence, originally developed to treat substance abuse by Miller and Rollnick [62]. In the past 20 years empirical support for MI has begun to accumulate across problem behaviors including health behaviors and treatment adherence, far beyond its origins in the treatment of addictive behavior [61]. An underlying theory that explains the mechanism of action in MI treatment has just recently came to interest and is currently still under development [63]. Thus far Miller proposed the following theory that emphasizes two specific active components – a relational component focused on empathy and the interpersonal spirit of MI, and a technical component involving the differential evocation and reinforcement of client change talk. The spirit of MI has three components, 1) is collaborative rather than authoritarian, and 2) evokes the client's own motivation rather than trying to installs it, and 3) honors the client's autonomy [64]. The "technical hypothesis" suggests that proficient use of the techniques of MI will increase clients' in-session change talk and decrease their sustain talk, which in turn will predict behavior change. He also emphasizes the importance of training in MI and treatment fidelity as process variables that determine outcomes. According to Miller et al. the resulting causal chain model links therapist training, therapist and client responses during treatment sessions, and posttreatment outcomes.

Although Cain et al incorporated MI principles into treatment, this intervention was delivered to 52 students in a lecture format, perhaps interfering with vital aspects of MI, such as autonomy, collaboration, and change talk. MI is typically delivered in an individual format and within a large group it would be fairly difficult to focus on each individual's needs. Still, it is important to note that individually-based interventions may not be feasible in many school settings, but perhaps small groups of students who are carefully screened for disturbed sleep may be plausible, while enhancing the quality of the MI-based intervention. Gold and Dahl recently published a chapter entitled "Using Motivational Interviewing to Facilitate Healthier Sleep-Related Behaviors in Adolescents" [65]. However, they indicate that to date there in no empirical evidence to indicate that MI is effective for pediatric sleep disorders.

It is evident from the early research in sleep and other health-related behavior that providing school-based intervention strengthens the effectiveness of interventions [16,66]. School-based interventions can not only do mass screening for sleep problems, but treatment through school can also eliminate many of the barriers to receiving treatment – time constraints, transportation, cost, and social stigma. Finally, many of the adolescents who could benefit from an intervention to improve sleep do not have a diagnosable psychiatric condition, creating another barrier and reducing feasibility of outpatient treatment. Therefore, despite the barriers associated with school-based intervention, such as time and appropriately trained staff, schools are seemingly the ideal site for intervention.

The review of interventions reveals that it is quite challenging to change adolescent thoughts and behavior. As an alternative approach to solve the problem of poor adolescent sleep, a study conducted over 10 years ago in the Minneapolis Public School System examined the effect of delaying high school start times [67]. Before the delay, high school classes began at 7:15 AM, and were dismissed at 1:45 PM. Another new schedule had a start time of 8:40 AM and dismissal time of 3:20. Surprisingly, students did not stay up later, but were much more likely to obtain an hour of additional sleep each night.

Furthermore, statistically significant improvements were noted in attendance rate, decreased rate of sleeping in class, and less student-reported depression. In the past decade, at least 80 school districts have delayed their high school start times [68]. The most recent data suggests that still only 16% of high schools start between 8:15 and 8:55 AM [5]. Researchers acknowledge the positive outcomes of delaying the beginning of school. However changing school schedules involves not only students and teachers but also several aspect of social life associated with school, such as transportation and parent work schedules [53]. Furthermore, changing school schedules is more difficult and more expensive than most school-based interventions [69]. In sum, current interventions are lacking and new approaches are needed.

Implications for Clinical Practice

The feasibility of outpatient treatment or intervention for inadequate sleep is poor due to the numerous barriers reviewed, including time constraints, transportation, cost, and social stigma. Due to the strong relationship between inadequate sleep and poor academic performance, the most logical setting for intervention is within the schools. Most researchers have implemented classroom-based interventions, as these are consistent with the culture of schools, provide students with equal opportunity, and can easily accommodate scheduling. However, research thus far has demonstrated poor outcomes among classroom-based interventions. Although a classroom approach is most practical for clinical practice, findings may be clouded in past research by those high baselines measures of sleep quality, duration, and daytime functioning for some adolescents. Furthermore, sleep intervention may not be the best use of time for adolescents who do obtain adequate sleep. There are many quick and easy screeners that can identify those adolescents who are in need of an intervention (e.g., Pediatric Daytime Sleepiness Scale, Adolescent Sleep-Wake Scale).

Researchers should collaborate with school professionals and work towards identifying an appropriate time to screen students for poor sleep and deliver an intervention. Still, three unanswered, vital questions exist – What does the intervention look like? Who would deliver such an intervention? And When would the intervention take place? At present, the authors of this manuscript have only anecdotal evidence (there is currently a study in process) to suggest that schools may be amenable to having middle school students participate during their elective class, which involves missing four class periods across a one-month period. Regarding high school students, thus far administrators, principals, and teachers have been receptive to having high school students participate during study halls, after school, in place of bimonthly homeroom, and as a "working lunch" in which students would participate during lunch and miss approximately 30 minutes of an elective class following lunch.

It is important to acknowledge that a trained professional with basic group therapy skills would likely be necessary to successfully implement a small group intervention. With the increase in development of school-based health centers in low-income urban and rural communities, there is an increase in the number of mental health professionals available in the schools that may be the most in need of intervention. Furthermore, with the tremendous growth in the area of pediatric school psychology, there are an increased number of licensed psychologists well-prepared to deliver and train masters level mental health professionals in school-based health promotion interventions, such as improving sleep. However, even after development of an evidence-based intervention to improve adolescent sleep, there will likely be challenges in identifying service providers in the schools for several school districts.

The answer to the first question proposed above regarding the content of such an intervention is far from clear. The limited research available suggests that education and classroom-style CBT is not very effective. It is our belief that a lecture style intervention is perceived as mundane and too academic for application to oneself for an adolescent. Furthermore, it appears very difficult to apply strategies of research validated therapeutic technique (e.g., motivational interviewing, CBT) to large groups of students in a lecture style format. According to Moseley et al. upon review of their program, adolescents indicated that they would have preferred more "hands-on" activities or discussions [18]. Increasing hands-on activities and improving individual motivation is very difficult in large groups. Furthermore, a "skills-building" approach may be helpful from a CBT perspective, and can serve as more hands-on content. One commonality of the previously implemented interventions is that all included sleep hygiene education, and basic education regarding the purpose of sleep. In the sole outpatient intervention, aspects of mindfulness and light therapy were strategies incorporated into treatment [44]. Again, it is unclear if these strategies are effective or not, provided the low retention rate in a small pilot study.

Additionally, the duration and frequency of intervention is unclear. It is important for future research to strike a balance between the frequency and duration of the intervention with practicality in a school setting. As such, researchers should work towards identifying the minimal number of sessions necessary to meet the minimum threshold of adequate sleep (e.g., 8 hours rather than 9).

Future research should focus on smaller groups that are screened for true, although subclinical, sleep problems, and should incorporate motivational approaches into treatment. After further research exploring the what, where, and when of school-based sleep intervention, the development of a manual-based treatment would increase the availability of such an intervention. In short, there are several avenues for exploration of behavioral sleep medicine intervention in adolescents.

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