Sleep and Aggression in Substance-Abusing Adolescents: Results From an Integrative Behavioral Sleep-Treatment Pilot Program

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Study Objective: To examine whether change in total sleep time during an integrative, behavioral sleep intervention is associated with aggression. Specifically, we tested whether adolescents who reported experiencing aggressive thoughts or actions after treatment had worse treatment trajectories (e.g., less total sleep time across treatment) than adolescents with no aggressive thoughts or actions after treatment.

Design: Nonpharmacologic open trial with 9 weeks of weekly assessment.

Setting: University of Arizona Sleep Research Laboratory

Patients or Participants: Twenty-three adolescents recently treated for substance abuse in outpatient community centers.

Interventions: Six-week integrative, behavioral sleep intervention.

Measurements and Results: Weekly sleep-summary indexes were calculated from daily sleep diaries and entered as dependent variables in a series of growth-curve analyses. Statistically significant Session × Post-treatment Aggressive Ideation interactions emerged when predicting changes in total sleep time, $\gamma_{13} = 9.76$ (SE = 4.12), $p < .05$, and time spent in bed, $\gamma_{13} = 10.08$, (SE = 4.33), $p < .05$, even after controlling for aggressive ideation and the frequency of substance use, as assessed at baseline. A similar pattern of results was seen for self-reported aggressive actions occurring during conflicts.

Conclusions: These pilot data suggest that inadequate sleep in substance-abusing adolescents may contribute to the experiencing of aggressive thoughts and actions. Limitations include a small sample size and a restricted assessment of aggression. Nonetheless, these findings lend preliminary support to the breadth of therapeutic effectiveness of an integrative, behavioral sleep-therapy program for adolescents with a history of substance abuse and related behaviors.

Keywords: Aggression, substance abuse, emotional dysregulation, sleep, behavioral therapy, adolescents

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INTRODUCTION

VIOLENCE AMONG ADOLESCENTS IS A SUBSTANTIAL PUBLIC-HEALTH CONCERN. HOMICIDE IS CURRENTLY THE SECOND LEADING CAUSE OF DEATH IN THIS AGE group.[1] Recently, research has focused on emotional dysregulation as a predictor of aggression and violence in adolescents.[2,3] Aggressive adolescents may be less able to inhibit impulses, urges, or strong affect[4] and, thus, act out on anger-related impulses. This type of violence has been termed impulsive aggression.[35] Acts of impulsive aggression may include physical aggression directed toward others, suicide attempts, self-mutilation, substance use, and property destruction.[5] Thus, an impulsive action may entail premeditation[4] if it is provoked by strong emotion.

Several studies have examined the relationship between sleep and suicide (one type of impulsive aggressive behavior) in adolescence. In a community sample, [6] adolescents with less than 8 hours of sleep were more likely to attempt suicide. In addition, insomnia[7] and increased rapid eye movement (REM) density[8] correlate with suicidal tendencies in depressed adolescents. Other studies have found that sleep disturbances are associated with markers of poor emotional/behavioral regulation, including worse academic performance, increased problems in the classroom,[9] more depressive symptoms,[9,10] and substance abuse.[11] To our knowledge, no study to date has examined the relationship between sleep and the larger construct of violence or impulsive aggression in adolescents.

In contrast with the relatively sparse literature on sleep and aggression, the relationship between substance use and aggression has been widely studied in adolescents. Alcohol and illicit substance use are high-risk behaviors related to violence in adolescents.[12,13] Also, substance use has been associated with an increased likelihood of internalizing and externalizing difficulties,[14] suicide attempts,[12] and expressions of anger.[15] It has been suggested that emotionally dysregulated adolescents use substances to "self-medicate" mood problems.[16]

In addition to the relationship between substance use and emotional dysregulation, substance use has been associated with sleep disturbance;[11,17] in fact, sleep disturbance in young children may be a significant risk factor for substance use in adolescence.[17] This and the associations between substance use and aggression provide support for a causal model in which the relationship between sleep and high-risk behaviors may be mediated by emotional dysregulation. A large epidemiologic study of adolescents recently found that psychopathology mediated the relationship between sleep disturbance and substance use,[11] thereby supporting this model.

We sought to test the relationship between sleep and aggression (a marker of emotional dysregulation) by examining response to an integrative, behavioral sleep treatment for adolescents who recently completed substance-abuse treatment. We hypothesized that adolescents who reported experiencing aggressive thoughts

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This was not an industry supported study. Drs. Haynes, Bootzin, Smith, Cousins, Cameron, and Stevens have indicated no financial conflicts of interest.

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or actions after treatment would have worse treatment trajectories (e.g., less total sleep time [TST] across treatment) than adolescents with no aggressive thoughts or behaviors after treatment. We expected that this relationship would persist when controlling for initial aggression and substance use, thereby suggesting a direct temporal relationship between poor sleep and later aggression.

METHODS

This study was approved by the Institutional Review Board at the University of Arizona. A confidentiality certificate was provided by the National Institutes of Health.

Design

We employed a longitudinal design predicting change in weekly sleep indexes over the course of 9 weeks. Time (or Session) was an independent variable entered into all analyses. All aggression independent variables were dichotomous. Each variable was separately entered into the model with its interaction term (Aggression Term × Session). The aggression terms were: (a) Aggressive ideation (AI) and (b) Aggressive actions (AA) assessed at 1 week after treatment, 3 months after treatment, and 12 months after treatment. We also included 2 covariates in the model, which were the matching baseline aggression term and the Substance Frequency Index (SFI) of the Global Appraisal of Individual Needs (GAIN) assessment (see below). Data used in these analyses were collected from a larger study testing the effectiveness of treating sleep and daytime sleepiness in adolescents with substance-abuse histories.[18]

Participants

Participants consisted of 23 adolescents between the ages of 13 and 19 who completed the sleep-treatment protocol. All participants had complaints of current sleep or daytime sleepiness problems and had recently completed local outpatient substance-abuse treatment programs. With regard to the sleep intervention, treatment completers were defined as those who attended at least 4 of 6 treatment sessions (mean ± SD: 5.17 ± .72).

We previously reported a description of the sample of adolescents who completed this sleep therapy.[18] In brief, the majority of adolescents who completed treatment were men (57%) and Caucasian (61%), with a mean age of 16.39 years (SD = 1.23). Marijuana was the most popular illicit drug of choice (48%), followed by hallucinogens (22%) and cocaine (22%). The majority of participants also used alcohol (52%) and smoked cigarettes (61%).

In Bootzin and Stevens,[18] nineteen 1 way ANOVAs were conducted comparing differences between treatment completers (n = 23) and noncompleters (n = 32) on demographic, mental-health, substance-use, and sleep variables.*[18] From these analyses, approximately 1 statistically significant difference would be expected by chance alone. Completers and noncompleters were significantly different on only 1 baseline sleep-diary variable (completers had less TST). Thus, the current sample of treatment completers is likely representative of the adolescents recruited into the larger study.

Only 16 adolescents in the noncompleter group and 22 adolescents in the completer group filled-out 1 of the first 2 weeks of baseline sleep diaries.

Measures

Multiple domains of functioning were measured including sleep, substance use, and psychological status. The main measure for sleep was the daily sleep diary. Adolescents were instructed to complete the sleep diary every morning, telephone the results to the study, and then hand in their sleep diaries weekly. The sleep diary includes entries for the time that participants retired to bed, turned off the lights, awoke in the morning, and arose from bed in the morning. Participants also recorded sleep latency, the number and duration of awakenings, and quality of sleep (1 = very restless to 5 = very sound). From these items, the following weekly average sleep-summary parameters were computed: TST, time in bed (TIB), wake time after sleep onset (WASO), number of awakenings, sleep-onset latency (SOL), sleep quality, time of going to bed in the evening (retiring time), time the lights were turned out with the intention to sleep (lights-out time), wake time in the morning (awakening time), and time of getting out of bed in the morning (arising time). Estimates of sleep parameters from sleep diaries have been found to be reliable and valid in adults with insomnia.[19]

Sleep-diary data with a least 3 days complete in the week were included in the present analyses (n = 20, mean ± SD = 6.12 ± .87 days); occasionally, weeks of data collection were longer than 7 days due to changes in therapy-session scheduling, holidays, or illness. Participants were included in analyses if they completed a minimum of 3 weeks of sleep-diary data, with at least 1 week of the sleep-diary assessments occurring during the last half of treatment (mean number of weeks completed = 6.65, SD = 1.46)

The primary measure for substance abuse, AI, and AA was the GAIN.[20] The GAIN (baseline assessment) and the GAIN-M90 (follow-up assessment) are structured clinical-interview assessments designed to assess the severity of clinical factors, including substance use and dependence, risk behaviors, mental and physical health, recovery environment, and social support. The GAIN has been tested and employed extensively among the adolescent substance abuse-population (e.g., Adolescent Outpatient and Continuing Care Study,[21] Illinois Youth Survey[22]). The GAIN assessed clinical symptoms over the past 90 days (Baseline, 3-month, and 12-month assessments) or since the start of treatment (Post-treatment assessment). A masters-level counselor, who was trained and certified in administration of the GAIN, administered both scales.

From the GAIN and GAIN-M90, the following valid and reliable scales were computed: Substance Problem Index, Substance Frequency Index, Self-Efficacy Index, General Mental Distress Index, and General Social Support Index. The Substance Problem Index is a symptom measure of drug-abuse severity; higher scores represent more-severe substance abuse (α = .88). The SFI is a percentage of days various substances were used across the assessed period (alcohol, marijuana, cocaine, heroin). The SFI measures the frequency of substances used in terms of the number of days used, the number of days in which the participant stayed high most of the day, and the number of days in which substance use caused problems (α = .87). The Self-Efficacy Index measures the confidence of individuals in resisting relapse in different situations, with higher scores indicating more self-efficacy (α = .76). The General Social Support Index is a measure of social support; higher levels of support are associated with higher scores (α =

.81). The General Mental Distress Index is a measure of mental distress, including somatic, depressive, and anxious symptoms (α = .95). General Mental Distress Index scores above 4 are considered clinically significant.

AI was assessed by a positive response to item M1c1 ("Thoughts about killing or hurting someone else?") on the GAIN-M90. Response to this variable was coded dichotomously so that 1 indicated a positive response and 0 indicated a negative response. The presence of an aggressive action was assessed by response to item E8p ("Since baseline assessment, on how many days did you have an argument with someone else in which you swore, threatened them, threw something, pushed or hit someone in any way?"). This variable was coded dichotomously so that 1 indicated at least 1 day in which the participant engaged in an aggressive action, and 0 indicated no aggressive actions since the baseline assessment.

The Sleep Treatment Program

The sleep treatment, described in more detail in Bootzin and Stevens,[18] was a 6-session multicomponent small-group treatment with 2 to 6 teenagers in each group. The sessions were 90 minutes long and were held weekly with a 1-week therapy break between the fifth and sixth sessions. This break was designed to 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, the use of natural bright light to change sleep-wake circadian rhythms, sleep education, and mindfulness based stress reduction.[23] The first session focused on only sleep and sleepiness, while subsequent sessions were divided in halves between the sleep treatment and mindfulness-based stress reduction. Two postmasters graduate-student therapists led each group under the supervision of the second author (RRB). Therapists had extensive training and experience in behavioral treatments of insomnia, and 1 of the 2 therapists in each group also had advanced training in mindfulness-based stress reduction.

Procedure

Adolescents were recruited from 4 outpatient substance-abuse treatment facilities in Tucson, Arizona. They were eligible to enroll in the study as soon as they completed substance-abuse treatment. At the screening appointment, study procedures were reviewed, written consent was received by at least 1 parent or guardian, and written assent was received by the adolescent. At this time, the GAIN was also administered to the adolescent, and she or he was given a sleep diary to complete over the next week. Treatment commenced an average of 3 weeks later (mean ± SD = 21.15 ± 19.18 days). Adolescents were instructed to complete the sleep diaries on a daily basis throughout the 6-week treatment period, including the 1-week assessment period between sessions 5 and 6. One week after treatment (post-treatment assessment), adolescents were given a final sleep diary and administered the GAIN-M90. The GAIN M-90 was also administered 3 months and 12 months after treatment.

Data Analyses

First, a number of preliminary analyses were conducted to identify clinical characteristics of individuals with and without aggressive ideation and aggressive actions at the post-treatment assessment. For the main analyses, mixed-effect linear modeling was used to examine the change in each sleep variable over time for adolescents with and without post-treatment AI. We first tested the unconditional growth model (Model A) in order to determine whether there was an overall improvement in each sleep index across treatment sessions. Next, we tested the growth model, including the covariates, AI Baseline and SFI Baseline, in order to statistically control for initial status differences in AI and substance-use frequency (Model B). Finally, we tested the hypothesized model (Model C) that included the Post-treatment AI variable and the Post-treatment AI × Session interaction. Participants were initially entered into the model as a random effect nested under time. We began analyses utilizing an unstructured covariance matrix. Differences in model fit were interpreted through the use of -2LL, Akaike Information Criteria, and Bayesian Information Criteria statistics under restricted maximum-likelihood procedures (for a technical discussion, see Willett and Singer[24]). For parsimony, we eliminated the random-slope parameter after the first model if it indicated that variation between slopes of individuals was nonsignificant. Thus, the covariance matrix used for the majority of these random-intercept models was compound symmetry.

To control for substance use across the course of treatment, we substituted the baseline SFI score with the post-treatment SFI score for all analyses. Because substance-use type might have differential effects on sleep, we also substituted the SFI global score with each SFI substance component (i.e., separately included the number of days individuals used alcohol, cocaine, marijuana, and heroin) as assessed at both the baseline and post-treatment assessments. Finally, analyses were conducted using AI scores as assessed at 3-month follow-up and 12-month follow-up. Because the post-treatment AI assessment includes the treatment timeframe, these follow-up analyses allowed us to test whether changes in sleep preceded the AI assessment, thereby allowing an inference of causal association. All analyses were repeated, substituting the AI term with the AA term.

RESULTS

Preliminary Analyses

At the baseline assessment, 10 of the 23 adolescents (44%) endorsed AI in the previous 90 days, and 7 adolescents experienced AI at least once throughout the treatment period (30% at the post-treatment assessment). Five of 21 adolescents (22%) reported AI in the 90 days preceding both the 3-month and 12-month post-treatment assessment.

Of the 24 demographic, protocol-adherence, and substance-use variables examined, 3 differences emerged between AI+ and AI- participants on substance-use variables only (see Table 1 for AI substance-use descriptive statistics; AA descriptives are in the text below). This pattern of results justifies the inclusion of SFI as a covariate. There were no differences between AI+ and AI- adolescents on baseline sleep variables.

A total of 16 of the 23 adolescents (70%) reported having engaged in an AA during an argument at the baseline assessment. This decreased to 52% (n = 12) at both post-treatment and the 3-month follow-up time points (11 of 21 adolescents who completed the assessments). Thirteen adolescents (62%) reported AA at the 12-month time point. On baseline variables, there were only 2 dif-

Table 1—Differences in Substance Abuse Indexes Between Adolescents With vs. Without Aggressive Ideation as Assessed After Treatment

	Post-treatment AI+ (n = 7)	Post-treatment AI- (n = 16)	p value
Baseline			
GAIN indexes			
Substance Problem Index	13.14 (2.73)	11.50 (4.63)	NS
Substance Frequency Index	.18 (.17)	.07 (.13)	NS
Alcohol	20.86 (28.38)	2.81 (7.43)	*
Marijuana	19.14 (32.47)	9.44 (18.50)	NS
Cocaine	8.00 (20.73)	2.81 (11.25)	NS
Heroin	.00 (.00)	.00 (.00)	—
General Mental Distress Index	13.14 (2.73)	9.75 (5.11)	NS
Global Social Support Index	8.43 (1.51)	8.44 (1.03)	NS
Self-Efficacy Index	2.71 (1.50)	3.50 (1.26)	NS
Post-treatment			
GAIN indexes			
Substance Problem Index	13.29 (1.70)	11.63 (3.77)	NS
Substance Frequency Index	.28 (.18)	.04 (.09)	**
Alcohol	28.86 (30.81)	2.81 (7.66)	**
Marijuana	30.57 (38.03)	10.56 (23.39)	NS
Cocaine	15.14 (30.06)	.06 (.25)	NS
Heroin	.14 (.38)	.06 (.25)	NS
General Mental Distress Index	9.00 (4.86)	6.00 (4.99)	NS
Global Social Support Index	8.14 (.90)	8.25 (.77)	NS
Self-Efficacy Index	3.00 (1.00)	2.88 (1.54)	NS

GAIN refers to Global Appraisal of Individual Needs; AI, aggressive ideation.
*p < .05
**p < .01

ferences between post-treatment AA+ and AA-, which is the number that would be expected by chance. As compared with AA- adolescents, AA+ adolescents had lower self-efficacy about resisting substance-use relapse, $F_{1,22} = 5.89$, $p < .05$ (mean ± SD: AA-, 3.91 ± .83; AA+, 2.67 ± 1.50) and fewer awakenings at baseline, $F_{1,19} = 6.72$, $p < .05$ (AA-, 2.73 ± 1.51; AA+ 1.33 ± .89).

Main Analyses

Results from the unconditional growth models (Model A) for each statistically significant sleep-diary index are reported in Table 2. Main effects for Session (γ_{10}) indicated that all participants had statistically significant improvements in TST, number of awakenings, WASO, SOL, sleep efficiency, and sleep quality across the course of treatment.

Aggressive Ideation

Main analyses results for TST are reported in Table 3. There was no significant association between participants' baseline TST and baseline AI (γ_{01}) or baseline SFI (γ_{02}). With the addition of these parameters, the effect of Session did not reduce significantly; TST continued to increase approximately 7 minutes with each session (γ_{10}). In Model C, a significant effect emerged for the Post-treatment AI × Session (γ_{13}) interaction, indicating that the change in TST across the course of treatment differed significantly between AI+ and AI- adolescents (see Figure 1). A statistically significant Post-treatment AI × Session interaction also emerged for TIB, γ_{13}= 10.08 (SE = 4.33), $p < .05$ (see Figure 1).

No other statistically significant AI × Session interactions or AI main effects emerged for the remaining sleep-diary indices, although there were interaction trends for in-bed (retiring) time, γ_{13} = -610.54 (SE = 302.65), $p < .10$, and lights-out time, γ_{13} = -599.64 (SE = 320.93), $p < .10$ (see Figure 2).

Results for TST and TIB did not change significantly when separately substituting the baseline SFI score with the post-treatment SFI score or with the baseline or post-treatment substance-type variables (alcohol, marijuana, cocaine, and heroin).

Aggressive Actions

The growth-trajectory patterns for these analyses are similar to those of AI+ adolescents. Across the course of treatment, AA+ adolescents received less TST (see Table 4) and less TIB (γ_{13} = 10.52, SE = 3.91, $p < .01$) than AA- adolescents (see Figure 3).

Table 2—Parameter Estimates (and Standard Errors) for Unconditional Growth Models (Model A) Examining the Rate of Change in Various Sleep Indexes Over the Course of Treatment

Parameter		Dependent Variable					
		TST	Number of awakenings	WASO	Sleep-Onset Latency	Sleep Efficiency	Sleep Quality
Fixed effects							
Initial status	β_0						
Intercept	γ_{00}	439.91*** (14.94)	1.93*** (0.29)	9.50*** (2.21)	33.78*** (4.05)	0.85*** (0.01)	2.69*** (0.10)
Rate of change	β_1						
Intercept	γ_{10}	6.59* (2.36)	-0.12*** (0.03)	-0.77* (0.33)	-2.36** (0.59)	0.01*** (0.002)	0.08** (0.02)
Random effects							
Level 1: Within-person residual	r_{ij}	2838.11*** (409.83)	0.34*** (0.05)	27.02*** (3.91)	132.03*** (19.36)	0.002*** (0.0002)	0.13*** (0.02)
Level 2: Variance of Intercept	μ_0	3238.28* (1441.71)	1.52** (0.55)	86.33** (31.72)	270.45* (105.78)	0.002* (0.001)	0.14* (0.07)
Level 2: Variance of Slope	μ_1	44.84 (36.18)	0.01 (0.005)	1.60* (0.73)	3.97 (2.31)	0.00001 (0.00001)	0.01* (0.003)

Data are presented as mean (SEM); N = 20.
An unstructured covariance matrix was used to model the error variance. TST refers to total sleep time; WASO, wake after sleep onset
*p < .05
**p < .01
***p < .001

Table 3—Parameter Estimates for Mixed Models Examining the Relationship Between Aggressive Ideation Assessed After Treatment and Change in Total Sleep Time Across the Course of Treatment

	Parameter	Model B	Model C
Fixed effects			
Initial status	β_0		
Intercept	γ_{00}	436.93*** (25.54)	442.05*** (35.57)
AI, baseline	γ_{01}	17.03 (27.40)	9.76 (29.11)
SFI, baseline	γ_{02}	-69.21 (88.79)	-36.57 (97.23)
AI, post-treatment	γ_{03}		-5.74 (36.20)
Rate of change	β_1		
Intercept	γ_{10}	6.80** (1.90)	-.14 (3.48)
AI, post-treatment	γ_{13}		9.76* (4.12)
Random effects			
Level 1: Within-person residual	r_{ij}	3161.41*** (420.06)	3032.57*** (404.71)
Level 2: Variance of Intercept	μ_0	2926.02* (1164.34)	3055.21* (1236.80)
Goodness-of-Fit			
-2LL		1465.94	1446.25
AIC		1469.94	1450.25
BIC		1475.68	1455.95

Data are presented as mean (SEM); N = 20.
A compound symmetry error matrix was used to model the error variance. AI refers to Aggressive Ideation; SFI, Substance Frequency Index; AIC, Akaike Information Criteria; BIC, Bayesian Information Criteria.
*p < .05
**p < .01
***p < .001

In addition to TST and TIB, a significant Post-treatment AI × Session interaction emerged for the mean number of awakenings, γ_{13} = -.09 (SE = .04), p < .05. A graph of the growth trajectory for each group appears in Figure 4. Interestingly, AA+ adolescents had a lower intercept than AA- adolescents on this measure.

These AA results did not change significantly when separately substituting the baseline SFI score with the post-treatment SFI score or with the baseline or post-treatment specific substance-use variables (alcohol, marijuana, cocaine, and heroin).

Follow-up Time-Point Analyses

Despite the small number of AI+ adolescents at the 3-month and 12-month follow-up time points, the same interaction effects emerged as for post-treatment AI (i.e., Aggressive Ideation x Session interaction effects for TST and TIB). At the follow-up time points, no AI × Session interaction trends emerged for retiring and lights-out time. Instead, there were interaction effects for both awakening time, γ_{13} = 1197.29 (SE = 454.22), p < .05, and arising time, γ_{13} = 1133.27 (SE = 434.42), p < .05, at the 12 month post-treatment assessment (these effects were trends at the 3 month post-treatment assessment). Graphical inspection revealed that the AI- group had arising times that became more delayed over the course of treatment, whereas AI+ had gradually advancing arising times (consistent with overall lower TIB for AI+ adolescents). There were also interaction effects for sleep efficiency, with AI measured at 3 months after treatment, γ_{13} = .01 (SE = .004), p < .01; number of awakenings with AI measured at 3 months after treatment, γ_{13} = -.17 (SE = .05), p < .01; and number of awakenings, with AI measured at 12 months after treatment, γ_{13} = -.17 (SE = .05), p < .01. The graphical display of each of these effects was consistent with the pattern of results described above.

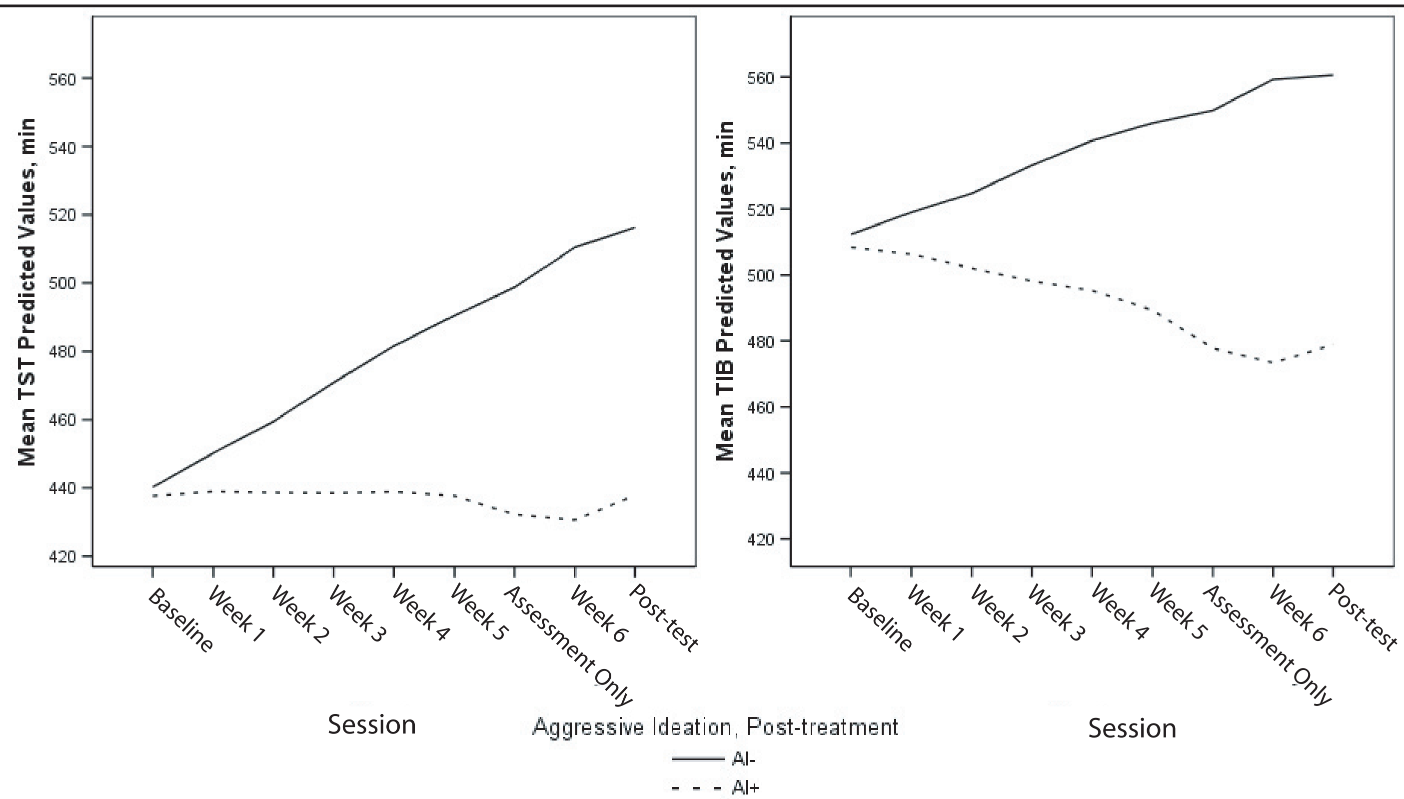

Figure 1—Post-treatment Aggressive Ideation (AI) x Session interactions predicting total sleep time (TST) and time in bed (TIB).

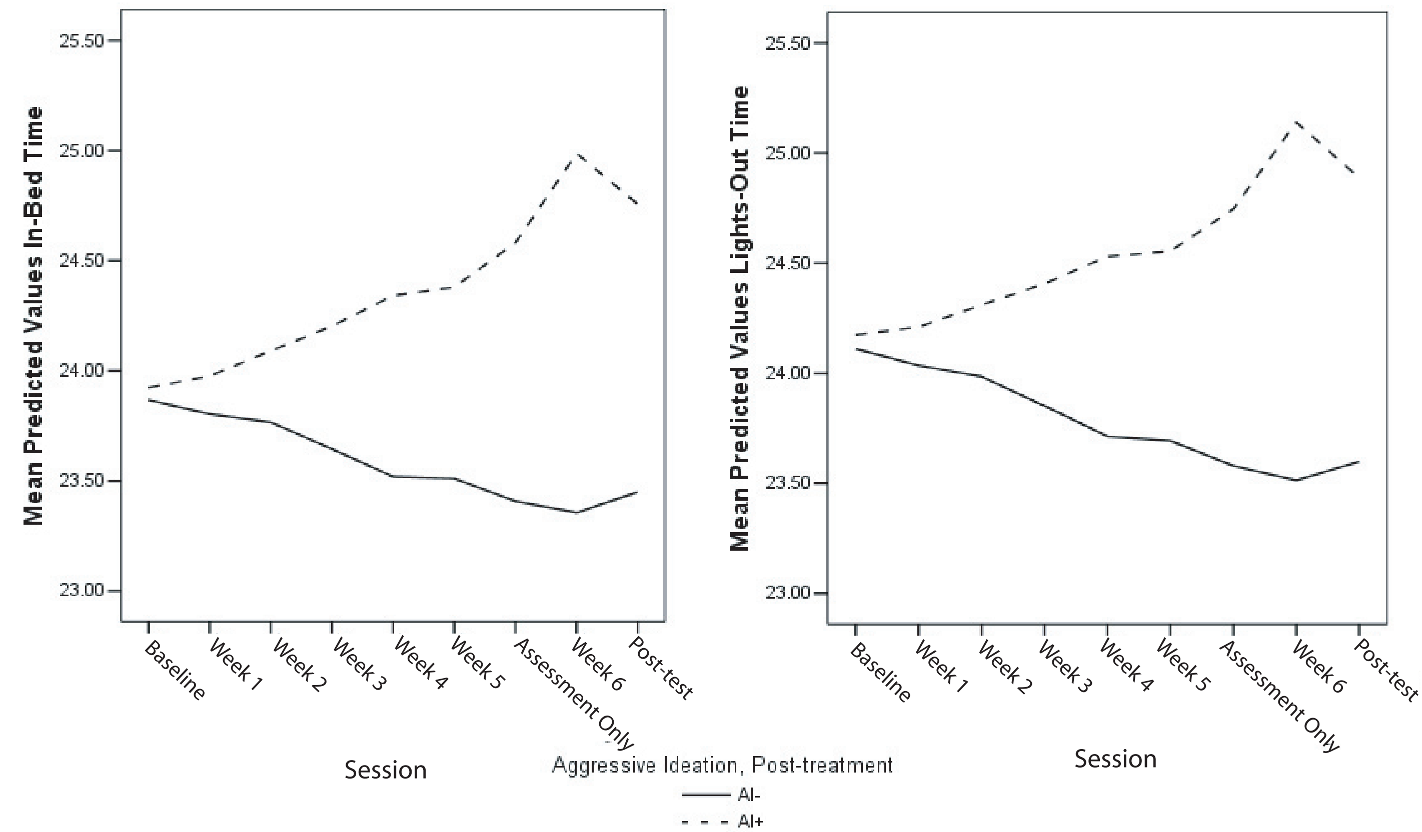

Figure 2—Post-treatment Aggressive Ideation (AI) x Session interaction trends predicting in-bed and lights-out times.

Table 4—Parameter Estimates for Mixed Models Examining the Relationship Between Engagement in an Aggressive Action assessed After Treatment and Change in Total Sleep Time Across the Course of Treatment

	Parameter	Model B	Model C
Fixed effects			
Initial status	β_0		
Intercept	γ_{00}	443.23*** (20.11)	459.01*** (24.12)
AA, baseline	γ_{01}	16.68 (31.12)	21.29 (40.70)
SFI, baseline	γ_{02}	-71.21 (88.95)	-72.37 (92.44)
AA, post-treatment	γ_{03}		-36.75 (37.96)
Rate of change	β_1		
Intercept	γ_{10}	6.83*** (1.90)	2.54 (2.54)
AA, post-treatment	γ_{13}		9.32* (3.74)
Random effects			
Level 1: Within-person residual	r_{ij}	3160.82*** (419.92)	3022.28*** (403.32)
Level 2: Variance of Intercept	μ_0	2949.95* (1170.58)	3176.40* (1278.53)
Goodness-of-Fit			
-2LL		1465.79	1446.26
AIC		1469.79	1450.26
BIC		1475.53	1455.96

Data are presented as mean (SEM); N = 20. A compound symmetry error matrix was used to model the error variance. AA refers to Aggressive Action; SFI, Substance Frequency Index; AIC, Akaike Information Criteria; BIC, Bayesian Information Criteria.
*p < .05
**p < .01
***p < .001

In contrast with AI, follow-up effects were more variable for participants who engaged in AA at the 3-month and 12-month time points. No statistically significant interaction effects emerged for AA at the 3-month follow-up. At the 12-month follow-up, there was a significant interaction effect for WASO, $\gamma_{13} = -1.41$ (SE = .42), $p < .01$. As compared with the WASO trajectory for AA- adolescents, the WASO trajectory for AA+ adolescents was characterized by a lower intercept and flatter slope (similar to the AA pattern seen previously for number of awakenings, Figure 4).

Overall, these findings provide confirmation for the main analysis findings, especially those measuring AI. The pattern of results was similar across all 24 total interaction effects and trends. We would expect 3 of these interaction effects to result from chance alone (66 analyses conducted in total).

DISCUSSION

The data presented in this report largely support our hypothesis. Inadequate amounts of sleep were associated with later aggression in adolescents recently treated for substance abuse, even when controlling for baseline aggression and frequency of substance use. Overall, these preliminary findings suggest that the successful treatment of sleep problems could be an important violence-prevention element within a high-risk adolescent population. Substance-abusing adolescents are much more likely than nonusing adolescents to engage in violent behaviors,[25] which is significant given the high rate of violence among teens. Thus, a conservative nonpharmacologic treatment that reduces aggression in adolescents could be of great public-health significance, as well as a great benefit to substance-abusing adolescents and their families.

In addition to the direct clinical implications of these findings,

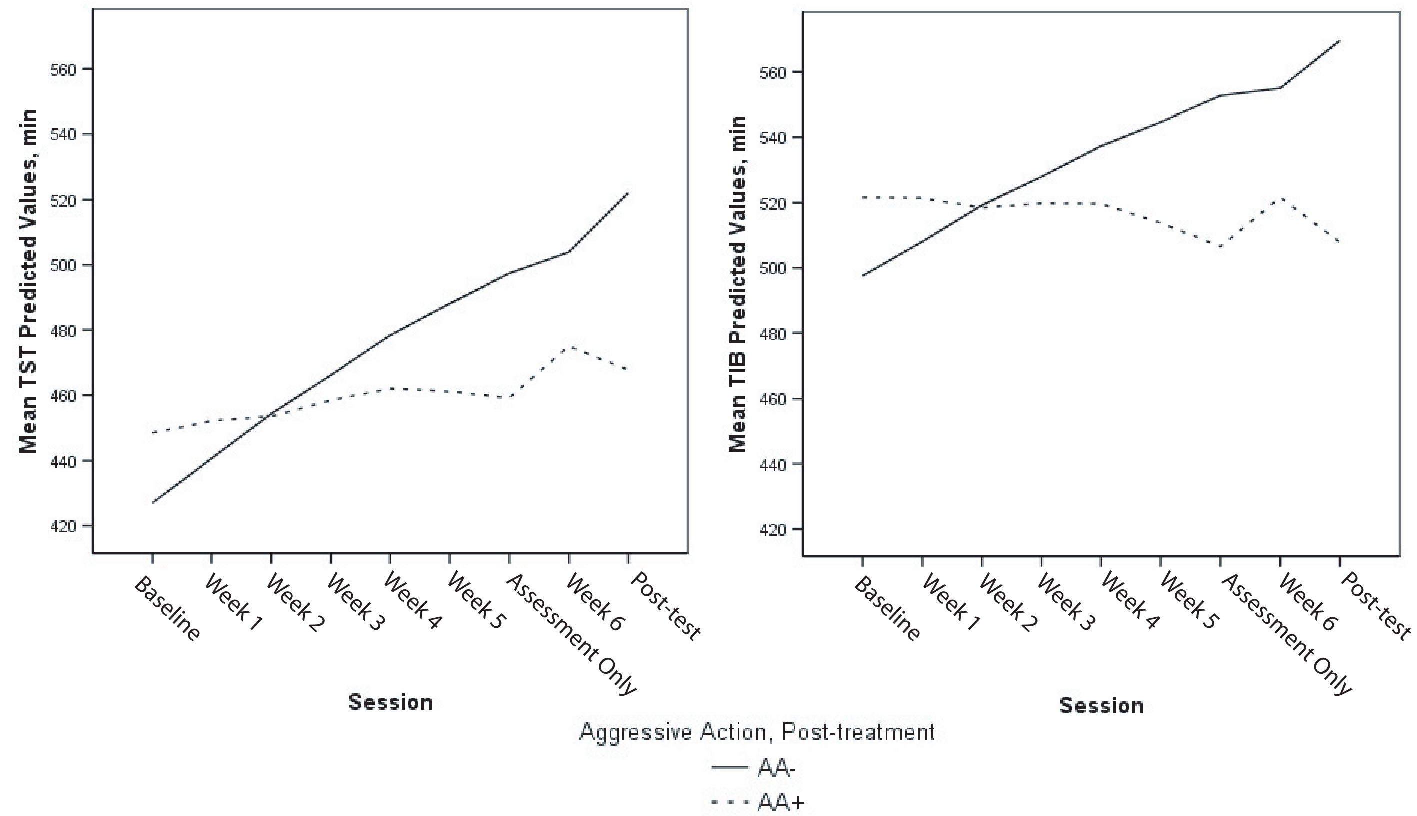

Figure 3—Aggressive Action (AA) × Session interactions predicting total sleep time (TST) and time in bed (TIB).

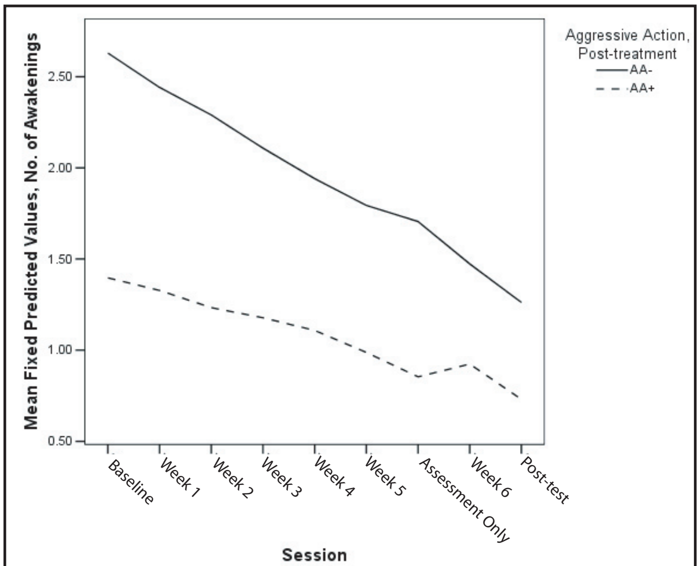

Figure 4—Aggressive Action (AA) × Session interaction predicting total number of awakenings.

these results provide some insight into the relationship between emotion and substance use in adolescence. In particular, our results are consistent with the causal model proposed by Johnson and Breslau,[11] in which psychiatric status partially mediated the relationship between sleep disturbances and illicit drug use. In the present study, less improvement in TST was associated with both aggressive ideation and actions. Also, AI+ adolescents were more frequent users of substances. Taken together, these results suggest that inadequate sleep may predispose adolescents toward affective and behavioral disinhibition. This disinhibition may be associated with the use of substances to "self-medicate" affective instability.[26]

Sleep-Specific Treatment Mechanisms

A number of findings emerged illuminating the nature of sleep complaints in this population. For instance, group comparisons of TST indicated that adolescents may require relatively large amounts of sleep to effectively regulate their behavior and affect (i.e., 8-hour cutoff[6]). Also, the primary mechanism by which TST increased appeared to be through an increase in the amount of TIB. SOL and sleep-continuity indexes did not predict whether adolescents reported AI after treatment. In fact, we found interaction effects indicating that adolescents with more awakenings were actually less likely to engage in aggressive actions. Given that the number of diary-reported awakenings in both groups was small, awakenings among adolescents may not be predictive of sleep disturbance. The pattern of sleep (i.e., less TST, insomnia indexes at normal clinical levels) in emotionally dysregulated substance-abusing adolescents stands in stark contrast to depressed or substance-abusing adults, who primarily experience insomnia complaints. Adolescents may be less likely than adults to use substances to "self-medicate" sleep disturbances. Sleep may not be as valued among adolescents as it is for adults. Options for stimulating and arousing activity at night (e.g., cable TV, telephone, Internet, video games, late-night social activities, use of activating substances) may be more exciting among teens and, thus, contribute to overall less time in bed.[27]

Considerations

A number of methodologic factors need to be considered when interpreting these findings. First, the assessment of aggression was based on response to several interview questions. Although these questions are widely used among mental health clinicians to assess for violence risk, future research could benefit by including measures specifically examining aggressive impulsivity, including documented aggressive outbursts (e.g., school, law-enforcement reports) and other clinical factors. Also, no studies to date have validated whether sleep diaries are valid and reliable measures to use in a substance-abusing adolescent population. At least 1 study has shown that diaries are acceptable outcome measures in normal high-school students.[28] However, an adolescent substance-abusing population is difficult to engage in a research protocol,[29] thereby suggesting a lesser likelihood of accurately completing daily assessments of sleep.

An additional consideration is generalizability. About half of the adolescents did not complete treatment due to logistic difficulties in completing the study protocol (e.g., employment, legal issues, time restraints), and the remaining adolescents did not complete treatment or sleep diaries for largely unknown reasons.[18] Our follow-up rate is consistent with those reported for other adolescent alcohol- and drug-treatment outcome studies (the reported rate has been as low as 36%).[29] We previously found no differences between completers and noncompleters on a variety of substance-abuse, sleep, and demographic variables.[32] Nonetheless, the demands of the treatment may select for particularly dedicated volunteers, including adolescents who are less likely to engage in serious delinquent and offending behavior.[29] In addition, high attrition and a relatively small number of completers limited the statistical power and ability to detect small to medium effects.

Despite these limitations, the results in this study provide valuable data about the change in sleep over time in a sample of adolescents with a history of substance abuse. To our knowledge, this is the first study to date examining the relationship between sleep and aggression in a high-risk adolescent population. The main finding, that adolescents with greater improvements in TST report significantly less aggressive ideation and fewer aggression actions, as compared with adolescents with less change in TST, justifies further research on the relationship between sleep and aggression. In addition, future studies targeting preadolescents with poor or inadequate sleep are indicated, especially given recent research suggesting that sleep problems reported as early as age 3 to 5 years are associated with substance use during adolescence.[17]

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