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# Poor actigraphic and self-reported sleep patterns predict delinquency and daytime impairment among at-risk adolescents

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ABSTRACT

*Objective:* To evaluate associations between actigraphic sleep patterns, subjective sleep quality, and daytime functioning (ie, sleepiness, symptoms of depression, and delinquency and other conduct problems) in at-risk adolescents.
*Design:* Prospective, observational cohort study.
*Setting:* Providence, RI, predominantly home and school and 2 visits to the Brown Center for the Study of Children at Risk.
*Participants:* A diverse group of low-income 13-year-olds (n = 49) with and without prenatal drug exposure.
*Interventions:* None.
*Measurements:* Actigraphy, sleep diaries, and sleep and health questionnaires.
*Results:* Above and beyond the effects of prenatal drug exposure and postnatal adversity, actigraphic daytime sleep was a significant predictor of daytime sleepiness and delinquency. Subjective sleep quality was a significant predictor of daytime sleepiness, delinquency, and depressive symptoms. Later bed times predicted increased delinquency.
*Conclusions:* There was a unique effect of actigraphic daytime sleep duration, subjective nighttime sleep quality, and bedtime on daytime functioning (ie, sleepiness, symptoms of depression, and delinquency and other conduct problems) of at-risk adolescents. In these vulnerable youth, these problematic sleep patterns may contribute to feeling and behaving poorly. Intervention studies with at-risk teens should be conducted to further explore the role of these sleep parameters on daytime functioning.
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Consequences of poor sleep on functioning and health have been supported by decades of research. For example, relative to good sleepers, adults with self-reported difficulty initiating and maintaining sleep reported more daytime fatigue, sleepiness, and concentration difficulties; were less well adjusted psychologically; and experienced more anxiety, tension, and depression.[1] In addition, findings support adults sleeping less than 6 or more than 8.5 hours per night as being less well adjusted psychologically with more symptoms of depression and anxiety compared with adults sleeping between 6 and 8.5 hours per night.[2] These more optimal sleepers report higher levels of personal growth, positive relations with others, purpose in life, and self-acceptance. Sleep duration also has been associated with daytime alertness, reaction time, and mood.[3]

The small body of research on adolescent sleep problems suggests that particular environmental, behavioral, and biological factors specifically affect adolescent sleep.[4] Environmental factors include part-time employment, early morning school schedules, and decreased parental involvement in setting bedtimes. Behavioral factors affecting sleep involve increased academic demands and social obligations. Self-reported nocturnal sleep duration declines throughout adolescence and alterations in sleeping and waking patterns increase, including delayed sleep onset, earlier rise times, and larger variations between weeknight and weekend sleep schedules.[4] Increased vulnerability to accidents and drug and alcohol abuse are potential consequences of insufficient and low-quality sleep in this population.

Academic performance has been a major focus of previous research investigating associations between adolescent sleep patterns and daytime functioning. A clinical review of studies assessing associations between adolescent sleep patterns and school performance by Wolfson and Carskadon[5] concluded that adolescents who reported inadequate sleep, irregular sleep patterns, and/or poor sleep quality tended to do poorly in school compared to their peers.

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More specifically, students who described themselves as struggling or failing in school obtained about 25 minutes less sleep per night, went to bed an average of 40 minutes later, and had greater weekend delays in sleep schedules than students making As and Bs.[6]

Notably, findings of a few studies support possible links between adolescent sleep and risk-taking and delinquent behavior. One longitudinal study of 13- to 15-year-old adolescents showed shorter time in bed associated with delinquent and aggressive behaviors as well as other externalizing problem behaviors in both sexes and internalizing problem behaviors in boys.[7] Another study[8] found that youth between 13 and 19 years old who slept 7 hours or less per night reported significantly more property delinquency (eg, theft and vandalism) and those sleeping 5 hours or less per night reported significantly more violent delinquency. Moreover, O'Brien and Mindell[9] documented increased risk-taking behaviors in adolescents between 14 and 19 years old reporting insufficient sleep compared with well-slept peers.

Predominantly the sleep of white, affluent adolescents has been studied. Our previous longitudinal work found that prenatal nicotine exposure was associated with parentally-rated sleep problems (ie, difficulties falling and staying asleep) through late childhood[10] and early adolescence[11] in mostly minority, low socio-economic status (SES) samples. Few studies, however, have assessed the association between sleep problems and daytime impairment in low SES, at-risk adolescents. Although demographic data on SES, ethnicity, and race were not included, 1 study[12] assessed subjective sleep problems and aggression in adolescent male juvenile offenders and found that shorter sleep duration and poorer sleep quality predicted increased hostility.

Are adolescents who are already at risk for daytime impairment because of prenatal and postnatal adversity at greater risk for daytime impairment and other problems if they sleep poorly? Our aim was to investigate whether problematic sleeping patterns common among at-risk teens (eg, late bed times and daytime dozing/napping) predicted increased problems in other areas of functioning, such as mood, behavior, and alertness, also commonly experienced by these youth. In this study, we specifically investigated irregular sleep schedules, late bedtimes, short sleep duration, disruptive sleep environment, poor sleep quality, and daytime napping as potential predictors of daytime sleepiness, symptoms of depression, and delinquency and other conduct problems. We hypothesized that these daytime outcomes were worse in adolescents with problematic sleep patterns, which were not fully accounted for by prenatal or postnatal adversity.

## Methods

### *Study design*

This study was cross-sectional and ancillary to the Maternal Lifestyle Study (MLS), which is a longitudinal, multisite investigation of the effects of prenatal cocaine exposure on child developmental outcome.[13–15] The largest prospective study of this kind, the MLS enrolled 1388 children (658 in the cocaine-exposed group and 730 in the comparison group) at birth in Detroit, MI; Memphis, TN; Miami, FL; and Providence, RI.[16] The MLS was approved by an appropriate institutional review board at each site. A NIDA Certificate of Confidentiality was obtained to assure confidentiality of information regarding the participants' drug use. Mothers were initially recruited in the hospital after delivery, and informed consent was obtained at that time.

Participants were recruited to maximize likelihood of having prenatal cocaine exposure or to be a group-matched control. All women delivering very low birth weight newborns (ie, 501-1500 g) were identified and recruited, and other mothers were recruited during normal hours of operation (ie, excluding nights and weekends). Mothers were screened for eligibility based on the following criteria: 18 years or older and without psychiatric disorders, developmental delays, or language barriers. Neonates were eligible provided that they were inborn, likely to survive, singleton, and less than 43 weeks gestational age. Mother-infant dyads were also excluded from the longitudinal study, which started with the 1-month visit, if the infant has a chromosomal abnormality or TORCH (toxoplasmosis, rubella, cytomegalovirus, herpes, and syphilis) infection or when the mother planned to move out of the catchment area. Comparison participants were group matched on ethnicity (black, white, Hispanic, and other), sex, and gestational age (within 2 weeks). When an infant in the comparison group did not attend the 1-month visit, another match was generated until a comparison infant was successfully enrolled or the recruitment period ended. The MLS conducted 15 follow-up visits from 18 months to 15 years. This ancillary sleep assessment study was administered in the Providence cohort only.

### *Participants*

The Providence cohort of the MLS (n = 211, 87 in the cocaine-exposed group and 124 in the comparison group) was recruited from Women and Infants Hospital. Mothers were assigned to the cocaine exposure group based on maternal report and/or meconium toxicology with gas chromatography–mass spectroscopy assay confirmation. Infants were assigned to the comparison group when mothers denied cocaine use during pregnancy and the meconium toxicology was negative. The same procedure applied for determination of opiate and marijuana exposure. Alcohol and tobacco use were determined by maternal report alone. Providence cohort participants were asked if they would like to participate in the ancillary actigraphy sleep assessment study at the time that their 13-year MLS visit was scheduled (mean age, 13; SD, 0.1); 50 agreed to participate and 49 completed the study: 56% female, 50% minority, 42% below the poverty line, and 82% with prenatal drug exposure (ie, cocaine, opiates, marijuana, alcohol, or nicotine or some combination of these). Only 9 (19%) of participants were free of postnatal adversity as we measure it in this study (see Measures section below), and of those, 8 (89%) had prenatal adversity in the form of drug exposure. See Table 1 for additional demographic characteristics of the sample.

### *Procedures*

Participants attended a clinic visit at the beginning and at the end of their assessment week and completed the following questionnaires: (1) the Sleep Habits Survey (SHS)[6] used to address factors such as sleep schedule, sleep environment, and phase preference; (2) the Sleep, Medical, Educational, and Family History Form (completed by 1 parent); and (3) the Sleep Diary. Participants monitored their sleep for 1 week using sleep diaries and actigraphy. We interviewed participants about their actigraphic data using interview and sleep diary procedures developed by Acebo et al.[17] We asked the parents and teens if the scheduled week was a "normal" week for them, and we did not allow them to participate in the week-long assessment during "vacation" or nonschool weeks. We also did not include data from weeks when the participants were physically ill. Participants were called midweek and asked questions about adherence; they were also asked to provide bed and rise times for the past 2-3 days. Any problems with adherence were addressed at that time. Successful completion of the study was defined as having at least 120 consecutive hours of actigraphic data in which the device was only removed according to our instructions (ie, during showers or contact sports) and having a complete sleep diary and questionnaires. Participants who did not have at least 5 days and nights of actigraphy data (or who became physically ill during their assessment week) were

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