Behavioral Intervention that Extends Sleep Duration Leads to Greater Self-Control in School-Aged Children

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ABSTRACT: ***Objective:*** **Short sleep and evening phase preference associate with impaired self-control, yet few studies have assessed the efficacy of sleep extension for improving this behavioral domain. Thus, this secondary analysis of a behavioral sleep intervention measured whether an intervention that enhanced children's sleep also affected self-control. Differences by chronotype were also explored.** ***Methods:*** **Sixty-seven children (8–11 yr), who reportedly slept <9.5 hr/d, were randomized to either a control or sleep intervention condition (i.e., 4-session behavioral intervention to enhance sleep by 1–1.5 hr/night). Chronotype was assessed using the Child Chronotype Questionnaire at baseline, and self-control was assessed using the Self-Control Rating Scale (SCRS, a caregiver report) at baseline and 8 weeks postrandomization. Total sleep time (TST) was measured using wrist actigraphy for 1 week at both baseline and 8 weeks postrandomization. Partial correlations and mixed-model ANOVAs were used for statistical analyses, with age as a covariate.** ***Results:*** **At baseline, children with shorter TST ($r = -0.29$, $p = 0.02$) and an evening preference ($r = 0.26$, $p = 0.049$) were perceived as having lower self-control by their caregivers. Significant condition*time interaction effects were found for TST ($p < 0.001$) and SCRS score ($p = 0.046$): From baseline to follow-up, children randomized to the sleep intervention exhibited a significant increase in TST and were perceived as having greater self-control by their caregiver; children randomized to the control condition exhibited no change in TST or in SCRS score. The condition*chronotype*time interaction effect was not significant.** ***Conclusion:*** **A brief sleep intervention that enhanced TST also resulted in enhanced caregiver reported self-control in school-age children. Results add to the growing evidence for the importance of sleep health in children.**

(*J Dev Behav Pediatr* 45:e463–e469, 2024) **Index terms:** youth, behavioral inhibition, chronotype.

Self-control, defined as the ability to inhibit impulses and abstain from gratifying immediate needs and desires, enables individuals to engage in goal-directed behavior and is a predictor of positive health outcomes.[1–3] Greater self-control in childhood is associated with a number of positive outcomes, including better academic performance and physical health, healthier social relationships, higher earnings and rates of employment, and decreased likelihood of breaking the law as adults.[2,4–7] Given its influence on a wide range of important outcomes and that it is a modifiable cognitive process,[1] self-control represents an important target for optimizing well-being.

One way to improve self-control may be to enhance sleep. Evidence from experimental studies in youth show that sleep deprivation impairs executive functions that rely on inhibition and self-control,[8–11] while observational studies have demonstrated associations between

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healthy sleep habits and greater self-control.[12–16] A meta-analysis of sleep and cognitive performance in school-age children concluded that short sleep duration is significantly related to poorer executive functioning and worse school performance as well as more behavioral problems.[17] Despite the importance of sleep for self-control, to our knowledge, no studies have directly examined whether enhancing sleep duration using a behavioral intervention leads to improved self-control among school-age children. This gap is particularly important given the high prevalence of insufficient sleep among children.[18] In addition, studies have shown that chronotype, an individual's preference for sleep/wake timing, also influences self-control. Adolescents/young adults who have an evening preference, and are also at increased risk for insufficient sleep, exhibit lower self-control[19–21] or behaviors associated with lower self-control (e.g., poor diet, smoking).[22–24] To our knowledge, no studies examining the relationship between chronotype and self-control in school-age children have been published.

The purpose of this data analysis was to determine whether a behavioral sleep intervention that was shown to increase sleep duration[25,26] secondarily led to improvements in self-control in children ages 8 to 11 years. We hypothesized that children randomly assigned to the intervention condition would exhibit improved self-control compared with children randomly assigned to a control condition. We also explored how chronotype and the child's preference for morningness (early bird) versus eveningness (night owl) are related to self-control and may influence the effect of the sleep intervention on self-control.

METHODS

Subjects

Children aged 8 to 11 years who had a caregiver report that they sleep ≤9.5 hours per night on average were eligible to participate in a randomized controlled trial to determine, relative to control, the efficacy of a brief behavioral intervention to enhance sleep.[25] This duration was selected as the cutoff based on recommendations for sleep in this age group. Caregivers were at least 18 years, the child's primary caretaker, and able to understand and complete the study questionnaires. Children were ineligible if caregivers reported diagnosis of a medical or psychiatric condition (including a sleep disorder) or current medication that could affect sleep, eating behaviors, or weight status.

Procedure

Families were recruited through mailings and advertisements distributed throughout the community. Trained staff screened families by phone and if the child seemed eligible, they were scheduled for an orientation visit. Families needed to understand and be able to communicate in English to participate. All procedures were approved by the Institutional Review Boards at Temple University, Philadelphia, PA; parents provided written consent, and children provided assent. The methods of this intervention study are summarized below and have been described in detail previously.[25,26] In brief, the primary aims focused on whether, relative to control, a brief behavioral intervention could enhance school-age children's nocturnal sleep and thus their eating behaviors and weight status. The sole focus of the intervention was on enhancing sleep; there was no focus on enhancing other health behaviors or self-control (i.e., the primary focus of these secondary analyses).

During an orientation visit, families were provided with a brief description of the study aims and procedures. If families were still eligible and enrolled, they completed questionnaires, including the chronotype measure, and were provided with an actigraph (Actiwatch 2; Mini Mitter, A Respironics Company, Bend, OR) and a 7-day sleep diary and instructed to wear the device, complete the diary, and call-in to a time-stamped voicemail to report sleep and wake times every day for 1 week. All families were instructed to continue with their child's typical sleep schedule for this week.

Families then returned to the Center, and research staff assessed the child's sleep to determine final eligibility based on actigraphy, sleep diary, and call-in data, which were reviewed with the family to confirm sleep-wake periods. If the child was reported to sleep approximately 9.5 hours or less/night and this was confirmed by actigraphy, they remained eligible; these data also served as the child's baseline sleep measurement. Families were then randomized to either the behavioral sleep intervention condition or the control condition. Both conditions participated in the 8-week study that included 2 in-person intervention/control sessions at the Center (immediately after randomization and 1 week postrandomization) and 2 phone sessions (4 and 6 weeks postrandomization). The first in-person session was approximately 45 to 60 minutes in length; the second approximately 30 minutes. The 2 phone sessions were approximately 15 minutes each. Outcome measures were collected during assessments at baseline, 2 weeks, and 8 weeks.

Families (caregiver and child) randomized to the behavioral sleep intervention were provided with behavioral strategies (e.g., goal setting, positive reinforcement, sleep hygiene and stimulus control recommendations, problem-solving) to enhance sleep by 1-1 ½ hours per night.[25,26] Given that this was a behavioral intervention, families were not blinded to their condition. Briefly, in-person sessions focused on enhancing the child's motivation to participate in the study, establishing goals for bedtimes and wake times (the intervention was flexible, with most children advancing their bedtime and then delaying their wake time when possible), using positive bedtime routines, reviewing basic sleep hygiene strategies, self-monitoring the child's sleep, using positive reinforcement for goal achievement, and working with

families to preplan and problem solve potential barriers to adherence to the sleep plan. Phone sessions were brief and focused on adherence to the sleep schedule, reinforcement of goal achievement, and problem-solving regarding challenges with the sleep goal.

Families randomized to the control condition attended in-person and phone sessions that focused on adherence to completing study activities, including wearing the actigraph, and completing the sleep diary and call-ins. Families in the control condition were instructed to continue with the child's typical sleep schedule for the duration of the study.

Procedures for the baseline, 2-week and 8-week assessments were identical. Families were provided with an actigraph (Actiwatch 2 (Mini Mitter, A Respironics Company, Bend, OR) and a 7-day sleep diary and instructed to wear the device, complete the diary, and call in to a time-stamped voicemail to report sleep and wake times every day for 1 week. At the end of the week, families visited the Center to complete other assessment measures. Only baseline and 8-week assessment data were examined in the current study, as we were interested in the effects of longer-term changes in sleep duration and the complete behavioral intervention on self-control.

Measures

Sleep

Actigraphy is a widely used, reliable, and valid device for measuring sleep that monitors motor activity to obtain continuous recordings estimating sleep-wake states.[27] Actiwatch 2 (Mini Mitter, A Respironics Company, Bend, OR), a watch-size monitor worn on the wrist, was used with standard procedures (children wore the device continuously on their nondominant wrist across the 24-hour period, medium sensitivity threshold).[27,28] Actigraphs were configured to store data in 1-minute epochs, and 7 days of data were gathered during each assessment. Epochs were scored as sleep or wake by Actiware 5.0 software using an algorithm that modifies activity counts during a single epoch by activity produced in the surrounding 2-minute period. In comparison with polysomnography, the sleep-wake algorithm is excellent at detecting sleep (sensitivity = 0.93).[28] Sleep diaries were used to collect bedtime, night wakings, wake time, daytime naps, caffeine/medication use, and illness (e.g., colds). This information was used to verify and score actigraphy data.[29] Total sleep time (TST) is defined as the number of minutes of actigraph-scored sleep during the sleep period (actigraph-estimated sleep onset [bedtime] to sleep offset [wake time]).

Chronotype

The Child Chronotype Questionnaire,[30] a 27-item validated measure used to report a child's sleep-wake patterns on scheduled and "free" days to determine whether the child is naturally a "morning" or "evening" person, was completed by a caregiver during the orientation visit. Higher scores on this measure indicate greater evening preference. When categorized, children with scores 23 or lower are considered to have a morning preference, those with scores 33 and higher are considered to have an evening preference, and those with scores 24 to 32 are considered to have an intermediate preference. Owing to the small number of morning types (n = 9) in this sample, morning and intermediate types were combined into 1 group. Therefore, 29 children were in the morning/intermediate group (n = 15 sleep intervention, n = 14 control) and 28 children were in the evening group (n = 14 sleep intervention, n = 14 control).

Self-Control

The Self-Control Rating Scale (SCRS),[31] a 33-item validated measure, was completed by caregivers at each assessment and measures children's behavioral and cognitive inhibition and impulsivity. Higher scores on the SCRS indicate greater impulsivity and less self-control.

Statistical Analysis

Between-subjects ANOVAs were used to compare demographic characteristics and baseline information between conditions. Partial correlations, with age as a covariate, were used to assess the relationships between baseline sleep duration, chronotype, and self-control. Mixed-model ANOVAs, with age as a covariate, were used to assess the change in sleep duration and self-control from the baseline assessment to the 8-week assessment between conditions. A mixed-model ANOVA was also used to assess the interaction effect of condition and morningness-eveningness on changes in self-control from the baseline assessment to the 8-week assessment. Effect sizes were calculated using Cohen's d. Statistical analyses were conducted with IBM SPSS Statistics for Windows (version 20.0; IBM, Chicago, IL). The data analyses for the current study were secondary to the primary goals of this intervention study.[26]

RESULTS

Of the 78 children randomized to the sleep intervention condition (n = 39) or control condition (n = 39), 67 (n = 33 sleep intervention, n = 34 control) were included in analyses.[26] Three participants were excluded from analyses because their 8-week assessment occurred more than 12 weeks postintervention (n = 1 sleep intervention, n = 2 control), and 6 participants were excluded from analyses because 8-week actigraphy was not usable due to nonwear or device malfunction (n = 3 sleep intervention, n = 3 control). Families were from a diverse socioeconomic background, with parental education ranging from high school or less (33.3%) to college (38.7%) and graduate/professional degrees (28.0%) and annual family income averaged $88,941 ($99,017). The morningness-eveningness questionnaire was added to the protocol after the study began and completed by 57 children, whose data are included in those analyses. The sample comprised a diverse sample

of 46 girls and 21 boys aged 8 to 11 years. There were no significant differences between conditions in age, sex, race, or in baseline TST, chronotype score, or self-control (all $p > 0.05$; Table 1).

At baseline, children with shorter TST (r = −0.29, $p = 0.02$) and a higher chronotype score (indicating stronger evening preference; r = 0.26, $p = 0.049$) were perceived as having lower self-control by their caregivers. Furthermore, when categorized, children with a morning/intermediate preference score were reported to exhibit greater self-control at baseline than those with an evening preference score (F (1, 54) = 4.10, $p = 0.048$).

When examining differences between conditions (i.e., intervention versus control) on changes in TST and self-control from baseline to the 8-week assessment, we observed significant condition*time interaction effects for TST (F (1, 64) = 26.89, $p < 0.001$, d = 1.26) and SCRS score (F (1, 64) = 4.16, $p = 0.046$, d = 0.49). Consistent with the primary outcome paper,[26] from baseline to the 8-week assessment, children randomized to the sleep intervention exhibited a significant increase in TST ($p < 0.001$, Fig. 1A). They were also perceived to have greater self-control by their caregiver ($p = 0.016$, Fig. 1B) whereas children randomized to the control condition exhibited no significant change in sleep ($p = 0.19$) or self-control ($p = 0.83$).

A mixed-model ANOVA was used to examine the interaction between chronotype category and sleep intervention on changes in self-control. Although the condition*chronotype*time interaction effect was not significant ($p = 0.40$), children in the sleep intervention with an evening preference exhibited a larger change in self-control than children with a morning/intermediate preference (Fig. 2). The effect size (comparing changes in self-control between intervention and control conditions) was larger among children with an evening preference (d = 0.65) than children with a morning/intermediate preference (d = 0.26).

DISCUSSION

To our knowledge, this is the first study to examine the effect of improving sleep on self-control in a racially diverse sample of healthy school-age children. Our findings suggest that habitual short sleep duration and evening chronotype preference are associated with worse self-control and that a brief sleep intervention that effectively enhanced children's sleep duration also led to improvements in caregiver reported self-control. These results add to the growing evidence for the importance of sleep health in children.

Our findings are consistent with previous studies showing an association between sleep duration and self-control in children.[14,15] This association has also been observed in adolescents, young adults, and adults[12,13,16] suggesting that intervening early in development to improve sleep habits could have long-lasting benefits for self-control. Indeed, a longitudinal study examining the relation between behavioral sleep problems and self-regulation in a large, representative cohort found that, across multiple measurements from infancy to 9 years of age, behavioral sleep problems consistently predicted poorer emotion regulation 1 to 2 years later and that poorer emotion regulation predicted subsequent challenges in attention regulation.[14,32] Our findings extend these observational findings and are consistent with experimental studies in children showing that short-term manipulation of sleep (where compliance to fixed sleep schedules is required) alters self-regulation.[33–37] For example, preschoolers randomized to a no-nap condition exhibited less effective self-regulation strategies when completing an unsolvable puzzle compared with those in a nap condition[35] and school-age children randomized to 5 nights of nocturnal sleep extension exhibited improved emotional lability and restless-impulsive behavior scores (assessed via teacher-reported questionnaire) compared with those randomized to the sleep restriction condition.[34] Our study builds on these by demonstrating,

Table 1. Demographic and Baseline Characteristics

	Total, N = 67	Control (n = 34)	Sleep Intervention (n = 33)
Mean (SD) age	9.75 (1.0)	9.85 (1.0)	9.64 (1.0)
N (%) Female	46 (68.7)	25 (73.5)	21 (63.6)
Race[a], n (%)			
White	22 (32.8)	13 (39.4)	9 (27.3)
Black	31 (46.2)	13 (38.2)	18 (54.5)
Other	13 (19.4)	8 (24.2)	5 (15.2)
Mean (SD) baseline	512.8 (39.3)	511.6 (42.0)	514.1 (36.9)
Total sleep time—minutes			
Mean (SD) baseline	31.8 (6.6)	31.8 (7.1)	31.8 (6.1)
Chronotype score			
Mean (SD) baseline	80.6 (30.5)	75.6 (24.2)	85.8 (35.4)
Self-Control Rating Scale Score			

[a]n = 1 (Sleep Intervention group) chose not to report race.

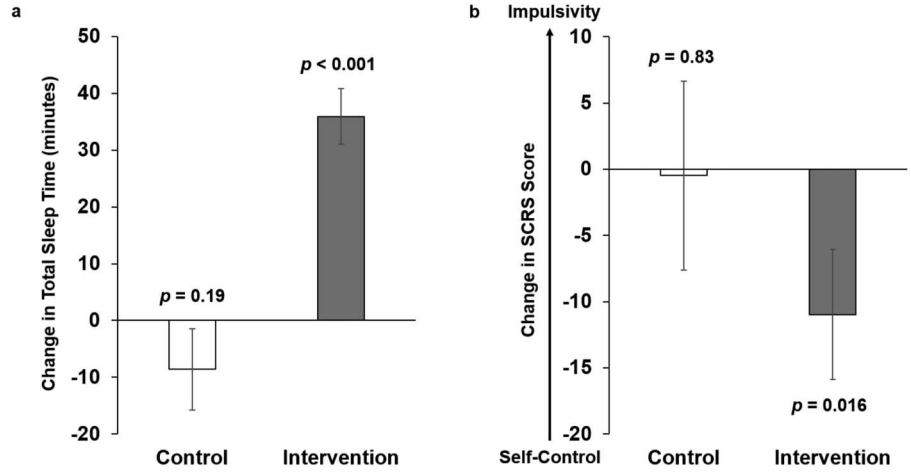

Figure 1. Effect of sleep intervention on sleep duration and self-control. From baseline to the 8-week assessment, children randomized to the sleep intervention exhibited a significant increase in total sleep time (TST) (A) and were perceived as having greater self-control by their caregivers (B) whereas children randomized to the control condition exhibited no change in TST or Self-Control Rating Scale (SCRS) score. Data expressed as mean ± SEM.

in a randomized controlled trial, a positive effect of a brief, at-home, behavioral sleep intervention after 2 months. Future studies are needed to assess how this sleep intervention affects self-control in various contexts (school, home, social settings) and across different domains of self-regulation (emotion, attention) to determine the stability and generalizability of the effect. In addition, studies including follow-up assessments over a longer period of time would elucidate whether there are long-term benefits of the intervention for sleep and self-control.

In addition to sleep duration, emerging evidence suggests that chronotype may also play a role in self-control, with those exhibiting an evening phase preference at risk for lower self-control.[19–21] Potential factors underlying the relationship between chronotype and self-control include sleep duration, in that evening chronotypes are at increased risk for insufficient sleep compared with morning chronotypes. Further late chronotype may affect time perspective in which morning chronotypes display a more future-oriented time perspective associated with less procrastination than evening chronotypes. Owens et al.[19] found that chronotype was a significant independent predictor of self-reported self-regulation among adolescents: Those with an evening preference exhibited significantly lower cognitive, emotional, and behavioral self-regulation subscores compared with those with a morning preference.[38] Consistent with these findings, we observed an association between chronotype and caregiver-reported self-control at baseline and observed that those with an evening preference exhibited significantly lower self-control scores than those with a morning/intermediate preference. In addition, we observed among those children randomized to the sleep intervention condition, a signal for improvements in self-control more marked in evening chronotypes; however, this interaction effect did not reach statistical significance. To our knowledge, this is the first study to compare the impact of a sleep intervention on self-control between chronotype groups. Given that evening types are at increased risk for adverse health behaviors associated with low self-control[22–24,39,40] and that a sleep intervention may affect self-control in evening types, the implementation of sleep interventions among school-age children who are habitual short sleepers may be particularly beneficial in this subgroup. However, future studies are needed to replicate this finding with larger sample sizes that are adequately powered.

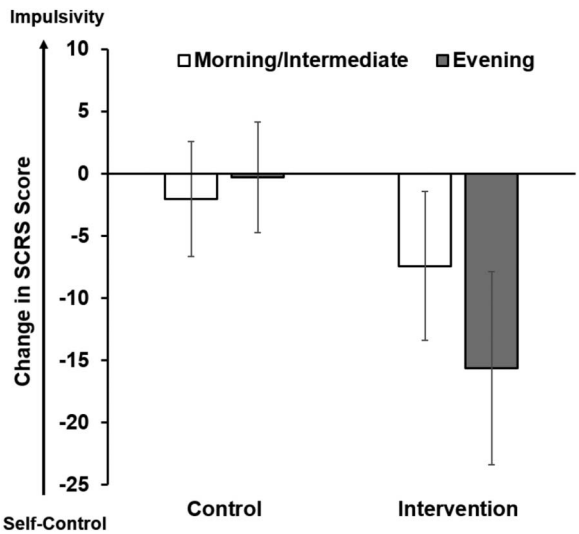

Figure 2. Interaction between chronotype and sleep intervention on self-control. Although the condition*chronotype*time interaction effect was not significant ($p = 0.40$), the effect size (comparing changes in self-control between intervention and control conditions) was larger among children with an evening preference (d = 0.65) than children with a morning/intermediate preference (d = 0.26). Data expressed as mean ± SEM.

Strengths of this study include the diverse sample, high retention across the 8-week study, and implementation of an effective behavioral intervention to enhance children's sleep. Several limitations are evident.

First, the sample was limited to children aged 8 to 11 years who habitually obtained less than 9.5 h sleep and whose families primarily speak English. Further chronotype can shift across the lifespan, with shifts toward Eveningness occurring around puberty.[19] Thus, findings may not generalize to other age groups nor to families whose primary spoken language is not English. Second, self-control was only measured through caregiver report, and there may have been reporter bias because caregivers were not blinded to treatment condition (sleep intervention vs control). Future studies are warranted to examine the impact of sleep interventions on measures of self-control that are blinded to condition (via teacher reports or using objective assessments) and that measure changes in sleep duration and self-control over a longer time scale.

CONCLUSION

Greater self-control in childhood predicts better cognitive, emotional, social, and health outcomes throughout the lifespan; thus, developing ways to improve self-control in children has the potential for a wide variety of long-term benefits. Here we demonstrated that short sleep duration and an evening chronotype preference associate with decreased self-control in school-age children and that a brief intervention to increase sleep duration significantly improved caregiver-rated self-control. These results add to the growing evidence for the importance of sleep health in children and support the need for a better understanding of the psychological factors underlying the relationship between sleep and health outcomes.

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