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Clinical Psychology Review 25 (2005) 629–644

CLINICAL PSYCHOLOGY REVIEW

# Adolescents, substance abuse, and the treatment of insomnia and daytime sleepiness

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**Abstract**

Adolescence is a time of change that can be both exciting and stressful. In this review, we focus on the central role that disturbed sleep and daytime sleepiness occupies in interactions involving substance abuse and negative health, social, and emotional outcomes. As a means of improving sleep and lowering risk for recidivism of substance abuse, we developed and implemented a six-session group treatment to treat sleep disturbances in adolescents who have received treatment for substance abuse. The components of the treatment are stimulus control instructions, use of bright light to regularize sleep, sleep hygiene education, cognitive therapy, and Mindfulness-Based Stress Reduction. Preliminary evidence indicates that participants who completed four or more sessions in the treatment program showed improved sleep and that improving sleep may lead to a reduction in substance abuse problems at the 12-month follow-up.


*Keywords:* Insomnia; Sleep; Treatment; Meditation; Substance abuse; Adolescence

Adolescence is a time of major social and developmental change. As teenagers progress through puberty, and cope with other maturational, personal, and social changes, they become increasingly sleepy during the daytime although their total sleep does not change substantially (Carskadon, 1990). Other changes are simultaneously taking place involving risk taking and experimentation with independence. Adolescence can be an exciting, but also a very stressful time.

The paper is divided into three sections. We first review the literature on substance use and mental health issues among adolescents, followed by a review on the relationship between substance use and

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doi:10.1016/j.cpr.2005.04.007

sleep disturbance including sleep disturbance as a pathway for substance use as well as a risk for relapse following substance abuse treatment. Second, we describe a treatment designed to help adolescents with substance abuse problems improve their sleep and daytime sleepiness. And third, we present preliminary data from a pilot study evaluating this treatment.

## 1. Substance abuse and sleep in adolescents

### *1.1. Adolescents and substance use*

After declining in the 1980s, illicit drug use among adolescents began to increase in the early 1990s; with current rates of illicit drug use at one and a half to two times the 1992 low (Dennis et al., 2002). Results from Monitoring the Future (MTF), a large national study of high school students, indicate that marijuana is the most widely used illicit drug. In the 2000 survey 20.3% of eight graders, 40.3% of tenth graders and 48.8% of twelfth graders reported use (Johnson, O'Malley, & Bachman, 2001). Data from adolescents entering substance abuse treatment programs indicate that the youth are predominately marijuana and alcohol users, although a substantial percentage of youth entering inpatient treatment centers are being treated for cocaine and/or heroin use (Dennis, Muck, Dawud-Noursi, & McDermeit, 2003).

Drug use trends differ by those entering outpatient versus residential treatment centers with those entering residential centers more frequently reporting higher use rates of harder drugs along with higher rates of substance dependency (Stevens, 2004). The younger the person is at substance use onset, the more likely he or she is to develop a substance use disorder and to have that disorder continue into adulthood (Dennis et al., 2003). With regard to gender differences in substance use, the MTF data indicate higher rates of illicit drug use (primarily marijuana) by males, but other treatment studies have reported females, when they use illicit drugs, have higher rates of harder drug use than males, including methamphetamine, cocaine, and heroin (Stevens et al., 2003).

Substance abuse treatment outcomes for adolescents have generally demonstrated reductions in alcohol and drug use following treatment exposure. One year posttreatment outcomes from the Drug Abuse Treatment Outcomes Studies of Adolescents (DATOS-A; Hser et al., 2001) showed a 37% decrease in weekly marijuana use, a 14% decrease in heavy alcohol use and a 6% drop in the use of other illicit drugs. Outcomes from the National Treatment Improvement Evaluation Studies (NTIES) indicated an 8% to 25% decrease on several drug-related variables at 1-year post baseline; although results showed a 5% increase in alcohol intoxication for the same time period (as reported in Dennis et al., 2003). Moreover, the Center for Substance Abuse Treatment (CSAT) Cannabis Youth Treatment Program indicated that, in general, there was a 35% reduction in use at the 3-month follow-up (Dennis et al., 2003). A closer examination of the recovery process for adolescents shows that adolescents go in and out of recovery (e.g. periods of abstinence and use) (Dennis, McDermeit, & Hodgkins, 2001), while the trajectory of use is typified by a steep decline in use during treatment and followed by a gradual increase in use as time passes (Morral, McCaffrey, & Ridgeway, 2004; Stevens, Estrada, Murphy, McKnight, & Tims, 2004).

### *1.2. Substance abusing adolescents and mental health*

Data from recent studies of adolescents entering substance abuse treatment programs suggest that the majority present with comorbid substance use and mental disorders. Grella and Joshi (2003) report that

62% of youth entering either outpatient, short-term inpatient, or residential treatment centers as part of DATOS-A presented with at least one comorbid mental disorder; while Hawke, Jainchill, and De Leon (2003) reported that 95% of adolescents entering residential substance abuse therapeutic community (TC) treatment programs had at least one psychiatric diagnosis at treatment entry.

The prevalence of psychiatric disorders among adolescents enrolling in substance abuse treatment programs not only varies by type of treatment program, but by age and gender as well. Younger adolescents have higher rates of comorbid psychiatric disorder and are at higher risk for "injury to self" (Unger, Kipke, Simon, Montgomery, & Johnson, 1997). Females are twice as likely to be diagnosed with depression (Grella, Hser, Joshi, & Rounds-Bryant, 2001). While the percentage diagnosed with any psychiatric disorder was similar for males (94%) and females (98%) entering residential TCs, there was a higher percentage of girls for each of the nine disorders inventoried (Hawke et al., 2003).

Mental health issues among adolescent substance users enrolled in drug treatment is closely linked with past experiences of traumatic stress (Cavaiola & Schiff, 2000). Recent literature (Giaconia et al., 2000) indicates that comorbid substance use dependency and Post Traumatic Stress Disorder (PTSD) in adolescents is increasingly prevalent; and that the risk for PTSD increases as the number of traumatic events increases. Those reporting higher levels and/or longer periods of traumatic stress, including childhood physical and sexual abuse, also report higher rates of substance use and problems associated with use along with higher rates of anxiety, depression, attention deficit or hyperactivity symptoms, anger, or aggressive outburst (Blood & Cornwall, 1996; Cohen, Berliner, & March, 2000; Hawke, Jainchill, & De Leon, 2000; Hornstein, 1996; Stevens, Murphy, & McKnight, 2003). In addition, Stevens and Murphy (2000) found that adolescents presenting for substance abuse treatment who reported traumatic stress also reported problems associated with their sleep (i.e., daytime sleepiness, not able to fall asleep, nightmares). In fact, 76% of males and 88% of females reported sometimes using alcohol or drugs to help them to sleep.

Mental health outcomes of adolescents participating in substance abuse treatment have been mixed, with some studies indicating positive outcomes while others report little change in mental health problems. Adolescents entering substance abuse treatment with more severe substance abuse report less improvement in mental health at follow-up than others. Examination of the trajectory of change for mental health indicates a less steep slope of change when compared to the slope of change for substance use. In addition, unlike the trajectory of change for substance use which begins to increase following treatment completion, mental health continues to improve after treatment completion and out to 1 year following treatment (Stevens et al., 2004).

### *1.3. Sleep disturbance as a pathway for substance abuse*

The relationship between substance abuse and sleep disturbance is bidirectional. Not only does substance abuse lead to sleep disturbances, but sleep disturbance can lead to substance abuse.

The most striking conclusion from data on adolescent sleep is that a substantial proportion of adolescents are sleep deprived (Carskadon, 1990). School schedules, social activities, and after-school employment often lead to irregular sleep schedules in which adolescents attempt to wake-up early during the school week and sleep late on weekends and vacations.

The daily sleep/wake rhythm is one of a number of daily biological rhythms, called circadian rhythms. Many teenagers have a circadian rhythm problem, delayed sleep phase disorder, in which the individual's biological time to fall asleep occurs later, and thus is delayed, compared to the time the

individual tries to go to sleep. A delayed sleep phase can develop because of both biological changes such as those associated with puberty and social factors that produce irregular sleep schedules as seen in large differences between weekday and weekend schedules (Lack & Bootzin, 2003; Wolfson & Carskadon, 1998). A single weekend of going to sleep 2 h later than during the week produces about 30 min of sleep phase delay in young adults (Yang et al., 2001). Teenagers who have a delayed sleep phase will have difficulty both falling asleep at night and difficulty waking up in the morning to go to school. They are likely to exhibit excessive daytime sleepiness, particularly in the morning. Excessive daytime sleepiness produces increased vulnerabilities to a number of poor outcomes (Carskadon, 1990; Wolfson & Carskadon, 1998) including academic performance failures, increased irritability, depressive mood, and automobile accidents.

One way that sleep disturbance may create a pathway for substance abuse is that the combinations of sleep disturbance, excessive daytime sleepiness, and poor outcomes, can lead to self-medication. Adolescents may use stimulants to increase daytime alertness and alcohol and marijuana to decrease depressive mood and sleep problems (e.g., Stevens & Murphy, 2000). When alcohol is used, it has the unexpected effect of interacting with insufficient sleep to substantially increase daytime sleepiness (Lumley et al., 1987). This cycle of sleep disturbances, daytime sleepiness, and self-medication can become an escalating cycle in which each factor exacerbates the other.

The relationships between irregular sleep schedules, daytime sleepiness, and frequency of alcohol, tobacco, and coffee use has been studied in a national sample of approximately 4000 Finnish 11-, 13-, and 15-year-old boys and girls (Tynjala, Kannas, & Levalahti, 1997). Structural equation models showed that irregular sleep schedules and daytime sleepiness accounted for 26% of the variance of substance use in 15-year-old boys and 12% of the variance of substance use in 15-year-old girls. The relationships between sleep schedules, sleepiness, and substance use were reciprocal. Substance use and irregular sleep schedules accounted for 24% of the variance of daytime sleepiness in boys and 20% in girls.

Additional evidence that sleep disturbance is associated with drug use has been reported from a sample of over 4500 adolescents (12 to 17 years old) from the 1996 National Household Survey on Drug Abuse (Johnson, Breslau, Roehrs, & Roth, 1999). Those 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 of 6.5), alcohol (odds ratio of 2.6), marijuana (odds ratio of 2.4), or cigarettes (odds ratio of 2.2). There were even stronger associations between trouble sleeping and psychological and social problems. Those who had trouble sleeping often were more likely than those who did not to report anxiety or depression (odds ratio of 22.7), attention problems (odds ratio of 10.9), and social problems (odds ratio of 6.2). There are strong interrelationships between sleep problems, daytime sleepiness, substance use, and negative outcomes of anxiety, depression, and social problems.

Evidence of causal relationships between sleep problems and both substance use and mental health variables has also been reported. In a long-term longitudinal study of sons of alcoholic men, Wong, Brower, Fitzgerald, and Zucker (2004) found that sleep and over-tiredness problems as rated by the mothers when the boys were 3 to 5 years old predicted the early onset of cigarette, alcohol, and other drug use at 12 to 14 years of age. In addition, sleep problems in the boys during early childhood predicted the development of attention problems and anxiety or depression in early adolescence.

The effects of sleep disturbance on health, interpersonal and psychological functioning were the focus of a 1-year longitudinal study of 11- to 17-year-old adolescents sampled from managed care rosters. Roberts, Roberts, and Chen (2002) found that sleep disturbances at time one were significantly associated with a wide range of variables at time two, 1 year later. These relationships held even when

the analyses controlled for the presence of the outcome variables at time one. The strongest relationships were found for psychological variables. For example, the odds ratio was 2.69 for lowered self-esteem at time two for those with insomnia at time one, controlled for self-esteem at time one. The comparable odds ratio for depression was 3.61. When time two insomnia was also controlled, the strength of the statistical relationships between time one insomnia and time two outcomes were reduced. These results indicate that continued sleep disturbance has a strong concurrent effect in maintaining problems in functioning. Consequently, the treatment of sleep disorders may be of benefit both before (as prevention) and concurrently if health, interpersonal, and psychological problems develop.

### *1.4. Sleep disturbance as a risk factor for relapse after treatment*

Sleep disturbance not only provides a pathway for the development of substance abuse, it also increases the risk for relapse and treatment failure. Although we could find no studies of adolescents, studies of adults provide persuasive evidence that sleep disturbance is a vulnerability factor for substance abuse and mood disorders. There is substantial evidence of vulnerability due to sleep disturbance from studies of relapse in alcoholics and studies of the recurrence of depression in formerly depressed patients.

Researchers who have followed alcoholics after treatment found that sleep problems preceded and predicted relapse (e.g., Brower, Aldrich, & Hall, 1998; Brower, Aldrich, Robinson, Zucker, & Greden, 2001; Drummond, Gillin, Smith, & DeModena, 1998; Foster & Peters, 1999). Brower et al. (1998) found that both subjective and objective measures of increased sleep latency and sleep disturbance were independent predictors of relapse. Brower et al. (2001) found that alcoholics who were most likely to relapse after treatment were those who had insomnia before treatment. Drummond et al. (1998) found that patients who relapsed between 19 weeks and 14 months were more likely to have increased sleep latency, and lower sleep efficiency at earlier measurement points. Foster and Peters (1999) found that increased sleep latency and sleep disturbance predicted relapse and were associated with poor outcomes in both outpatient and inpatient alcohol-abusing individuals.

Sleep disturbance in adults has also been found to be a vulnerability factor for depression. Odds ratios for new cases of depression for those 21 to 30 years old who had sleep disturbances 3 years earlier were 3.95 for insomnia and 2.91 for hypersomnia (Breslau, Roth, Rosenthal, & Andreski, 1996). Sleep disturbance is also an early marker and predictor of the recurrence of depression in formerly depressed patients (Perlis, Giles, Buysse, Tu, & Kupfer, 1997). Many primary alcoholic patients meet diagnostic criteria for major depressive disorder during the first weeks of abstinence (Brown et al., 1995). This is particularly important in light of evidence suggesting that individuals with depression and alcoholism are at a greater risk for alcoholism and depression relapse (Hasin et al., 1996). Many adolescents who abuse substances are also depressed. Consequently, targeting sleep disturbance for treatment has the double benefit of increasing treatment success for both substance abuse and depression.

The studies reviewed above indicate that sleep disturbance can play a causal role in the development and maintenance of substance abuse. What is not known is whether treating the sleep disturbance and preventing the recurrence of negative emotional states breaks the casual chain and makes relapse less likely. There is a small literature indicating that relaxation and meditation reduce alcohol and other substance abuse in adults, presumably by reducing stress and other negative emotional states (e.g., Gelderloos, Walton, Orme-Johnson, & Alexander, 1991, Greef & Conradie, 1998). Recently, Currie, Clark, Hodgins, and el-Guebaly (2004) found that a multicomponent cognitive–behavioral treatment of insomnia in recovering alcoholics was effective at improving sleep and helping the participants to

discontinue the use of sedative medication. However, the treatments were not effective in preventing relapse during a 6-month follow-up. There have been no comparable treatment studies with adolescents who have histories of substance abuse.

## 2. A multicomponent sleep and daytime sleepiness treatment for adolescents with substance abuse problems

To evaluate whether treating the sleep and daytime sleepiness problems of adolescents who have had a history of substance abuse could result, first, in improved sleep, and second, in lowered risk for reuse of substances, we embarked on a demonstration project (Bootzin & Stevens, 2001; Bootzin et al., 2003).

The sleep treatment was a six-session multicomponent small group treatment with from 2 to 6 teenagers in each group. The sessions were 90 min long and were held weekly with a week's break between the fifth and sixth sessions to help shift the focus to the maintenance of gains beyond the treatment period.

Treatment components were selected to have maximal impact on the sleep problems of adolescents. The components included stimulus control instructions (SC), the use of bright light to change the sleep/wake circadian rhythms, sleep hygiene education, cognitive therapy, and Mindfulness-Based Stress Reduction (MBSR) including mindfulness meditation as described by Jon Kabat-Zinn (1994). The first session focused on only sleep and sleepiness while subsequent sessions were divided in halves between the sleep and sleepiness treatments and MBSR. The sessions were divided in half, instead of integrating the treatments throughout the session, to provide increased focus on the separate components of the treatment. The treatment sessions began with a discussion of the sleep diaries and the sleep treatment instructions and ended with practice of a meditation procedure to strengthen the instruction to practice meditation between sessions. Each treatment group had two advanced graduate student therapists, both of whom had training and experience in behavioral treatments of insomnia and one of whom had advanced training in MBSR.

### *2.1. Stimulus control instructions (SC)*

SC (Bootzin, 1972; Bootzin & Epstein, 2000; Bootzin, Epstein, & Wood, 1991; Bootzin & Nicassio, 1978) is intended to help the insomniac relearn how to fall asleep quickly in bed. SC is based on a conditioning analysis in which falling asleep is conceptualized as an instrumental act emitted to produce reinforcement (i.e., sleep). Thus, stimuli associated with sleep become discriminative stimuli for the occurrence of reinforcement. Difficulty in falling asleep, then, may be due to inadequate stimulus control. Strong discriminative stimuli for sleep may not have been established and/or discriminative stimuli for activities incompatible with sleep may be present (Bootzin & Nicassio, 1978). In insomnia, the goal is to increase the frequency of quickly falling asleep by strengthening the cues for sleep as well as decreasing the cues for behaviors that are incompatible with sleep. Bed and bedtime may become cues for behaviors that are incompatible with falling asleep. This can include a variety of activities such as watching television, reading, eating, and worrying. Many insomniacs seem to organize their entire existence around their bedroom, with television, telephone, books, and food within easy reach. For others, bedtime is the first quiet time during the day available to rehash the day's events and to worry and plan for the next day. Under these conditions, bed and bedtime become cues for arousal rather than cues for sleep (Bootzin & Nicassio, 1978). In addition, internal cues, such as mind-racing, anticipatory

anxiety, and physiological arousal can become interoceptive cues for further arousal and sleep disruption. SC reduces cues associated with arousal as well as cues that are discriminative stimuli for activities that are incompatible with sleep.

SC is intended to help the individual with sleep disturbances relearn to use the bed and bedroom as cues to fall asleep quickly. SC consists of a set of instructions designed to (1) establish a consistent sleep/wake rhythm, (2) strengthen the bed and bedroom as cues for sleep, and (3) weaken them as cues for activities that might interfere or are incompatible with sleep. The same principles are used whether the sleeper has difficulty falling asleep initially or has trouble sustaining sleep in the middle of the night.

Reviews and meta-analyses of studies from many different investigators indicate that SC is one of the most effective, if not the most effective, single component therapy for insomnia (Morin, Culbert, & Schwartz, 1994; Morin et al., 1999; Murtagh & Greenwood, 1995). SC has also been shown to be effective in multicomponent interventions (e.g., Chambers & Alexander, 1992; Epstein, 1994; Morin, Colecchi, Stone, Sood, & Brink, 1999; Morin, Stone, McDonald, & Jones, 1994).

### 2.2. Use of bright light to change circadian rhythms

In recent years, increased focus has been placed on the use of bright light to regularize the sleep/wake circadian rhythm (Lack & Bootzin, 2003). It is particularly useful for individuals, including adolescents, whose circadian rhythms are phase delayed such that the individual cannot fall asleep until very late at night and then has difficulty awakening in the morning. Encouraging results have been reported for the use of bright light with adult insomniacs (Campbell, Dawson, & Anderson, 1993; Lack & Wright, 1993; Lack, Wright, & Paynter, 1995). The increasing literature on the effectiveness of bright light in resetting the sleep/wake circadian rhythm in a variety of settings has led many clinicians to add exposure to bright light to sleep hygiene recommendations. In an evaluation of exercise and bright light recommendations with adults, the strongest improvement was found for insomniacs who received morning bright light instructions (Guilleminault et al., 1995).

### 2.3. Sleep hygiene education

Basic information about sleep and the individual variability of sleep need is a core component of cognitive–behavioral treatments for insomnia. Inadequate sleep hygiene refers to daily living activities that are inconsistent with the maintenance of good quality sleep and daytime alertness (ASDA, 1997; Stepanski & Wyatt, 2003). Among the activities included in this category are the use of substances that interfere with sleep such as alcohol, caffeine, nicotine, and other drugs, irregular use of daytime naps, extended amounts of time in bed, irregular sleep/wake schedules, scheduling of exercise close to bedtime, engaging in exciting or emotionally upsetting activities close to bedtime, having a poor sleep environment such as an uncomfortable bed or a bedroom that is too bright, stuffy, hot, cold, or noisy. Irregular sleep/wake schedules are a common problem among adolescents. Regularizing sleep schedules is a powerful means of decreasing daytime sleepiness in young adults (Manber, Bootzin, Acebo, & Carskadon, 1996).

### 2.4. Cognitive therapy

Insomniacs often subscribe to a number of irrational beliefs about sleep. Examples of these beliefs include that the adolescent's sleep is getting worse all the time and that there is nothing that can be done

to help, or that alcohol and drugs are a good solution to sleep problems, or that after a poor night's sleep it is best to stay home from school and cancel other activities (Morin, 1993). Cognitive therapy directed at changing maladaptive attitudes and beliefs is called *cognitive restructuring*. Five types of dysfunctional cognitions are identified. These are (1) misconceptions about the causes of insomnia, (2) misattributions or amplifications of the consequences of poor sleep, (3) unrealistic sleep expectations, (4) diminished perceptions of control and predictability of sleep, and (5) faulty beliefs about sleep-promotion practices (Morin, 1993). Treatment involves providing accurate information and having the insomniac identify and rehearse alternative belief statements.

### *2.5. Mindfulness-Based Stress Reduction (MBSR)*

MBSR is a meditation-based approach that is particularly suited as a treatment for stress-induced sleep disturbance (also see Bootzin, Franzen, & Shapiro, in press) as would be experienced by many adolescents coping with drug withdrawal. Stress is a likely contributor to the initiation and continuation of alcohol and drug use as well as to relapse (Brady & Sone, 1999). As mentioned earlier, relaxation training and transcendental meditation has been shown to reduce sleep problems associated with alcohol and substance abuse. It was expected that MBSR would have a similar outcome.

MBSR reduces physiological arousal, facilitates sleep onset in those who are stressed, and enhances daytime alertness. MBSR is also a method of attention control (Teasdale, Segal, & Williams, 1995). Mindfulness-based interventions have demonstrated significant effects for the treatment of stress related disorders including patients with chronic pain (Kabat-Zinn, Lipworth, & Burney, 1985), anxiety (Kabat-Zinn et al., 1992; Miller, Fletcher, & Kabat-Zinn, 1995), and depression (Teasdale et al., 2000).

Mindfulness meditation is particularly relevant to sleep related disorders because it serves the dual functions of reducing arousal (like relaxation techniques), and affecting cognitive processes such as worrying and mind-racing which are commonly reported problems of insomniacs (Bootzin et al., in press). Five studies of meditation that report sleep outcomes have been published in the past decade (Carlson, Speca, Patel, & Goodey, 2003; Cohen, Warneke, Fouladi, Rodriguez, & Chaoul-Reich, 2004; Kaplan, Goldenberg, & Galvin, 1993; Shapiro, Bootzin, Figueredo, Lopez, & Schwartz, 2003; Singh, Berman, Hadhazy, & Creamer, 1998). Improvements in sleep have been reported for patients with breast cancer, prostate cancer, or fibromyalgia. None of these studies, however, have been specifically directed at the sleep problems of substance abusing adolescents or adults.

## 3. Preliminary evaluation of the multicomponent sleep treatment

### *3.1. Methods*

#### *3.1.1. Participants*

Fifty-five adolescents who had complaints of sleep or daytime sleepiness problems and who were completing or had recently completed outpatient substance abuse treatment programs were recruited for the study. These broad inclusion criteria were employed to evaluate whether sleep treatment was effective for a representative sample of adolescents with a substance abuse history. Reflecting the demographics of the treatment programs from which they were referred most (62%) were male and approximately two-thirds were Caucasian.

Participants between the ages of 13 and 19 who had complaints about either sleep disturbance or daytime sleepiness were included in the study and assigned to treatment. Approximately 42% (23 of 55) attended four or more of the six therapy sessions and were considered to have completed the treatment. Completers attended a mean of 5.04 sessions (S.D. = 0.767; 30.4% of the completers attended all 6 sessions); noncompleters attended a mean of 0.65 sessions (S.D. = 0.877; 56.3% of the noncompleters did not attend any sessions). Noncompleters dropped out for a variety of reasons including incarceration, competing work commitments, and unwillingness to complete the high assessment burdens or travel to the treatment sites. The vast majority of the noncompleters had either one or no treatment sessions.

See Table 1 for the demographic and baseline characteristics of the sample. At this writing, the treatment waves have been completed, but follow-up assessments are ongoing.

### *3.1.2. Measures*

Participants kept daily sleep diaries which were also phoned to an answering machine each morning for 9 weeks, beginning with the baseline week through the posttreatment week. During the baseline and posttreatment weeks participants wore actiwatches at night when they went to sleep. Actiwatches are devices the size of a wrist-watch that measure body movement. Scoring algorithms have been developed to convert activity counts into the sleep variables. Thus, actigraphy provides estimates of sleep that does not depend on the participant's subjective assessment. Noncompleters were less likely to continue to provide sleep diary and actigraphy data than completers.

Participants also spent one night in the sleep research laboratory during baseline and posttreatment so that saliva could be collected hourly for assessment of dim light melatonin onset (DLMO). Melatonin is suppressed by bright light and the timing of its release reflects the sleep/wake circadian rhythm. Adolescents who are sleep phase delayed would be expected to have DLMO occur later at night than it would for those who are not phase delayed. DLMO, thus, provides a biological measure of the presence of sleep phase delay and whether treatment produces improvement. Analyses of this measure are ongoing.

Participants completed substance abuse information and the general mental health distress index from the GAINS substance abuse self-report assessment (Dennis, 1999) and filled out the Epworth Sleepiness Scale (Johns, 1991) and the Penn State Worry Questionnaire (Meyer, Miller, Metzger, & Borkovec, 1990) at baseline, posttreatment, and at the 3- and 12-month follow-ups. Participants continued to be retained in the study for questionnaires and interviews at the posttreatment and follow-up schedules even if they did not complete the treatment. Ninety percent of subjects have continued to participate in the interviews whether or not they completed the treatment.

### *3.1.3. Preliminary results*

As described in Table 2, all of the adolescents in the study used alcohol and marijuana. Lifetime use of other illicit drugs that were used by at least 30% of the study sample included hallucinogens (76.4%), inhaled powder or injectable cocaine (74.5%), other narcotics such as morphine, methadone, dilaudid, and opium (61.8%), pills (56.4%), stimulants (47.3%), and other opiates such as percocet, oxycontin, and demeral (30%). Age of first use indicates that, on average, adolescents begin using alcohol and then marijuana while not yet teenagers (12.0 and 12.4 years, respectively), and progress to drugs that are considered "uppers" (i.e. cocaine, stimulants, hallucinogens). While prior studies have indicated that marijuana is the most widely used illicit drug (e.g., Johnson et al., 2001), this data indicates that both marijuana and alcohol are used by all study youth, with alcohol use occurring, on average, first. Heroin

Table 1
Demographics and baseline characteristics

| Characteristics | *n* (%) Completers | *n* (%) Noncompleters |
|---|---|---|
| Sex | | |
| Male | 13 (56.5) | 21 (65.6) |
| Female | 10 (43.4) | 11 (34.4) |
| Ethnicity | | |
| Caucasian | 16 (69.5) | 22 (68.7) |
| Hispanic | 4 (17) | 7 (22) |
| African American | 1 (4) | 2 (6) |
| Asian American | 2 (9) | 0 (0) |
| Native American | 0 (0) | 1 (3) |
| | Mean (S.D.) Completers ($n=23$) | Mean (S.D.) Noncompleters ($n=32$) |
| Age | 16.35 (1.23) | 15.91 (1.20) |
| SPI | 2.74 (3.70) | 1.25 (2.38)$^{+}$ |
| Drug use (past 30 days) | 10.26 (16.24) | 5.00 (12.85)$^{\#}$ |
| GMHI | 12.00 (5.61) | 11.16 (5.07) |
| Worry | 35.00 (10.06) | 36.19 (10.85) |
| ESS | 7.87 (4.40) | 8.16 (4.27) |
| Sleep diaries | Mean (S.D.) Completers ($n=21$) | Mean (S.D.) Noncompleters ($n=15$) |
| SOL (min) | 36.71 (30.20) | 28.67 (18.10) |
| TST (min) | 439.38 (75.46) | 495.53 (73.72)* |
| No. of awakenings | 1.96 (1.42) | 2.67 (3.27) |
| SE | 0.85 (0.08) | 0.84 (0.09) |
| Sleep quality | 2.81 (0.60) | 3.07 (0.59) |
| Sleep soundness | 1.95 (0.22) | 2.00 (0.53) |
| Actigraphy | Mean (S.D.) Completers ($n=21$) | Mean (S.D.) Noncompleters ($n=18$) |
| SOL (min) | 45.81 (27.28) | 49.83 (31.13) |
| TST (min) | 406.10 (61.82) | 422.11 (68.97) |
| No. of awakenings | 39.67 (9.78) | 35.61 (12.45) |
| SE | 0.77 (0.07) | 0.79 (0.07) |

SPI=substance problem index; GMHI=general mental health distress index; Worry=Penn State Worry Questionnaire; ESS=Epworth Sleepiness Scale; SOL=sleep onset latency; TST=total sleep time; SE=sleep efficiency.
* $p<0.05$.
$^{\#}$ $p<0.10$.
$^{+}$ $p<0.20$.

and other narcotics closely follow with an average age of first use at 15.0 years. Speedball, an injectable combination of heroin and cocaine is initiated last, at 15.7 years, with regard to chronological age. Average number of days of use at baseline is low for most drugs even including alcohol at 1.8 days and

Table 2
Substance use

| Drug | Ever used *n* (*N*=55) | Percent (%) | Mean age first use (S.D.) | Baseline[a] (S.D.) |
|---|---|---|---|---|
| Alcohol | 55 | 100.0 | 12.0 (2.5) | 1.80 (4.3) |
| Marijuana | 55 | 100.0 | 12.4 (2.2) | 2.60 (7.1) |
| Hallucinogens | 42 | 76.4 | 14.7 (1.4) | 0.10 (0.4) |
| Cocaine | 41 | 74.5 | 14.7 (1.4) | 0.95 (3.6) |
| Other narcotics | 34 | 61.8 | 15.0 (1.1) | 0.16 (0.5) |
| Pills | 31 | 56.4 | 14.5 (1.6) | 0.70 (3.1) |
| Stimulants | 26 | 47.3 | 14.8 (1.7) | 0.79 (2.8) |
| Other opiates | 17 | 30.1 | 14.9 (1.4) | 0.18 (0.5) |
| Inhalants | 12 | 21.8 | 13.5 (1.4) | 0.00 (0.0) |
| Crack | 9 | 15.0 | 15.0 (1.4) | 0.00 (0.0) |
| Speedball | 5 | 9.0 | 15.7 (1.6) | 3.00 (6.7) |
| Heroin | 3 | 5.5 | 15.0 (1.7) | 0.00 (0.0) |

Other narcotics=morphine, methadone, dilaudid, and opium; Other opiates=percocet, oxycontin, and demeral; Speedball=an injectable combination of heroin and cocaine.

[a] Mean number of days used in the past 30 days at the start of the sleep treatment which was after substance abuse treatment had been completed.

marijuana at 2.6 days of the 30 days prior to baseline. Speedball was used most frequently – although reported use was by only five youth – at 3.0 days. It should be remembered that drug use was probably low because the teenagers had been recruited into the study near the end of their substance abuse treatment programs. The majority of adolescents (50.9%) reported marijuana as their drug of choice followed by cocaine (18.2%) and hallucinogens (16.4%). Speed, alcohol, or heroin is the drug of choice for only 14.6% of the study sample.

The comparison of completers and noncompleters on demographics and baseline measures is presented in Table 1. There were no significant differences on sex, age, or ethnicity, the general mental health distress index (GMHI), the Penn State Worry Questionnaire (Worry), or the Epworth Sleepiness Scale (ESS). There was a trend indicating worse drug use at the sleep treatment baseline for completers than for noncompleters. Completers had a trend for a significantly higher substance problem index (SPI, $p<0.20$) and more days of drug use ($p<0.10$) than noncompleters. The higher the SPI score the greater the severity of problems associated with substance use, with a score of 4.0 suggesting substance dependence.

With regard to GMHI, at baseline participants had an average of 11.5 (ranging from 7.0 to 22.0) which suggests acute mental distress. Participants had an average Penn State Worry Questionnaire score of 35.7 which indicates moderate worry. The average baseline score for the ESS was 8.0 which indicates moderate daytime sleepiness. There was 27.3% of the sample that scored above 10 which has been used as a threshold for excessively daytime sleepiness in adolescents (Shin, Kim, Lee, Ahn, & Joo, 2003).

On the sleep diary baseline data, the only significant difference between completers and noncompleters was on total sleep time (TST). Completers slept almost an hour less than noncompleters. Completers slept an average of 7 h and 19 min a night while noncompleters slept an average of 8 h and 16 min a night ($p<0.05$, see Table 1). There were no significant differences in sleep between completers and noncompleters as measured by actigraphy. However, all subjects had long sleep onset latencies, frequent brief awakenings, and poor sleep efficiency; i.e., less than 80% of the time participants were in bed was spent asleep.

*3.1.4. Preliminary outcome results*

Data from the participants who completed four or more of the treatment sessions exhibited marked improvement on sleep as reported in their daily sleep diaries. Significant improvement was shown in sleep efficiency ($p<0.001$, $n=17$, 0.84 to 0.92, S.D.=0.071), sleep onset latency ($p<0.01$, $n=17$, 36 to 17 min, S.D.=22.9 min) number of awakenings ($p<0.001$, $n=17$, 2.29 to 1.41, S.D.=0.78), total sleep time ($p<0.05$, $n=17$, 440 to 501 min, S.D.=91.4 min), and self-ratings on the diaries of quality of sleep ($p<0.001$, $n=17$, 2.71 to 3.47, S.D.=0.66) and soundness of sleep ($p<0.01$, $n=17$, 1.94 to 2.41, S.D.=0.51). Actigraphy showed a trend for improvement in total sleep for completers ($p<0.20$, $n=20$, 408 to 431 min, S.D.=63.1 min) and a marginally significant interaction between completers and noncompleters on sleep onset latency ($F=3.84$, $df=1/24$, $p=0.06$, completers, $n=20$, improved 44 to 36, and noncompleters, $n=6$, got worse 52 to 75 min).

There were significant improvements ($p<0.05$) for all participants in reductions of sleepiness, worry, and the mental health distress index and completers did not improve significantly more than noncompleters. Participants who completed the treatment strongly endorsed the program. On anonymous participant satisfaction forms, 17 of 18 completers rated the program as having lasting value and gave average importance rating of 5.38 (out of 7). The most commonly reported benefits to an open-ended question were “improved sleep”, “ways to relax”, and “more energy”.

With regard to drug use, at baseline all participants had recently finished a substance abuse treatment program and were at low levels of drug use. Drug use increased for both completers and noncompleters through the treatment period. As follow-up evaluations are being completed, an encouraging pattern is emerging that indicates that drug problems as measured by the SPI decreases for completers during the follow-up periods but continues to increase for the noncompleters (interaction $F=1.65$, $df=3/57$, $p<0.20$, $n=10$ completers, $n=11$ noncompleters). It appears that whereas sleep improves during treatment, the effect on drug abuse is delayed and is not fully seen until the 12-month follow-up.

Interestingly, completers reported twice the number of days of substance use during the past 30 days when they entered the sleep intervention compared to the noncompleters. It may be that adolescents who are more frequent users are aware that they need additional intervention or, alternatively, it may be that their elevated substance use may more negatively affect their sleep. In this regard, completers reported almost an hour less sleep per night than noncompleters.

The rise in drug use during the treatment period may be due to the departure of the adolescents from formalized substance abuse treatment programs. For many of the youth, the end of the substance abuse treatment program also marks the completion of juvenile probation supervision and the end of urine screens for substance use. Past data suggest an increase in drug use following treatment completion (Stevens et al., 2004). The decrease in substance problems at 12 months could be attributed to a delayed intervention effect and/or contextual or internal mediating factors that foster reductions in substance use.

A limitation to the evaluation of this pilot project is the lack of a randomized control condition. It is hoped that the positive preliminary results presented here will encourage replication.

## 4. Conclusion

As our review indicated, there is substantial evidence for the interaction between sleep disturbance, substance use, and social and mental heath problems. Sleep disturbance and the resulting daytime sleepiness is a central determinant for these outcomes for adolescents, not just adults. Remarkably, the

demonstration study we describe here is the first treatment study for adolescents who have a substance abuse history. It seems clear that we have the tools for treating sleep disturbance and that the same techniques that work for adults, are effective for adolescents—even for adolescents who have a substance abuse history. Nevertheless, there are serious challenges to be met with regard to motivation, commitment, and compliance. The proportion of treatment noncompleters was unacceptably high. Research on methods for increasing the applicability of behavioral treatments for sleep for hard to treat populations such as substance-abusing adolescents is needed.

## Acknowledgements

This work was supported by a contract from the Office of National Drug Control Policy. The authors wish to thank John Leggio, Patrick J. Barasso, Robert Miller, and Lucy Ledi for help in recruiting adolescents from their substance abuse treatment programs, and members of the research and clinical teams: Jennifer C. Cousins, Keith Fridel, Brant Hasler, Barbara Estrada, Michael Cameron, Rein Vidad, Shauna L. Shapiro, Sabrina Hitt, Elaine T. Bailey, and Willoughby Britton.

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