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Does Increased Consolidated Nighttime Sleep Facilitate Attentional Control? A Pilot Study of Nap Restriction in Preschoolers

Janet C. Lam[1,2], **Taylor A. Koriakin**[1], **Steven M. Scharf**[3], **Thornton B. A. Mason**[4], and **E. Mark Mahone**[1,2]

[1]Kennedy Krieger Institute, Baltimore, MD, USA

[2]Johns Hopkins University School of Medicine, Baltimore, MD, USA

[3]University of Maryland, Baltimore, USA

[4]Children's Hospital of Philadelphia, PA, USA

Abstract

Objective—The aim of this study is to understand the impact of a 5-day period of nap restriction on sleep patterns and cognitive function in typically developing preschoolers, aged 3 to 4 years.

Method—Following 1 week of baseline assessment, 28 children were randomly assigned to either a "napping as usual" group (n = 15) or a 5-day period of nap restriction (n = 13). Sleep was assessed with sleep logs and actigraphy; cognition was assessed at baseline and at the end of the intervention week.

Results—No group differences in sleep or cognitive function were observed at baseline. For the no-nap group, the 5-day period of daytime nap restriction resulted in increased nighttime sleep. Children in the no-nap group also showed a significant improvement in attentional control compared with baseline, whereas no such changes were observed among children in the napping-as-usual group.

Conclusion—In preschool children who typically take naps, short-term nap restriction is associated with increased nighttime sleep and may contribute to improved attentional function.

Keywords

napping; nap restriction; cognitive function; preschoolers; sleep

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Corresponding Author: E. Mark Mahone, Department of Neuropsychology, Kennedy Krieger Institute, 1750 East Fairmount Avenue, Baltimore, MD 21231, USA. mahone@kennedykrieger.org.

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Introduction

There is a national trend in the United States toward reducing or eliminating regular napping opportunities in lieu of increased educational time in early childhood centers (Daniels & Lewin, 2005). In a national survey of the States' Boards of Education, 28% have napping policies for prekindergarten and kindergarten, and three states (Alabama, Arizona, Georgia) actually restrict napping (Daniels & Lewin, 2005). This topic is of great public health importance, given the increasing enrollment in early childhood programs, that is, a 15% increase from 1994 to 2007 in 3- to 4-year-olds, representing the age group with the largest increase in enrollment rates (U.S. Department of Education, 2009).

Despite these recent changes, there are no clear evidence- based guidelines (based on cognitive or behavioral function) that indicate how or when children outgrow the need for naps. It is not known if there is an optimal amount of napping required among preschool children to maximize cognitive and behavioral function in the preacademic setting. This issue of naps in preschool is pressing because learning potential and cognitive development depend on an appropriate degree of alertness. In addition, one of the (presumed) benefits of napping is the memory consolidation that occurs as a function of sleep (Berger, Miller, Seifer, Cares, & LeBourgeois, 2012). However, the majority of published investigations involving napping in preschoolers are observational studies (Lam, Mahone, Mason, & Scharf, 2011; Ward, Gay, Anders, Alkon, & Lee, 2008), and the effects of controlled nap restriction in this age range are less clear.

Among school-age children who have "aged-out" of naps, the quality of nighttime sleep is associated with cognitive efficiency. While it is presumed that an adequate amount of sleep fosters growth and development of the brain (Frank, Issa, & Stryker, 2001), the role of naps in promoting learning and performance in preschoolers is not well understood, and results have been inconsistent. For example, in a recent study of typically developing preschoolers, sleep spindle density during napping was shown to be predictive of recall on a spatial memory task after the nap (Kurdziel, Duclos, & Spencer, 2013). Similarly, Williams and Horst (2014) demonstrated that preschoolers who napped after hearing a story once recalled as many words from the story as children who had heard the story repeatedly but did not nap afterward. Conversely, in a study of younger (30- to 35-month-old) children who were taught a series of artificial words, those who napped after the learning trial had *poorer* retention and generalization than those who stayed awake during the 4-hr period (Werchan & Gomez, 2014), suggesting that the effects of napping may be dependent on the age of the children being studied. In addition, absent from these studies is the examination of the role that napping plays in the facilitation or maintenance of consolidated *nighttime* sleep, which may be even more critical than naps for learning and development in young children.

Thus, the practice of reducing naptime among preschool-age children remains controversial and not data-driven. On one hand, some preschoolers may have outgrown naps and do not require sleep during the day. The need for afternoon naps appears to decline between the ages of 2 and 5 years, at which time the biphasic sleep/wake pattern gives rise to a more consolidated rest period at night (Iglowstein, Jenni, Molinari, & Largo, 2003; Webb & Dinges, 1989; Weissbluth, 1995). Nevertheless, some preschool children continue to have an increased diurnal sleep drive that results in difficulty maintaining wakefulness for a full preschool day. It remains unclear which biological and psychosocial factors determine whether preschool children continue to benefit from naps versus more consolidated nighttime sleep.

During the preschool years, reasoning and problem-solving skills develop in parallel with attentional control (Zelazo, Carter, Reznick, & Frye, 1997). This association between development of attentional control and higher reasoning skills may be due to the parallel nature of maturation within attentional systems and associated catecholamine neurotransmitters in prefrontal, striatal, and associated subcortical systems during the preschool years (Ghuman & Ghuman, 2014). Animal studies have further shown that environmental experiences, such as sleep, can shape the developing brain by influencing cellular development and neurotransmitter regulation (Frank et al., 2001). Sleep is also known to stimulate neuronal development and consolidation. For example, maturational changes in visual development coincide with the periods of heightened cortical plasticity during rapid eye movement (REM) sleep (Marks, Shaffery, Oksenberg, Speciale, & Roffwarg, 1995). It remains unclear, however, if these maturational changes occur during naps or only during nighttime sleep.

In a recent published observational study, researchers examined the relationship between daytime napping and cognitive function in 59 healthy, typically developing preschool children (ages 3–5 years) who were enrolled in full-time child care (Lam, Mahone, Mason, & Scharf, 2011). The study found that children who napped less during weekdays also did not nap on weekends, suggesting that they did not need to “catch up” on sleep. In addition, weekday napping and nighttime sleep were inversely correlated, such that those who napped more during the day slept less at night, while total weekday sleep remained relatively constant. There was also a complex relationship identified between sleep patterns and cognition, such that weekday napping was *negatively* associated with attention span and vocabulary, while weekday nighttime sleep was positively associated with vocabulary. Nighttime sleep was also negatively correlated with impulsivity, such that those who slept less at night made more impulsive errors (commissions) on a computerized go/no-go test. These findings suggested that preschoolers who napped less actually performed better on cognitive tasks—likely as a function of greater consolidated nighttime sleep.

The present investigation represents a pilot study that is an experimental extension of these naturalistic observational findings. The goal of the current study was to examine the effects of a 5-day period of nap restriction on behavior, attentional control, and nighttime sleep among preschool children who typically nap. We hypothesized that, during this trial, nap restriction would facilitate consolidated nighttime sleep, and thereby improve cognitive and behavioral functions in preschoolers.

Method

The study was approved by the Institutional Review Boards of the University of Maryland and Johns Hopkins Medicine.

Participants

Participants were recruited from seven day care centers in the greater Baltimore area. Preschool/day care centers throughout the area were contacted by phone and letters, and asked (a) if they would be interested in taking part in the study and (b) if they had at least one classroom for preschoolers who did not take naps. Those centers that agreed to participate and who had a non-napping classroom were then asked to distribute flyers to parents of 3- and 4- year-old children in their center. Parents of potential participants contacted the study coordinator who conducted a brief telephone screen to rule out developmental and behavioral conditions. Children were included in the study if they were 3 to 4 years of age, typically developing, attended fulltime child care, and who (by parent report) napped daily. Participants were excluded if they had any medical problems/took medications, did not attend day care full-time, did not regularly take naps, had parent report of developmental delays, or received early intervention services.

After the telephone screen but prior to entry into the study, children were screened for developmental delay using the *Peabody Picture Vocabulary Test, Fourth Edition* (PPVT-IV; Dunn & Dunn, 2007). The PPVT-IV is a measure of single-word listening vocabulary and a screening test of verbal ability, as well as an estimate of intellectual functioning. Children were excluded if they scored more than one standard deviation below the mean for age (standard score < 85) so that all the participants were within the normal range of development.

Procedures

Each of the participating child care centers had at least one non-napping classroom that provided quiet midday activities (e.g., books, toys, soft music) for children who did not regularly nap. The napping classrooms were not modified by the study and were observed to have minimal ambient light and no overhead lights. Participants were monitored for naps via actigraphy during a 1-week baseline period in their regular classrooms. Following baseline, children were randomly assigned either to a 5-day period of typical nap opportunity in the regular classroom (“napping as usual”) or to a nap restriction group in one of the non-napping classrooms during their regular nap times (see Table 1). For those in the nap restriction group, parents were asked to try to keep their child awake while driving home but were allowed to let the child go to bed earlier if needed. Specifically, during the car rides to and from day care, parents were instructed to try to keep their child awake by talking or having their child engage in activities. Otherwise, the child was allowed to increase nighttime sleep as needed to provide a minimum of 11 hr at night, given that current recommendations are that preschoolers need 11 to 13 hr of sleep (Mindell & Owens, 2003). Assessment of cognitive skills was made at the end of the baseline week and again at the end of the intervention week.

Sleep Assessment

Assessments of participants’ sleep patterns were completed by parent log and actigraphy.

Sleep logs—Parents were instructed to maintain sleep logs for the duration of the study. When the child was in day care, day care workers monitored nap times and reported information regarding the child's nap to parents at the end of the day. Afternoon nap times were recorded before bedtime. Bedtime, sleep latency, awakenings, and sleep end time were recorded the following morning. Sleep onset time was calculated by adding sleep latency to the bedtime.

Actigraphy—Actigraphy monitoring was performed on participants through a noninvasive wristwatch (i.e., Actiwatch 2, Respironics, Inc.). This monitoring provided an objective measure of rest periods and was performed during the same time period that the sleep logs were being completed. The watches were worn for 2 weeks (i.e., Monday to Monday) on the nondominant wrist. Sleep/wake cycles were scored with the Respironics software program (version 2.6). Sleep epochs were determined based on the Sadeh algorithm (de Souza et al., 2003; Sadeh, Sharkey, & Carskadon, 1994). If there were prolonged periods of inactivity during normal awake times, parent logs were reviewed for notations indicating that the watch may have been removed from the child. Nighttime awakenings were scored if the awakening lasted 5 min or more. Actigraphy variables used in analyses included: napping sleep onset and offset, napping duration, nighttime sleep onset and offset, duration of nighttime sleep, total weekday daytime napping, total daytime weekend napping, total weekday nighttime sleep, and total weekend nighttime sleep.

Definitions of sleep phases—Nighttime sleep was defined as sleep between 6:00 p.m. and 9:00 a.m. Napping was defined by any discrete period of sleep between 9:00 a.m. and 6:00 p.m., separated from morning sleep end time by at least 1 hr. These times were based on day care hours, which were typically 8:00 a.m. to 5:00 p.m. Weekday sleep was defined as sleep on Monday through Friday, whereas weekend sleep was on Saturday and Sunday.

Brief Neuropsychological Assessment

Participants completed a brief neuropsychological assessment protocol emphasizing attention, short-term memory, response inhibition, and motor persistence at 2 time points (i.e., Friday during baseline week and Friday of intervention week). As shown in Table 1, testing was performed at a consistent time (4:00 p.m.) throughout the study. Data from Time Points 1 (baseline) and 2 (Friday of intervention week) were analyzed for the present study. The protocol emphasized areas of functioning (i.e., attention, inhibitory control, motor persistence) that have been shown to be sensitive to changes in sleep patterns and was designed to be completed in a brief 15-min assessment setting. The tests administered were as follows: (a) *Number Recall* (Kaufman Assessment Battery for Children, Second Edition [KABC-II]; Kaufman & Kaufman, 2004), which is a measure of auditory attention/verbal span; (b) *Hand Movements* (KABC-II), a measure of visual short-term memory and motor control in which sequences of three hand movements (palm, fist, side) are presented and the child is asked to reproduce progressively longer sequences; (c) *Statue* (A Developmental Neuropsychological Assessment—Second Edition [NEPSY-II]; Korkman, Kirk, & Kemp, 2007), a measure of inhibition and motor persistence in which the child is asked to maintain a body position with eyes closed during a 75-s period and to inhibit the impulse to respond to sound distracters; and (d) the *Auditory Continuous Performance Test for Preschoolers* (ACPT-P; Mahone, Pillion, & Hiemenz, 2001), a computerized, auditory go/no-go task, designed to assess sustained attention and inhibitory control, which has been shown to be sensitive to reduced nighttime sleep in preschoolers (Lam et al., 2011).

Data Analyses

Group comparisons (napping vs. no-napping) were made at baseline for demographic and screening measures using one-way ANOVAs (for continuous measures) or chi-square tests (for categorical measures). Group comparisons were made at baseline and again at the end of the intervention week with one-way ANOVA, using all available data at each time point for parent logs, actigraphy, and neuropsychological measures. Repeated-measures ANOVAs were also used to examine change between baseline and intervention week for sleep logs, actigraphy, and neuropsychological measures. Repeated-measures analyses included only data from children who had usable scores at both time points. Significance level was set at $p < .05$.

Results

Participants

A total of 28 children were enrolled into the study after parental consent. Of these, 15 were randomized to the napping-as-usual group and 13 were randomized to have nap restriction during the intervention week. There were equal numbers of boys and girls enrolled in the study, with 6 girls assigned to the napping group and 8 girls assigned to the no-nap group. Mean age of the sample was 49.4 months (±9.6). There were no significant differences in age, $F(1, 26) = 0.28$, $p = .60$, or sex distribution, $\chi^2(1) = 1.29$, $p = .23$, in the napping and no-nap groups. At baseline, there were also no significant group differences in estimates of intellectual functioning (PPVT-4), $F(1, 26) = 0.04$, $p = .84$.

Actigraphy data were not available for the intervention week for four children in the nap restriction group due to equipment failure ($n = 3$) and loss of the actigraphy watch during the second week ($n = 1$). As such, repeated-measures analyses for the actigraphy data included only those participants in the nap restriction group with data from both baseline and intervention week ($n = 9$). Likewise, parent log data were not available for one child in the nap restriction group. As a result, that child’s data could not be included in the analysis.

Sleep Assessments

Sleep logs—Parent and day care provider report of children’s sleep duration based on sleep logs is outlined in Table 2. At baseline, there were no significant group differences in any of the sleep variables (weekday daytime and nighttime sleep, weekend daytime and nighttime sleep, total weekly daytime and nighttime sleep), all *p*s > .60. Conversely, at the end of the intervention week, there were significant group differences (based on sleep logs) for mean daytime sleep on weekends, $F(1, 25) = 11.56$, $p = .02$, $\eta_p^2 = .32$, such that children in the no-nap group exhibited less sleep. As demonstrated in Table 2, average daytime sleep was significantly decreased in the no-nap group compared with the nap group at the end of the intervention week, $F(1, 24) = 7.04$, $p = .014$, $\eta_p^2 = .22$. At the end of the intervention week, however, there remained no significant differences between groups in average nighttime sleep during the week or on weekends, or for total daytime or nighttime sleep for the entire week (all *p*s > .29).

Repeated-measures ANOVAs were used to examine change in parent-reported sleep patterns from baseline to the end of the intervention week. Compared with baseline, children in the no-nap group were observed to nap, on average, 54 min less per day on weekdays during the intervention week, which represents a significant decrease, $F(1, 11) = 7.36$, $p = .02$, $\eta_p^2 = .40$. At the same time, children in the no-nap group were reported to sleep an average of 28 min longer per night on weekdays during the nap restriction period. The findings suggest that, by parent and day care provider report, the nap restriction intervention was generally successful in most children for most days, and, across the sample, resulted in a slight increase in average nighttime sleep during the restriction week, compared with baseline, and compared with children in the napping-as-usual group.

Actigraphy—Sleep duration based on actigraphy recordings is outlined in Table 3. At baseline, there were no significant group differences in any of the sleep variables (weekday daytime and nighttime sleep; weekend daytime and nighttime sleep; total weekly daytime and nighttime sleep), all *p*s > .10. At the end of the intervention week, there were significant group differences (based on actigraphy) for mean daytime sleep on weekdays, $F(1, 21) = 50.89$, $p < .0001$, $\eta_p^2 = .71$, and mean total (weekday + weekend) daytime sleep, $F(1, 22) = 35.11$, $p < .0001$, $\eta_p^2 = .62$—in both cases, children in the no-nap group exhibited less sleep. In addition, at the end of the intervention week, there were significant differences between groups in average nighttime sleep during the week, $F(1, 21) = 4.14$, $p = .05$, $\eta_p^2 = .17$, and for the total week (weekday + weekend), $F(1, 21) = 4.26$, $p = .05$, $\eta_p^2 = .17$—in both cases, children in the no-nap group exhibited more nighttime sleep than those in the napping group. Based on mean actigraphy scores, children in the no-nap group slept an average of 59 min more per night during the week and 55 min more per night across the whole week, when compared with children in the nappingas-usual group. In both groups, children slept more during the day on weekdays (compared with weekends) during both weeks. During the baseline week, the no-nap group slept an average of 78 min on weekdays (compared with 50 min on weekends), whereas the napping-as-usual group slept 95.3 min on weekdays (compared with 54.9 min on weekends). Likewise, during the intervention week, the no-nap group slept 18 min during weekdays and 9.8 min during weekends. The napping-as-usual group slept 96.7 min during weekdays and 46.1 min during weekends.

Repeated-measures ANOVAs revealed that, compared with baseline, children in the no-nap group napped, on average, 68 min less per day on weekdays during the intervention week, which represents a significant decrease, $F(1, 7) = 18.3$, $p = .004$, $\eta_p^2 = .72$]. At the same time, children in the no-nap group were observed (by actigraphy) to sleep an average of 26 min longer per night on weekdays during the nap restriction period. These actigraphy findings also suggest that the nap restriction intervention was generally successful in most children, and led to a slight increase in average nighttime sleep during the restriction week, compared with baseline, and a large increase, compared with children who napped as usual.

Neurobehavioral assessment—Results of the neurobehavioral assessment protocol are outlined in Table 4. At baseline, there were no significant group differences in any of the neuropsychological variables (ACPT-P, Number Recall, Hand Movements, Statue). Similarly, at the end of the intervention week, there were also no significant group differences in any of the neurocognitive measures.

Repeated-measures ANOVAs were used to examine change in neuropsychological function from baseline to the end of the intervention week for the napping and no-nap groups. Within the napping-as-usual group, none of the measures showed a significant change from baseline to intervention week. Conversely, children in the no-nap group showed a significant improvement from baseline following a week of nap restriction on a measure of sustained attention, that is, reduction in ACPT-P omission errors, $F(1, 11) = 5.4$, $p = .04$, $\eta_p^2 = .33$, and a strong trend (with large effect size) for improved performance on an auditory short-term memory test (Number Recall), $F(1, 12) = 3.78$, $p = .07$, $\eta_p^2 = .24$.

Discussion

The observed sleep patterns and cognitive outcomes of this pilot study of a 5-day period of nap restriction protocol are generally consistent with the findings from prior observational studies (Lam et al., 2011) and suggest that preschool children tend to maintain an overall total amount of sleep, but may proportion their sleep differently between day and night. Those children who napped less tended to consolidate their nighttime sleep. Conversely, those who napped more tended to sleep less at night, and divided their overall sleep into daytime and nighttime sessions. In this study, there is some preliminary evidence that children in this age group can adapt to shifting toward a consolidated nighttime sleep schedule, although these findings need to be replicated in a larger sample and under more controlled conditions. The shift from biphasic to consolidated nighttime sleep is what occurs naturally as children mature, and the present results raise the question of whether this shift can be made at an earlier age without decrements in cognitive performance.

It is also of note that there may be carryover effects of weekday nap restriction that extend into the weekend. That is, children who had naps reduced during the weekdays in the intervention week tended to nap less on the following weekend. This finding may indicate that nap restriction did not lead to sleep deprivation requiring “make up” sleep on the weekends (typically seen when children are not receiving adequate rest during the weekdays). A related finding was that children tended to nap longer on weekdays at day care than at home on the weekends. This observation may be due to a variety of factors, including parental choice and the presence of other children in the home who may reduce the nap opportunity. Longer term monitoring of sleep/wake cycles would be needed to determine whether this was a permanent change versus a transient one over the following weekend. Additional testing after the intervention would also be required to demonstrate whether the change had a lasting positive or negative effect on cognitive outcomes.

The results of cognitive assessment following the 5-day period of nap restriction suggest that nap restriction may facilitate consolidated nighttime sleep, which in turn may lead to facilitation of some cognitive functions during the day. Children who missed their naps (and also slept more at night) tended to perform better on a measure of attentional control—ACPT-P Omissions—following the week of nap restriction. Their performance on auditory recall (Number Recall) also improved slightly, and with large effect size, suggesting that in larger samples the effect may become statistically significant. Conversely, there was no significant change in performance on the measures of visual short-term memory and motor persistence. This pattern of findings provides some preliminary evidence that the potential adverse effects of nap restriction on attention may be attenuated by the concomitant presence of nights with increased sleep. Thus, in *some* preschool children who are beginning to make the shift from biphasic sleep to consolidated nighttime sleep, the pattern of consolidated nighttime sleep may be preferred for facilitation of attention-related tasks, perhaps reflecting the beneficial effects of consolidated sleep on long-term potentiation in cortical systems supporting attentional control (Aton et al., 2009). The challenge for future research is to determine which children in this age range may benefit from interventions to facilitate consolidated nighttime sleep (e.g., whether the benefits are age- or sex-dependent or determined by other maturational factors).

The shift from biphasic sleep to consolidated nighttime sleep occurs in parallel with changes in brain development that support attentional control. Between ages 3 and 6 years, peak growth rates of the anterior corpus callosum and frontal cortex (important for motor, attention, and general cognitive functioning) have been noted (Zelazo et al., 1997). Maturation of chronobiological mechanisms may also play a role in the timing of spontaneous nap cessation (Doi, Ishihara, & Uchiyama, 2013), such that spontaneous cessation of napping may serve as a developmental milestone of brain maturation. Interpretation of this shift in preschoolers is challenging, as changes in nap habits may be attributed to other factors such as cultural or parental choice (Mindell & Owens, 2003; Sadeh et al., 1994), or personality factors such as temperament (Kohyama, Shiiki, Ohinata-Sugimoto, & Hasegawa, 2002). Either way, the findings suggest that consolidated nighttime sleep may be more critical than daytime napping for the facilitation of daytime attentional control in preschoolers. Our preliminary findings mirror those from animal studies which demonstrated that if total daily sleep is stable, then sleep fragmentation during the day is not associated with adverse effects in consolidation of new learning (Rolls et al., 2011). In the present sample, those who napped less did not appear to be sleep-deprived if they compensated with increased nighttime sleep. Furthermore, if the total amount of sleep (daytime + nighttime) remains relatively consistent, certain cognitive functions may be facilitated.

Overall, the findings from the present investigation provide some initial support for our hypotheses and highlight the dynamic relationships between napping, nighttime sleep, and cognitive function in preschoolers. Nevertheless, the results should be considered in light of several important limitations. First, the sample size was relatively small. A larger sample size may have increased consistency and provided more significant differences between the groups on neuropsychological testing measures. Another limiting factor was the occasional malfunction and reduced battery life of the watches, which resulted in the loss of some actigraphy data. In addition, while the nap restriction protocol was generally well followed in the day care settings, there were some violations of the protocol, such that some of the children in the no-nap group had brief periods of daytime sleep on some days. This finding highlights the challenge inherent when attempting to manipulate patterns of napping in naturalistic settings and calls for continued studies of daytime napping in more controlled settings. Another factor that may limit the generalizability of the findings is the overall limited parental interest in participation due to concerns about the effects of nap restriction on their children. Finally, given the design of this pilot study, neither parents nor examiners were blind to experimental study condition, which may have affected the pattern of results. Future controlled studies of nap manipulation should assess these outcomes using blinded raters and examiners.

Future work in this area should include larger samples with more frequent assessment to assess the day-to-day changes associated with the manipulated shift from biphasic to consolidated nighttime sleep. Frequent testing is a challenge in this age group, given the brief attention span and limited types of testing which have been validated for this age. One area of cognition that was not evaluated in this study is how naps or lack of naps affect the ability to learn and remember new tasks or information presented earlier that day. Another important area of investigation is to identify objective signs and symptoms which indicate when a child is able to consolidate nighttime sleep and does not need a daytime nap. For example, neurobiological mechanisms (e.g., sleep spindle density, neurochemical changes) may be affected by the shift from biphasic to consolidated nighttime sleep and could be measured and evaluated for their influence on cognitive and behavioral development in young children. Finally, the results of this study apply to typically developing children. A future direction in this line of research would be to investigate how this shift occurs or differs in children with neurodevelopmental conditions (e.g., ADHD, autism).

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Biographies

Janet C. Lam, MD, MHS, is an assistant professor of neurology at the Johns Hopkins School of Medicine and a physician in the Department of Neurology and Developmental Medicine at the Kennedy Krieger Institute. She is also a diplomate of the American Board of Psychiatry and Neurology.

Taylor A. Koriakin, BA, is a research assistant in the Department of Neuropsychology at the Kennedy Krieger Institute.

Steven M. Scharf, MD, PhD, is a professor of medicine and director of the Sleep Disorders Center at the University of Maryland.

Thornton B. A. Mason, MD, PhD, is an assistant professor of clinical neurology and pediatrics and director of the Sleep Core at the Children's Hospital of Philadelphia.

E. Mark Mahone, PhD, is board certified in clinical neuropsychology by the American Board of Professional Psychology and a licensed psychologist in Maryland. He is the president of the American Academy of Clinical Neuropsychology. He is a professor of psychiatry at the Johns Hopkins School of Medicine and director of the Department of Neuropsychology at the Kennedy Krieger Institute.

Table 1

Study Flow.

	Week 1—Baseline		Week 2—Randomization		Week 3
Screening	**(Monday-Sunday) nap as usual**		**(Monday-Friday) nap restrict or nap opportunity (Saturday-Sunday) nap as usual**		**Conclude study**
- Napping status - Medical problems - PPVT-IV	*Monday* - Start actigraphy monitoring - Start sleep logs	*Friday* - Neuropsychological testing (T1) at 4:00 p.m. - Download actigraphy data	*Monday* - Nap restrict or nap as usual	*Friday* - Neuropsychological testing (T2) at 4:00 p.m.	*Monday* - Download actigraphy data - Collect sleep logs

Note. PPVT-IV = *Peabody Picture Vocabulary Test, Fourth Edition.*

Table 2

Sleep Log Data.

	Baseline week						Intervention week					
	No nap (n = 12)		Nap (n = 15)		Baseline week between-group comparison		No nap (n = 12)		Nap (n = 15)		Intervention week between-group comparison	
Reported sleep duration (minutes)	***M***	***SD***	***M***	***SD***	***p***	η_p^2	***M***	***SD***	***M***	***SD***	***p***	η_p^2
Average weekday daytime sleep	71.0	41.2	63.4	48.4	.67	.008	17.0	35.6	51.6	35.0	.06	.131
Average weekday nighttime sleep	551.4	56.7	549.3	35.2	.91	.001	579.5	61.3	544.7	98.3	.29	.044
Average weekend daytime sleep	49.1	38.0	56.7	37.9	.61	.011	14.6	29.5	56.2	33.1	.02	.316
Average weekend nighttime sleep	580.1	60.1	573.1	82.9	.81	.002	568.3	111.5	582.5	96.8	.73	.005
Average total daytime sleep	67.8	33.0	61.5	31.0	.80	.002	16.3	33.4	51.6	35.0	.01	.220
Average total nighttime sleep	559.9	46.1	556.1	35.0	.80	.003	576.3	58.9	555.4	84.7	.48	.020

Table 3

Actigraphy Data.

	Baseline week						Intervention week					
	No nap (n = 13)		Nap (n = 15)		Baseline week between-group comparison		No nap (n = 9)		Nap (n = 15)		Intervention week between-group comparison	
Sleep duration via actigraphy (minutes)	***M***	***SD***	***M***	***SD***	***p***	η_p^2	***M***	***SD***	***M***	***SD***	***p***	η_p^2
Average weekday daytime sleep	78.0	29.7	95.3	24.6	.11	.099	18.0	21.7	96.7	28.0	.001	.708
Average weekday nighttime sleep	533.3	45.2	516.6	36.9	.29	.042	550.0	63.5	491.0	70.4	.05	.165
Average weekend daytime sleep	50.3	72.8	54.9	105.1	.91	.001	9.8	17.3	46.1	35.1	.02	.289
Average weekend nighttime sleep	534.7	32.9	522.5	98.2	.73	.006	566.6	28.7	529.2	67.7	.16	.106
Average daytime sleep	67.7	30.0	84.1	30.9	.17	.071	15.5	15.3	82.6	19.7	.001	.615
Average nighttime sleep	536.8	38.1	518.6	40.8	.24	.054	553.9	45.5	499.4	70.0	.05	.169

Table 4

Neuropsychological Assessments.

Neuropsychological measure	Baseline week						Intervention week					
	No nap (n = 13)		Nap (n = 15)		Baseline week group comparison		No nap (n = 13)		Nap (n = 15)		Intervention week group comparison	
	M	*SD*	*M*	*SD*	*p*	η_p^2	*M*	*SD*	*M*	*SD*	*p*	η_p^2
ACPT-P Mean RT (ms)[a]	1,620.7	1,014.1	1,333.3	751.3	.43	.028	1,396.2	699.4	1,469.8	1,038.1	.84	.002
ACPT-P Variability[a]	0.3	0.4	0.4	0.4	.66	.009	0.3	0.3	0.40	0.43	.60	.012
ACPT-P Omissions[a]	4.3	4.4	3.2	4.5	.57	.014	1.5	3.1	1.6	3.8	.94	.000
ACPT-P Commissions[a]	6.1	16.3	1.0	1.0	.27	.052	4.4	13.8	1.2	2.0	.42	.029
KABC-II Number Recall (raw score)	8.1	2.3	7.8	2.2	.74	.004	8.9	2.6	8.2	2.3	.49	.018
KABC-II Hand Movements (raw score)	5.1	2.7	3.8	2.3	.28	.077	4.0	3.2	5.4	1.3	.23	.093
NEPSY-II Statue (raw score)	16.6	8.4	21.7	6.1	.07	.118	16.8	9.9	20.3	7.6	.30	.041

Note. ACPT-P = Auditory Continuous Performance Test for Preschoolers; RT = reaction time; KABC-II = Kaufman Assessment Battery for Children, Second Edition; NEPSY II = A Developmental Neuropsychological Assessment—Second Edition.

[a]Lower scores indicate better performance.