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Sleep and behavior of preschool children under typical and nap-promoted conditions

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ABSTRACT

Background: Children transition out of naps in early childhood. However, there is disagreement about when this transition should occur.
Aims: We compared measures of sleep and behavior in children divided into *Frequent, Sometimes, and Rarely* nappers to determine what factors predict when napping should cease. We then examined the effect of an experimenter-promoted nap on measures of sleep and behavior.
Methods: We studied 133 children (50.4% female; mean = 52.77 months) over 16 days. Parents completed questionnaires, whereas children wore actigraphs. On 1 study day, children were nap-promoted.
Results: Overnight sleep duration was significantly less for children who napped frequently than those who rarely napped, yet total 24-hour sleep and other sleep parameters did not differ across napping groups. Effortful control was marginally greater in those who rarely napped. Nap promotion was 91% successful across nap groups. When typical sleep was compared with sleep following a promoted nap, frequent nappers slept more on the nap-promoted night. Total 24-hour sleep increased in all children following the promoted nap, and other sleep parameters did not differ between groups.
Conclusions: The emergence of self-regulatory behaviors may predict when children should cease napping, consistent with the hypothesis that transitioning out of naps may be related to brain maturation. Given previously reported benefits of sleep on cognition and the observed increase in 24-hour sleep following nap promotion, nap promotion may benefit early education. Further research should explore maturational cues that illuminate when children are ready to transition out of napping.

Introduction

A number of recent studies support the benefit of naps on learning and emotional regulation in preschool children. For instance, we have reported that declarative memories are consolidated over naps, with recall of learning from the morning ~10% greater following a nap compared with when children stay awake during naptime.[1] Likewise, children are less biased toward emotional stimuli following a nap,[2] and emotional regulation is greater following a nap compared with nap deprivation.[3,4] Moreover, naps at this age are rich in sleep spindles and slow wave sleep,[1] which are features of sleep associated with cognitive benefits in children[1,2] and young adults.[5–8]

Given these benefits, naps may promote the goals of early education settings. However, this raises the perennial question of when a child "grows out" of napping. Nap duration decreases around 3-4 years of age,[9–11] which coincides with the commencement of more adult-like sleep architecture.[12,13] The transition from biphasic (2 sleep bouts/day) to monophasic (1 sleep bout/day) sleep patterns has been suggested to reflect brain maturation.[14] Consistent with this, memory decay over wake is slower in those who do not nap habitually compared with habitually napping children,[1] suggesting more efficient processing or capacity. Brain development may also contribute to the maturation of homeostatic processes, thereby slowing the accumulation of sleep pressure.[15]

Although assessing brain maturation remains out of reach for parents and classroom teachers, behaviors may indicate the transition to monophasic sleep. For example, delayed nap onset may provide indication that the child has outgrown napping.[16] Furthermore, infrequent naps were associated with the emergence of effortful control (EC) and more "adult-like" cortisol patterns in 3-year-old children,

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which could reflect brain maturation.[17] Habitual daytime napping in early childhood may also be responsible for immature cortisol level patterns.[18] Alternatively, Ward and colleagues[19] suggest that the length of overnight sleep duration dictates nap habits, with sleep <10 hours as an indicator of nap need. More recently, a review by Thorpe and colleagues[20] suggested that a specific age (2 years) may be a marker of when naps become costly, reducing overnight sleep.

It is important to systematically examine what factors influence whether children nap habitually. In the current study, we examined whether typical overnight sleep is greater for non–habitually napping children compared with those who nap habitually or frequently as suggested by others.[19,20] In addition, we assessed whether there were differences in other sleep parameters (eg, sleep efficiency, sleep latency) for non–habitually napping children compared with habitual or frequent nappers, which would support the hypothesis that naps are detrimental to overnight sleep.[20]

Second, to elucidate biological factors that predict the cessation of napping, we examined behavioral measures that reflect brain maturation. Nonhabitual nappers, for example, may exhibit higher EC,[17] lower bedtime resistance,[16] and higher IQ,[14] all of which have been suggested to reflect maturation of cognitive and homeostatic processes, thus reducing the need for a nap.[14,15]

Finally, to evaluate the consequences or benefits of a nap on overnight sleep, we compared the child's sleep parameters following classroom nap promotion with their typical overnight sleep patterns. Although there may be reductions in overnight sleep after napping (eg,[20]), total sleep duration within a 24-hour period may not change.[19,21] Conversely, the lack of change in total 24-hour sleep duration between napping children and nonnapping children could reflect maturational changes in homeostatic processes, which dictate how quickly sleep pressure accumulates, thereby resulting in the need for a nap.[15]

Methods

Participants

Participants were 137 children with ≥5 days of usable actigraphy data (68 female; mean = 52.77 months; SD = 10.02) recruited from local preschools in western Massachusetts as part of a larger study of sleep and cognition. Children were eligible to participate if they met the following criteria: (*a*) aged 33-71 months; (*b*) normal or corrected-to-normal vision and hearing; (*c*) no current or past diagnosis of a sleep disorder or developmental disability;(*d*) not using sleep-effecting or psychotropic medications; and (*e*) had not traveled outside of local time zone in the week before the study.

Measures

Actigraphy

The Actiwatch Spectrum (Philips Respironics, Bend, OR) is a water-resistant, wrist-worn device with off-wrist detection and triaxial accelerometer to measure motion. Data collected by the actigraph were stored in the internal memory of the device and subsequently downloaded to a computer for analysis.

Child sleep diaries

To aid in actigraphy scoring, caregivers were given a daily sleep diary to record any nap periods in the home, periods where the watch was taken off, time the child was in bed, time it took the child to fall asleep, and wake time. Classroom teachers were given a nap diary for each participating child and instructed to make note of whether children napped or not in the classroom during the 16-day study window.

Child Sleep Habits Questionnaire

The Child Sleep Habits Questionnaire (CSHQ)[22] was used to provide a subjective measure of children's sleep habits during a typical week. Of interest to the current study were items pertaining to bedtime resistance, specifically "Child resists going to bed at bedtime," "Child struggles at bedtime," and "Child falls asleep within 20 minutes after going to bed." Caregivers rated items on a 3-point scale: *Usually* (5-7 days per week), *Sometimes* (2-4 days per week), and *Rarely* (0-1 days per week). The CSHQ is a reliable measure of sleep problems in community and clinical samples (Cronbach's alpha = 0.68 and 0.78, respectively; Owens et al., 2000) and has established clinical utility in preschool children.[23]

Peabody Picture Vocabulary Test, 4th Edition

The Peabody Picture Vocabulary Test, 4th Edition (PPVT-IV),[24] is a proxy for IQ in children that is thought to be reflective of brain maturation.[14,25] The PPVT-IV is a norm-referenced scale that evaluates vocabulary acquisition by measuring understanding of a spoken word in standard American English. Children were presented with 4 full-color pictures on a page and asked to point to the picture that represents a particular word spoken by the experimenter. The PPVT-IV consists of 228 test items divided into 19 test sets. Children progressed through each set until committing a certain number of errors. Raw score totals were used for analyses.

Child Behavior Questionnaire

The Child Behavior Questionnaire (CBQ)[26] was used to assess temperament on 3 broad scales. We used an abbreviated form of the CBQ (ie, CBQ–Very Short Form) comprised of 36 items. Of interest in this study, items probing EC included: "When drawing or coloring in a book shows strong concentration"; "Notices it when parents are wearing new clothing"; and "Approaches places s/he has be told are dangerous slowly and cautiously." The EC scale has been shown to correspond with the development of executive functions, such as inhibitory control and sustained attention (eg, go/no-go tasks) in children.[27–29] For each question, caregivers rated the likelihood of behaviors occurring within the past 6 months on a 7-point Likert ranging from 1 (*Extremely Not True*) to 7 (*Extremely True*). Caregivers rated items that did not apply to their child as *Not Applicable*, and these items were not included when calculating the child's score for EC. The CBQ–Very Short Form subscale for EC is significantly correlated with that reported by the full CBQ ($r = 0.83$; see Putnam and Rothbart[26]). Raw scores for the EC scale were used for analyses.

Procedure

Procedures were approved by the University of Massachusetts Amherst's Institutional Review Board. Caregivers provided written informed consent for their own and their child's participation, and child assent was obtained before procedures commenced. On day 1, actigraphs were distributed to participating children. The actigraph was fitted to the nondominant wrist, and caregivers and children were instructed to press a button (an event marker) at the start and end of daytime and nighttime sleep opportunities. Caregivers were asked to encourage their child to wear the actigraph continuously for the subsequent 16 days (15 nights). At the same time, questionnaires and diaries were given to parents to complete at any point during the study. Teachers completed nap diaries for the weekdays that children were in the classroom, which were used to corroborate actigraphy-recorded weekday naps.

On 1 of the 16 days, children were nap-promoted during the classroom nap opportunity (approximately 1-3 PM). Children were encouraged to nap through verbal encouragement ("Today is nap day. Try to sleep.") and typical classroom sleep promotion techniques (eg, back and foot rubbing). Children laid on their mats/cots, and the room lighting was dimmed. Experimenters noted whether each child fell asleep and the time of nap and wake onset. The week in which children were nap-promoted was counterbalanced to avoid order effects related to when the study experimenters administered the nap manipulation. Nap-promotion day typically occurred in the middle of the week to avoid shifts in sleep schedule due to the weekend.[19]

Children were given the PPVT-IV in a quiet part of the classroom on 1 visit during the 16 days. Children were tested individually. After going through the practice set of items, children went through the test sets until reaching a predetermined error rate (see Dunn and Dunn[24]). On day 16, actigraphs and completed questionnaires and diaries were collected. Caregivers received monetary compensation for completing questionnaires, and children received an age-appropriate book for their participation.

Data analysis

Actigraphy data were scored for sleep or wake in 15-second epochs using the Actiware software (Philips Respironics, Bend, OR) default algorithm. This algorithm was applied to portions of the record identified as sleep through a combination of sleep diaries and event markers. In the absence of diaries or event markers, *sleep onset* was defined as the first of 3 consecutive minutes of sleep, and *wake onset* was the last of 5 consecutive minutes of sleep.[3,30,31] Sleep episodes were excluded if sleep onset or offset was identified as off-wrist.

Sleep episodes were calculated for both daytime and nighttime intervals, and all sleep variables described below were derived from these episodes. For each sleep variable, an average was calculated excluding data from the days where the child's nap was experimentally promoted. Sleep behavior on the days that children were nap-promoted were examined separately. Sleep variables for analysis included: (*a*) daytime sleep duration: total minutes scored as sleep between daytime sleep onset and wake time; (*b*) nighttime sleep duration: total minutes scored as sleep between nighttime sleep onset and wake time; (*c*) wake after nighttime sleep onset (WASO): total minutes identified as wake by Actiware algorithm during a sleep interval; (*d*) sleep onset time: time of night that the child falls asleep; (*e*) variability in sleep onset time: standard deviation of nighttime sleep onset; (*f*) wake onset time: time of day that the child woke up from overnight sleep; (*g*) variability in wake onset time: standard deviation of wake onset following nighttime sleep; (*h*) sleep onset latency: difference in time (minutes) between the beginning of the nighttime rest period and the beginning of the nighttime sleep period; (*i*) variability in sleep onset latency: standard deviation of sleep onset latency; (*j*) % sleep efficiency (quality of sleep): (total minutes scored as sleep − WASO)/total minutes scored as rest; and (*k*) nap frequency: number of naps per week/weekend. Nap frequency was calculated for both weekdays and weekends. *Weekdays* were defined as Monday through Friday, whereas *weeknights* were defined as Monday through Thursday (Friday nights were considered part of the weekend).

Nap habituality was classified according to actigraph-recorded nap frequency. Given our interest in overnight sleep following successful nap promotion, we excluded data from 61 of the initial 198 participants for whom actigraphy data were not available for the nap promotion day, leaving usable data for 137 children. A further 4 participants were excluded from age-controlled analyses because of missing age data, resulting in usable data from 133 children. For remaining participants, nap opportunities (days for which actigraphy data were available during the typical nap time [1 PM-4 PM]; off-wrist data excluded) on nonexperimental days were summed. The percentage of these days for which a nap was identified in the actigraphy data was calculated, and a percentage of days with a nap to days where a nap opportunity was present was computed. Those who napped >70% of available days (≥5 nap days per week) are considered *Frequent nappers*. We chose this cut-off because many children nap habitually when given time and space (preschool) but often lack naps on weekends. Those who napped 15%-70% of available days were classified as *Sometimes nappers*. Those that napped <15% (≤1 nap day per week) were classified as *Rarely nappers*.

Although children and caregivers were encouraged to keep the Actiwatch on as much as possible over the 16-day interval, the mean number of days of actigraphy in the 137 qualifying children was 13.13 days. The number of usable days of actigraphy did, however, differ across groups. Specifically, *Frequent nappers* (mean days = 11.03) had significantly fewer useable actigraphy days than both the *Sometimes nappers* (mean days = 13.62; $t[40.07] = -5.23$, $P < .001$) and *Rarely nappers* (mean days = 14.93; $t[44.72] = -4.08$, $P < .001$). *Sometimes nappers* also had significantly fewer usable actigraphy days than *Rarely nappers* ($t[102] = -2.37$, $P = .02$).

All statistical analyses were performed in SPSS Version 20.0 (SPSS Inc, Chicago, IL). Analyses controlled for age.

Results

Group demographics

Descriptive data for the 3 groups are presented in Table 1. Although the *Sometimes* and *Rarely napping* groups did not differ in age, *Frequent nappers* were significantly younger than *Sometimes* and *Rarely napping* children. For this reason, analyses controlled for age.

Does typical sleep vary as a function of nap habituality?

We examined whether typical sleep time and qualities varied as a function of nap frequency. Typical nap length (experimental days and nap length = 0 excluded) differed significantly across groups (main effect of group: $F_{2,120} = 3.19$, $P = .045$, $\eta^2 = .050$), with *Frequent nappers* napping longer than *Rarely nappers* ($P = .029$, 95% confidence interval [CI] = 3.04-53.08; Table 2). Average overnight sleep duration also differed significantly between the groups ($F_{2,129} = 5.89$, $P = .004$, $\eta^2 = .084$; Table 2). Specifically, children who *Rarely napped* slept longer than children who *Frequently napped* ($P = .02$, 95% CI = −65.52 to −5.83) and marginally more than *Sometimes nappers* ($P = .055$, 95% CI = −44.11 to .51). In contrast, there were no group differences in other sleep parameters including: % sleep efficiency ($F_{2,129} = .350$, $P = .705$); WASO ($F_{2,129} = 1.02$, $P = .364$; Table 2); wake onset time ($F_{2,129} = 1.198$, $P = .305$; Table 3); variability in wake onset ($F_{2,129} = .204$, $P = .815$); sleep onset time (main effect of group: $F_{2,129} = 2.73$, $P = .07$); variability in sleep onset (main effect of group: $F_{2,129} = 1.483$, $P = .231$); sleep onset latency ($F_{2,129} = .394$, $P = .675$); or variability in sleep onset latency ($F_{2,127} = 1.302$, $P = .276$). Despite differences in overnight sleep duration, there were no significant differences across groups for total 24-hour sleep time ($F_{2,129} = 2.01$, $P = .138$; Table 2).

Table 1
Descriptive data for the full sample and groups based on nap frequency.

	N	Sex, F:M	Age, mo (SD)
All	133	67:66	52.77 (10.02)
Nap frequency			
Frequent	32	18:14	48.56* (10.83)
Sometimes	88	46:42	53.55* (9.55)
Rarely	13	3:10	57.85* (7.76)

* *Frequent* < *Sometimes*, $P = .016$; *Frequent* < *Rarely*, $P = .008$.

Table 2
Descriptive data for typical and nap-promoted sleep variables related to duration and quality.

	Nap time (min)		Overnight sleep time (min)		% Sleep efficiency		WASO (min)		24-h sleep time (min)	
	Typical	Nap-promoted	Typical	Nap-promoted	Typical	Nap-promoted	Typical	Nap-promoted	Typical	Nap-promoted
All	92.55 (24.06)	94.33 (26.28)	565.76 (40.02)	560.71 (54.00)	87.91 (3.86)	87.68 (5.57)	56.68 (19.72)	57.45 (28.43)	608.79[a] (39.39)	649.04[a] (57.40)
Nap frequency										
Frequent	99.37[†○] (20.42)	100.67 (27.53)	553.09[*] (43.07)	568.19 (50.28)	87.91 (3.67)	87.48 (6.69)	56.39 (16.60)	62.57 (36.37)	623.64[○b] (45.16)	659.42[b] (60.86)
Sometimes	90.71[†] (24.14)	92.91 (25.80)	566.97[†a] (35.91)	555.57[a] (54.91)	87.99 (4.00)	87.72 (5.10)	55.97 (20.57)	55.51 (24.48)	606.10[○b] (33.95)	647.42[◆b] (53.99)
Rarely	80.08[○] (47.01)	74.50 (15.79)	588.77[*†b] (49.63)	577.10[b] (55.27)	87.35 (3.55)	87.90 (6.10)	62.24 (21.48)	58.00 (32.10)	590.46[○b] (49.38)	634.46[◆b] (70.71)

† *Frequent* > *Sometimes*, $P < .10$; *Sometimes* < *Rarely*, $P < .10$.
* *Frequent* < *Rarely*, $P < .05$.
○ *Frequent* > *Sometimes*, $P < .05$; *Frequent* > *Rarely*, $P < .05$; *Frequent* > *Rarely*, $P < .05$.
◆ *Rarely* > *Sometimes*, $P = .002$; *Rarely* > *Frequently*, $P < .001$.
a Typical < nap-promoted, $P < .001$.
b Typical < nap-promoted, $P < .07$.

Do correlates of brain maturation vary as a function of nap habituality?

Of interest was whether measures posited to reflect brain maturation (ie, EC, IQ, and bedtime resistance) differed between nap groups. With regard to EC, there was a small difference in the level of EC exhibited across nap groups, which was marginal ($F_{2,118} = 2.923$, $P = .058$, $\eta^2 = .047$), with children who *Rarely napped* exhibiting greater EC than *Frequent nappers* ($P = .034$, 95% CI $= -1.24$ to $-.05$) and marginally more than *Sometimes nappers* ($P = .054$, 95% CI $= -.67$ to $-.01$; Table 4). Conversely, IQ—as measured by the PPVT—did not differ between nap groups ($F_{2,122} = 1.125$, $P = .328$; Table 4).

Finally, we compared responses to questions on the CSHQ that would reflect bedtime resistance. The main effect of nap group was not significant for responses to questions "Child resists going to bed at bedtime," "Child struggles at bedtime," or "Child falls asleep within 20 minutes after going to bed" (*P*s > .80; Table 4).

Does nap promotion differentially alter sleep as a function of nap habituality?

Nap promotion was successful overall (91% napped when nap promoted). However, nap promotion success rate was greater for *Frequent nappers* (100% success) than for *Sometimes* (92%) and *Rarely* (73%) nappers ($F_{2,180} = 5.40$, $P = .005$, $\eta^2 = .057$).

When nap-promoted nap length did not differ from typical nap length ($F_{2,115} = .19$, $P = .83$; Table 2). Overnight sleep did differ from typical overnight sleep duration when nap-promoted ($F_{2,129} = 4.90$, $P = .009$, $\eta^2 = .071$; Table 2), with *Sometimes nappers* sleeping significant less the night following nap promotion ($P = .009$, 95% CI = 2.92-19.88) and *Rarely nappers* sleeping marginally more on the nap-promotion day ($P = .068$, 95% CI $= -31.39$ to 1.20). Yet, there were no differences between a typical night and the nap-promoted night for other sleep measures including % sleep efficiency ($F_{2,129} = .280$, $P = .756$; Table 2), WASO ($F_{2,129} = 1.03$, $P = .360$), wake onset ($F_{2,129} = 1.89$, $P = .155$; Table 3), and sleep onset latency ($F_{2,129} = .132$, $P = .877$). Differences in sleep onset time were marginal ($F_{2,129} = 3.08$, $P = .05$, $\eta^2 = .046$), with *Frequent nappers* going to sleep 21 minutes earlier on the nap-promoted day ($P = .013$, 95% CI = .08-.62). Finally, when 24-hour sleep time for the nap-promoted day was compared with 24-hour sleep time on a typical day, there was no significant difference between nap groups ($F_{2,129} = .164$, $P = .849$; Table 2). Importantly, overall, children got significantly more total sleep on the day they were nap-promoted compared with a typical day ($t[132] = 9.43$, $P < .001$, 95% CI = 31.81-48.69) regardless of nap group (Table 2).

Discussion

When a child is ready to cease napping is a controversial topic. Although there is evidence that naps benefit learning and memory[1] and promote emotion regulation[2,3] in preschoolers, recent studies suggest that naps may negatively impact overnight sleep.[19,20] Therefore, the main goal of the current study was to investigate factors that might predict when children should stop napping by comparing sleep characteristics and behavioral outcomes of habitual and nonhabitual nappers. The current study further examined the impact of naps on overnight sleep quality by experimentally manipulating daytime naps and comparing subsequent overnight sleep with typical sleep patterns. Our results suggest that, although typical overnight sleep did differ between nap habituality groups, with *Rarely napping* children sleeping more than children who *Frequently napped*, there was no difference in total sleep across the 24-hour day. These findings are consistent with previous research, which suggests that short overnight sleep durations are associated with longer naps[30]

Table 3
Descriptive data for typical and nap-promoted sleep variables related to overnight sleep and wake onset.

	Sleep onset time		Wake onset time		Variability in sleep onset time (min)	Variability in wake onset (min)	Sleep onset latency (min)		Variability in sleep onset latency (min)
	Typical	Nap-promoted	Typical	Nap-promoted	Typical	Typical	Typical	Nap-promoted	Typical
All	9:39 (61.06)	9:35 (59.67)	7:08[c] (43.59)	6:56[c] (46.63)	50.04 (51.55)	38.95 (19.15)	8.26 (10.12)	9.43 (16.42)	10.67 (11.37)
Nap frequency	[a]								
Frequent	9:47[b] (60.00)	9:26[b] (61.61)	7:00 (44.40)	6:54 (48.71)	43.31 (20.66)	37.72 (24.39)	7.65 (12.04)	7.05 (16.13)	8.28 (11.40)
Sometimes	9:41 (59.40)	9:40 (58.59)	7:12[c] (40.8)	6:56[c] (43.67)	55.07 (61.24)	39.68 (18.04)	8.77 (10.06)	10.54 (16.85)	11.79 (11.88)
Rarely	9:09 (70.64)	9:19 (61.39)	6:58 (58.41)	6:56 (62.86)	32.53 (17.05)	37.03 (11.16)	6.37 (3.30)	7.83 (14.51)	9.20 (6.18)

Standard deviations reported in minutes.
[a] Main effect of group, $P = .05$.
[b] Post hoc paired t test typical < nap-promoted, $P < .05$.
[c] Typical > nap-promoted, $P < .001$.

and that napping may be a compensatory mechanism for insufficient sleep.[19] However, in the current study, there was no difference between *Rarely napping* children and *Frequent* and *Sometimes nappers* in other sleep measures. This suggests that although children who nap may sleep less during the night, the overall quality of overnight sleep is not impacted and total sleep time is preserved regardless of nap habituality.

It has been proposed that the consolidation of sleep from a biphasic to a monophasic pattern in early childhood may reflect differences in sleep homeostatic control.[15] Because of maturational brain changes, younger children may accumulate sleep pressure more quickly during the day compared with older children, resulting in an increasing need for daytime naps. As children age, homeostatic sleep pressure may accumulate more slowly, thereby allowing children to sustain longer periods of wakefulness, which would result in fewer daytime naps and an eventual transition to a consolidated sleep-wake pattern. Although directly measuring brain maturation remains challenging, evidence using behavioral and neurocognitive correlates of brain maturation supports this hypothesis. Specifically, Lam et al[14] showed a negative correlation between vocabulary performance (as measured by the PPVT) and daytime napping in preschool children, whereas vocabulary performance was positively correlated with nighttime sleep duration. Moreover, nap and nighttime sleep duration were negatively correlated, suggesting that improvements in cognitive performance that correspond to the cessation of napping may reflect a developmental milestone in brain maturation. However, PPVT performance did not differ across nap groups in the present study possibly because of differences in methods and groups. This suggests that IQ may not be an appropriate proxy for brain maturation with respect to the monophasic transition.

Behavioral changes linked to brain maturation also include changes in temperament, specifically the ability to regulate one's responses to external stimuli (ie, EC).[32] In the current study, we examined whether there were differences in EC across nap habituality groups and found a marginal difference—specifically that children who *Rarely napped* exhibited significantly more EC than *Frequent nappers* and marginally more than *Sometimes nappers*. Similarly, previous research found that the emergence of EC correlated with a reduction in napping behavior in 3-year-old children.[18] Moreover, the increase in EC and decrease in napping were associated with more "adult-like" decreases in cortisol levels from mid-morning to mid-afternoon. This, in turn, corresponded with the development of self-regulatory behaviors. Therefore, the observed differences in EC between nap habituality groups may reflect underlying brain development. However, as the difference observed in EC between nap habitually groups was marginal, this interpretation should be approached with caution.

We also examined whether bedtime resistance was more prevalent in those who rarely napped. Decreased resistance of bedtime may reflect maturation leading to EC or increased sleep pressure at bedtime. However, markers of bedtime resistance as measured by the CSHQ did not differ across nap habitually groups. We posit that bedtime resistance may emerge from a combination of factors such as reduced sleep pressure[15,33] and/or behavioral phenotypes.[34] Moreover, recent evidence[35] suggests that bedtime resistance may emerge because of a dissonance between parent-selected bedtimes and the child's circadian physiology. In addition, this dissonance may actually be greatest in children who habitually nap.[36] Thus, the relationship between nap habitually and bedtime resistance warrants additional research.

Children are deemed to transition to monophasic sleep when they no longer nap during naptime. We considered whether rarely napping children would nap when nap-promoted and the effect of this nap on subsequent sleep. If children have transitioned out of biphasic sleep to the extent that a nap disrupts overnight sleep as recently suggested in a review by Thorpe and colleagues,[20] then children who no longer nap should exhibit shorter and potentially less efficient nighttime sleep following a nap. However, there were only 2 differences observed between the nap-promoted night and typical nights for any of the actigraphy-based sleep measures: nighttime sleep, which decreased on the nap-promoted day for *Sometimes nappers* and marginally increased for *Frequent nappers*, and total sleep time, which increased on the nap-promoted days for all groups. The lack of any detrimental effects of napping was observed

Table 4
Descriptive data for measures related to brain maturation.

	CBQ-EC		PPVT		Child resists going to bed at bedtime		Child struggles at bedtime		Child falls asleep within 20 min	
	n	Mean	*n*	Mean	*n*	Mean	*n*	Mean	*N*	Mean
All	123	5.01 (.80)	126	84.53 (26.92)	119	2.41 (.61)	116	2.63 (.63)	122	1.53 (.67)
Nap frequency										
Frequent	29	4.72* (.92)	30	78.47 (26.45)	26	2.50 (.51)	25	2.60 (.71)	28	1.36 (.62)
Sometimes	81	5.06* (.73)	83	84.24 (26.23)	80	2.38 (.64)	78	2.59 (.63)	81	1.62 (.68)
Rarely	13	5.37* (.79)	13	100.38 (28.07)	13	2.46 (.66)	13	2.92 (.28)	13	1.31 (.63)

* *Rarely* > *Sometimes*, $P = .054$; *Rarely* > *Frequent*, $P = .034$.

regardless of nap habituality. Taken together, these results suggest that not all children who cease to nap have fully matured into an adult-like pattern of consolidated sleep. Indeed, previous research has observed variability in the transition to monophasic sleep, with some children continuing to nap until early school age.[10,37] It has also been demonstrated that environmental factors can influence when children stop napping. For example, parent discouragement of napping behavior has been shown to lead to a reduction in naps in preschool-aged children, regardless of whether or not the child is ready to cease napping.[21] In fact, it has been shown that the majority of young children will nap if given the opportunity to do so.[11,19]

Importantly, the hypothesis that naps may be detrimental at a certain point in early childhood[20] is based on the assumption that nighttime sleep is more important than daytime sleep. This assumption contradicts both behavioral evidence demonstrating cognitive benefits of naps in children[1–3] and physiological evidence indicating that early childhood naps are rich in slow wave sleep and sleep spindles,[1,2] which have also been shown to benefit cognition in children and adults.[1,2,4–7] Furthermore, the studies reviewed by Thorpe and colleagues[20] varied in terms of design, sample size, nap duration, and timing, which may confound interpretations regarding the effects of naps on overnight sleep. Given the limitations of previous work and the observed increase in 24-hour total sleep following nap promotion across nap habituality groups in the current study, it may be premature to set rigid cut-offs for when children should transition out of napping.

Despite the numerous strengths of the current study, it was not without limitations. One caveat is that we were unable to assess differences in daytime sleepiness between the nap habituality groups. The hypothesis that the transition from biphasic sleep to monophasic sleep posits that as children age out of napping, homeostatic sleep pressure accumulates more slowly, thereby reducing the need for a nap.[15] As a result, daytime sleepiness measures might provide additional evidence to support a brain maturation account for transitioning out naps. In addition, although the current study examines the effects of a single experimenter-promoted nap on subsequent sleep, we were unable to assess the effects of nap promotion beyond the nap-promotion day. Future studies should extend the current study's paradigm to measure the effects of a prolonged nap-promotion intervention. The current study was also unable to measure brain maturation directly and instead relied on indirect behavioral and cognitive measures. Future research should use neuroimaging techniques, such as structural magnetic resonance imaging, to assess whether developmental changes in brain structure correlate with changes in daytime napping.

Conclusions

Overall, the results of the current study demonstrate that naps do not negatively impact overnight sleep as suggested by previous research (eg, Thorpe et al[20]). Instead, our results suggest that promoting sleep in preschool classrooms may, in fact, increase total 24-hour sleep time. These results, in addition to recently reported cognitive[1] and self-regulatory emotional[3] benefits of naps, can guide policies around napping for early education settings. First, naps, both typical and promoted, were 60-90 minutes in length. Although not reported here, nap sleep onset latency is typically around 20 minutes. This suggests that a nap opportunity of 2 hours should be provided. Second, in spite of habitual nap patterns, nap promotion was highly successful. Thus, early education programs should consider whether staff can aid in promoting sleep in the classroom.

Under nap-promoted conditions, a minority of children may not nap, likely reflecting maturation of neural resources that reduce accumulation of sleep pressure. Future research is essential to aid in the identification of this critical point.

Disclosure

All authors have no disclosures to report.

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