Published in final edited form as:
Behav Sleep Med. 2014 November 2; 12(6): 507–516. doi:10.1080/15402002.2013.838765.

Changes in Sleep Duration, Timing, and Quality as Children Transition to Kindergarten

Alyssa Cairns and
Pulmonary Disease and Critical Care, Assoc, The Center for Sleep Disorders, 10710 Charter Drive, Columbia, MD 21044

John Harsh
The University of Southern Mississippi, Psychology, 118 College Drive, Hattiesburg, MS 39406

Alyssa Cairns: acairns@pulmdocs.com

Abstract

Sleep can be seen as a biologically driven behavior shaped by cultural context. A “poor fit” occurs when contextual demands for the timing and duration sleep periods are incompatible with the underlying biology. Such contextual factors are well-known for adults, yet little is known of the contextual factors that shape young children’s sleep health and to what degree such factors impact sleep duration, timing, and quality. This study attempted to identify how the transition to kindergarten was associatedwith changes in sleep timing, duration, and quality for children enrolled in preschool prior to attending kindergarten vs. those who were not. Wrist actigraphy in 38 5-yearold children was collected at three longitudinal points before and after the start of kindergarten. Our data suggested that the transition to kindergarten was associated with a reduction in weekday sleep (mostly due to lost napping) and an advance in the weekday nocturnal sleep period that was most pronounced for children not enrolled in preschool prior to kindergarten. These sleep changes paralleled objective and caregiver-reported data of increased sleep pressure that lasted well into the first month of kindergarten.

INTRODUCTION

Sleep can be seen as a “biologically driven behavior” shaped by cultural context (Jenni & O’Connor, 2005). Goodness of fit is a concept that refers to how well an individual’s biologically-preferred sleep-wake schedule matches with the social/cultural context. A “poor fit” occurs when contextual demands for the timing of wake and sleep periods are incompatible with the individual’s sleep biology. In adults, major contextual factors that challenge sleep/wake scheduling include work demands, family obligations, and lifestyle choices. Poor sleep health, defined as too little, poor quality, and/or poorly timed sleep, is common among adults (Colten & Altevogt, 2006) and has consistently been associated with cognitive, behavioral, emotional, and metabolic decrements (Banks & Dinges, 2007; Boivin, Tremblay, & James, 2007).

Poor sleep health is also common in childhood (Smaldone, Honig, & Byrne, 2007) and is associated with both short-term and long-term developmentally important consequences including behavioral and emotional dysregulation (Dahl, 1996), inattention and hyperactivity (Owens, 2009) poor academic performance (Fallone, Acebo, Seifer, & Carskadon, 2005), and poor physical health including overweight and obesity (Chen, Beydoun, & Wang, 2008). Sleep in children is known to be determined by a complex interplay of intrinsic factors such as chronotype and temperament (Atkinson, Vetere, & Grayson, 1995; Russo, Bruni, Lucidi, Ferri, & Violani, 2007) and extrinsic factors such as parental style, culture, routines (Owens, 2004). At least short-term changes in sleep health may accompany age- and development-related transitions in contextual factors such as moving out of the parental bed and giving up daytime sleep (Sadeh, Raviv, & Gruber, 2000). The significance of changing contextual factors however, has not been heavily investigated.

The transition to kindergarten may be a contextual event that challenges children's ability to maintain good sleep health. Early school start times are known to result in unfavorable sleep/wake patterns among adolescents (Carskadon, Wolfson, Acebo, Tzischinsky, & Seifer, 1998). This may be the case for children as well (Zhang, Li, Fok, & Wing, 2010). Early school start times may require earlier rise times and result in inadequate sleep if parents aren't able to successfully advance bedtimes. Also, restricted nap opportunities in kindergarten (Trejos, 2004) could result in lost sleep for children accustomed to daytime sleep (naps). The purpose of the present study is to examine changes in the timing, duration, and quality of sleep in young children as they transition to kindergarten. The sleep of 5-year-old children was recorded by actigraphy and sleep diary at 3 intervals: prior to the start of kindergarten (summer), within 14 days after the start of kindergarten, and one month after the start of kindergarten. As attending a preschool program may affect sleep timing, children were grouped by whether they were attending a preschool/daycare program prior to kindergarten. The data reported here were collected as a part of a larger investigation of sleep, diet, and waking cortisol changes across the transition to kindergarten.

METHODS

Sleep data for this paper were derived from 24-hour wrist worn actigraphy over three longitudinal assessments as children transitioned to kindergarten. Each longitudinal assessment contained up to 7, 24-hour periods of actigraphy data. Caregiver reported sleep diaries were used to establish actigraph sleep start and end times, but diary data are not reported here. The USM Institutional Review Board for the protection of human subjects approved of all procedures prior to the initiation of this study. Caregivers provided informed consent before being scheduled for the first assessment. Families were given a gift certificate to a local eatery upon completion of each assessment. At the completion of the study, each family was rewarded with a $50.00 money order.

Participants

Caregivers of 5-year-old children scheduled to attend kindergarten for the first time were recruited from various sites in the community (e.g. preschools, daycares, community events, churches, etc.). Children were excluded if they co-slept or reported any sleep, major medical, or developmental disorder. A total of 38 children were enrolled. All were 5-years of age at the start of data collection. Four children were excluded for failure to complete all three longitudinal assessments. The final sample of 34 children consisted of 19 males and 15 females (62% White; 32% Black). One child was identified as Latino and another was identified as American Indian. One child had a history of controlled asthma. Fourteen children were enrolled in an all-day preschool/daycare program during the summer prior to the start of kindergarten (hereafter referred to as “Pre-School group”) and 20 were in the care of a primary or secondary caregiver (hereafter referred to as “No Pre-School group”).

Procedures

Caregivers and children who met inclusion criteria were scheduled for three 7-day assessments. The first assessment (Summer) was completed approximately 2 to 3 weeks prior to the beginning of kindergarten. The second (K1) and third (K2) assessments were within two weeks and after one month of the start of kindergarten, respectively. At each assessment (Summer, K1, and K2), caregivers and children visited The University of Southern Mississippi (USM) Sleep Laboratory at which point they were given a tutorial on how to use and care for the actigraph and on how to complete the 7-day sleep diary. Caregivers were instructed to have their child follow their typical daily routine for each 7-day assessment. At the end of each longitudinal assessment, actigraph data were downloaded, printed, and cross-checked on a day-by-day basis with caregiver sleep diaries and teacher nap diaries.

Measures

Sleep/Wake Diary—During each 7-day assessment interval, caregivers were instructed to keep a daily sleep/wake diary recording bed and wake times for nocturnal sleep period along with the times the actigraph was removed and reattached. Co-sleeping or atypical occurrences (nightmares, illness, long car trips, etc.) were also recorded. Diary entries for naps included nap start time and end time as well as location (bed, cot, vehicle, etc.). On days when children were attending preschool/daycare or kindergarten, nap start and end times and atypical events were logged on a separate nap diary by teachers.

Actigraphy—Actigraphs are small movement detectors used to estimate sleep under naturalistic conditions (Acebo and LeBourgeois, 2006). In the current study, we used AW64 Actigraphs (Actiwatch 64™; Mini-Mitter Philips Respironics, Bend, OR, USA), which have a weight of 16 g, sensitivity to .01g, and a sampling rate of 32 Hz. The devices were worn on the child’s non-dominant wrist and were programmed to collect data in 1-minute epochs with a sensitivity setting of 40 (medium). Data were scored using the Actiware v.5.0 algorithm, which processes epoch-by-epoch activity counts within a moving 2-minute window (Weiss, Johnson, Berger, & Redline, 2010). Compared to videosonography in young children, the algorithm has shown high epoch-by-epoch agreement (94%), sensitivity for detecting sleep (97%), but less accuracy in estimating wake after sleep onset (specificity = 24%; Sitnick, Goodlin-Jones, & Anders, 2008).

The actiware algorithm was applied to portions of the record identified as sleep using standard procedures for establishing the start and end of the sleep period via a combination of diary reports and event markers (Acebo et al., 2005; Berger, Miller, Seifer, Cares, & LeBourgeois, 2012). Specifically, the start of each sleep period (sleep onset) was found by scrolling ahead in time from the diary-indicated bedtime and corresponding event marker until the algorithm detected 3 consecutive epochs of sleep. The first of these three epochs was marked as sleep onset. This method with the AW64 unit in young children has shown adequate sensitivity for detecting sleep onset compared to PSG (r = .87; Craven, Seifer, & Lebourgeois, 2012). Likewise, the end of the sleep period (wake-up time) was found by scrolling back in time from the diary-indicated wake-up time and corresponding event marker until the algorithm detected 5 consecutive epochs of sleep. The last of the 5^{th} epoch was marked as wake-up time. In total, indices of interest included sleep onset and offset, sleep period duration, and sleep efficiency. Sleep period duration (hereafter called 'sleep duration') refers to the duration of the interval from sleep onset to wake-up time. Sleep efficiency refers to the percent of the sleep period scored as asleep (% sleep).

Sleep periods were excluded if diary-reported bed and wake times were ≥ 30 minutes discrepant from that visually displayed on the actogram when the caregiver did not have an explanation for such discrepancy (ex 'difficulty falling asleep, etc.). Sleep periods were also excluded if the caregiver reported any illness or sleep disturbance or if the child was reported to co-sleep or sleep in a vehicle for any duration of the sleep period. On average, 17% of sleep periods were excluded for the aforementioned reasons.

Napping—Identical procedures were used for determining nap periods as for nocturnal periods. Actigraphic nap periods were set based on the caregiver/teacher diary reports of nap start time and end time and corresponding actigraph event markers. Nap periods were excluded if the start or end times were > 15 minutes discrepant from that visually displayed on the actogram or if the child napped in a moving vehicle, or was ill. Measures included nap frequency (count) and duration. On average, 19% of nap periods were excluded for the reasons listed above.

Sleep Quality

Sleep quality was assessed with the Children's Sleep-Wake Scale (CSWS), a 26-item pencil-and-paper research instrument that measures children's sleep quality in 2- to 12-year-olds. Five behavioral dimensions are assessed: Going to Bed, Falling Asleep, Maintaining Sleep, Reinitiating Sleep, and Returning to Wakefulness. Parents report how frequently during the past month their child exhibited different sleep-related behaviors using a six-point response set (always, frequently-if not always, often, sometimes, not often, never). CSWS subscale scores and the total sleep quality scale (average of subscales) range from 1 (poor sleep quality) to 6 (good sleep quality). Psychometric assessment showed high internal consistency reliability for the CSWS subscales and total scale (α = 0.81 to α = 0.91), high test-retest reliability (r=.67 to r=.84; all ps<.001), moderate-to-strong correlations between CSWS subscale scores and corresponding parental diary ratings (r=.58 to r=.72; all ps<.001), and weak-to-moderate correlations between CSWS subscales and actigraphic measures (r=.38 to r=.61; all ps<.001). Thus, the CSWS had adequate reliability and validity for research instruments. (Lebourgeois, 2003).

DATA ANALYSIS

Following exploratory analysis of the data, outliers (scores ≥ 3 standard deviations from the mean) were replaced with the next closest score (1.8% of data). Group (Pre-School, No Pre-

School) by Assessment (Summer, K1, K2) mixed model ANOVAs were used to assess changes in sleep period timing, duration, and quality. Significant Group by Assessment interaction effects were followed-up with independent samples T-tests. Separate analyses were used for weekday and weekend nap data as actigraphic data were available for fewer weekend days. Analysis of sleep parameters focused on weekday sleep. The significance level for all comparisons was set at $\alpha = .05$.

RESULTS

The Summer Assessment

Children averaged 593.0 min (9 hrs and 53min) of total sleep on weekdays and 583.2 min (9 hrs and 43 min) on weekend days. Total daily sleep duration was unrelated to preschool attendance, race, gender, and napping. Weekday naps were recorded for 23 (67.8%) of the children and weekend naps for 12 (35.3%) of the children. Mean nap duration was 78.3 min (range 20.0 min to 150.5 min) with nap length unrelated to day of the week, preschool attendance, race, or gender.

Children in the Pre-School group and No Pre-School group differed in how their sleep was distributed on weekdays. The groups were equally likely to be taking 1 or more weekday naps however, children in the Pre-School group napped on more weekdays (3.6 ± 1.1vs. 1.8 ± 1.1 per 5 weekdays), $T(22) = 4.33$ $p < .001$. Additionally, nocturnal sleep onset (see Table 1) was 62 min earlier for the Pre-School group vs. the No Pre-School group (21:34 vs. 22:36), $T(32) = 3.0$, $p = .01$, and wake-up times 72 min earlier (06:49 vs. 08:01), $T(32) = 5.0$, $p < .001$. No differences were found on weekends.

The Kindergarten Transition

The transition to kindergarten was associated with changes in both the distribution and the amount of sleep. Weekday (but not weekend) nap duration dropped from 82.0 min ± 24.2 to 34.2 ± 30.5 and 41.9 min ± 22.4 at K1 and K2, $F(2,55) = 20.46$, $p < .001$, $\eta^2 = .436$. On weekdays, the number of children taking 1 or more naps did not significantly change however, the number of weekdays with a nap for children in the Pre-School group dropped from 3.6 ± 1.1 weekdays in the summer to 2.7 ± 1.4 weekdays at K1, $T(13) = 3.4$, $p = .005$. The number of weekday naps for the Pre-School and No Pre-School groups did not differ at either K1 or K2. No weekend napping changes were detected.

Primarily due to the reduction in weekday nap durations, total weekday sleep duration (nocturnal and diurnal) declined following the start of kindergarten. Figure 1 presents box plots showing the distribution of total weekday sleep duration before and after the start of kindergarten. Notably, at the Summer assessment, close to half (47.0%) of the children were sleeping ≥10 hours on weekdays with only 2 (5.9%) of the children sleeping < 9 hours. Following the start of kindergarten, the percentage of children sleeping ≥10 hours was reduced from 47.0% to 5.9% and 11.8% at K1 and K2, respectively. The percentage of children sleeping less than 9 hours was increased from 5.9% to 29.4% and 23.5% at K1 and K2, respectively. No changes in weekend sleep duration were detected.

Figure 2 illustrates that children in both the Pre-School and No Pre-School group experienced a kindergarten-related advance in the weekday nocturnal sleep period. The advance was notably greater for the Pre-School group. As can be seen Table 1, weekday sleep onset for the No Pre-School group advanced 68 minutes ($p<.001$) and 77 minutes ($p<.001$) at K1 and K2, respectively; whereas, the advance for the Pre-School group was only 35 minutes ($p = .001$) and 29 minutes ($p = .04$), respectively. Weekday wake-up times for the No Pre-School group were earlier by 84 minutes ($p <.001$) and 78 minutes ($p <.001$) at K1 and K2 compared to 34 minutes ($P<.001$) and 27 minutes ($p = .002$) for the Pre-School group. Weekend sleep onset times advanced comparably for both groups by approximately 30 min (22:33, 21:59, 21:56 at Summer, K1, and K2, respectively), $F(2,64) = 6.9$, $p < .01$, $\eta^2 = .18$. Weekend wake-up times advanced by approximately 25 min (07:49, 07:23, 07:26 at Summer, K1, and K2, respectively), $F(2,64) = 4.4$, $p < .05$, $\eta^2 = .12$.

Changes were found in indices of sleep quality with the transition to kindergarten. Actigraphically-assessed weekday nocturnal sleep efficiency was increased for both groups of children as they transitioned to kindergarten (Table 1). Behavioral indicators of sleep quality also changed. Based on the CSWS, after the start of kindergarten, caregivers rated their children as having less difficulty going to bed, $F(2,42) = 5.8$, $p = .006$, $\eta^2 = .22$ and falling asleep $F(2,42) = 3.9$, $p = .03$, $\eta^2 = .16$. Ratings of returning to wakefulness in the morning did not change across assessments for children in the Pre-School group. However children in the No Pre-School group were rated as having more difficulty returning to wakefulness after the start of kindergarten as compared to the Summer assessment, $F(2,42) = 6.3$, $p = .004$, $\eta^2 = .23$.

CONCLUSIONS

To the best of our knowledge, this is the first study to investigate sleep/wake patterns in 5-year-old children as they transitioned to kindergarten. These data suggest that the transition to kindergarten may challenge the sleep/wake system in that children lost weekday sleep once kindergarten started. This was mostly due to loss of time spent napping. The nocturnal sleep period advanced with the start of kindergarten, especially on weekdays, and especially for children not enrolled in a preschool/daycare prior to kindergarten. These sleep changes paralleled objective and caregiver-reported data of increased sleep pressure that lasted well into the first month of kindergarten.

The Summer Assessment

This sample of 5-year-old children can be estimated to have been getting an average of about 10 hours of sleep over 24-hours during the Summer assessment which is at the low end of the recommended amount of sleep for five year olds (Meltzer & Mindell, 2006). This is consistent with other reports of sleep patterns in young children in this age group (Acebo et al., 2005). The majority of children were still taking naps during the summer assessment, which is similar to reports by Crosby et al. (2005) and Ward et al. (2007). As in other reports (Acebo et al., 2005), more time spent napping was associated with less nocturnal sleep. Nap sleep in this age group appears to reduce the homeostatic drive for sleep at night.

It would appear from these data that preschool/daycare attendance can be a contextual determinant of how five year-olds distribute their sleep. The finding that children enrolled in an all-day preschool/daycare program napped more than those who not enrolled in a preschool/daycare program was not surprising given that the preschool/daycares in this study typically allotted between 60 to 90 minutes per day for scheduled napping. It is probable that the family demands associated with getting children to their preschool/daycare programs relatively early in the morning explains the relatively much earlier wake up times and sleep onset times.

Transition to Kindergarten

The loss of 30 to 40 min or more of weekday sleep time associated with the start of kindergarten is a concern as the children in this sample were on average, barely getting the minimum recommended amount of recommended sleep time before kindergarten. Although it unknown how this loss of sleep time impacted actual daytime function, they did exhibit signs of increased sleep pressure (increased sleep efficiency and improved behavioral sleep quality) that persisted into the first month of kindergarten. While further data are needed, evidence of sleep loss by children starting kindergarten is a call to attention for teachers and caregivers alike as it may contribute to inattention and/or hyperactivity (Dahl, 1996), performance decrements (Santhi, Horowitz, Duffy, & Czeisler, 2007), and changes in metabolic and endocrine function (Scheer, Hilton, Mantzoros, & Shea, 2009). Mounting research is beginning to suggest that short sleep is an independent risk factor for overweight and obesity, especially in young children (Chen et al., 2008). It is notable in this regard that attending kindergarten was associated with a marked decrease in the number of children sleeping more than 10 hours and a marked increase in the number of children sleeping less than 9 hours on weekdays. Further research is warranted on the long-term developmental trajectories that might be altered in association with sleep restriction and/or abrupt changes in sleep schedules during childhood (Fukuda & Asaoka, 2004).

The behavioral and physiological significance of a sudden nocturnal phase advance at the start of kindergarten is unknown. Among the children in this study, children waking as late as 8:30 a.m. before kindergarten were required to wake as much as 3 hours earlier (5:30 a.m.) to be ready for an early school bus. Children likely vary in how quickly and successfully they adjust to sudden changes in their weekday schedules and poor adjustment may have negative psychosocial and academic consequences at the beginning of their school experience.

Caregivers may consider preparing their children for the changes in sleep timing that may be demanded by kindergarten attendance by gradually reducing weekday napping and gradually advancing the nocturnal sleep period. Attending an all-day preschool/daycare program would appear to be advantageous as smaller sleep period changes are required at the start of kindergarten. However, a challenge to shifting sleep to a single nocturnal period results if preschool/daycare programs schedule long nap intervals. There appears to be a national trend in the U.S. towards limiting or terminating nap opportunities in kindergartens (Trejos, 2004). Whether, when, and how to advance young children’s sleep periods before starting school would appear to deserve careful investigation.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

There are many limitations of this field-based study. The summer assessment differed from the kindergarten assessments in many ways and conclusions about the impact of kindergarten on sleep variables must be tempered by consideration of differences in diet, physical activity, exposure to sunlight, etc. Although actigraphy and caregiver diaries provide a useful way to estimate sleep in field settings, they are still limited with regards to precision. More data is needed on the precision of the AW64 for estimating sleep, especially diurnal sleep and sleep offset, in young children. Given this, the data presented here with regard to napping should be interpreted cautiously. Unfortunately, too few weekend days (i.e. 2) limited statistical power for analyses of weekend data. Finally, statistical power would also have benefited from a larger sample size.

References

Acebo C, Sadeh A, Seifer R, Tzischinsky O, Hafer A, Carskadon MA. Sleep/wake patterns derived from activity monitoring and maternal report for healthy 1- to 5-year-old children. Sleep. 2005; 28(12):1568–1577. [PubMed: 16408417]

Atkinson E, Vetere A, Grayson K. Sleep disruption in young children. The influence of temperament on the sleep patterns of pre-school children. Child: Care, Health and Development. 1995; 21(4): 233–246.

Banks S, Dinges DF. Behavioral and physiological consequences of sleep restriction. J Clin Sleep Med. 2007; 3(5):519–528. [PubMed: 17803017]

Berger RH, Miller AL, Seifer R, Cares SR, LeBourgeois MK. Acute sleep restriction effects on emotion responses in 30- to 36-month-old children. Journal of Sleep Research. 2012; 21(3):235–246.10.1111/j.1365-2869.2011.00962.x [PubMed: 21988087]

Boivin DB, Tremblay GM, James FO. Working on atypical schedules. Sleep Med. 2007; 8(6):578–589. S1389-9457(07)00115-3 [pii]. 10.1016/j.sleep.2007.03.015 [PubMed: 17481949]

Carskadon MA, Wolfson AR, Acebo C, Tzischinsky O, Seifer R. Adolescent sleep patterns, circadian timing, and sleepiness at a transition to early school days. Sleep. 1998; 21(8):871–881. [PubMed: 9871949]

Chen X, Beydoun MA, Wang Y. Is sleep duration associated with childhood obesity? A systematic review and meta-analysis. Obesity (Silver Spring). 2008; 16(2):265–274. oby200763 [pii]. 10.1038/oby.2007.63 [PubMed: 18239632]

Colten, H.; Altevogt, B. Sleep Disorders and Sleep Deprivation. Washington, D.C: The National Academies Press; 2006.

Craven H, Seifer R, Lebourgeois M. Correspondence between actigraphy and PSG measures of sleep onset latency in young children. SLEEP. 2012; 35:A366.

Crosby B, LeBourgeois MK, Harsh J. Racial differences in reported napping and nocturnal sleep in 2- to 8-year-old children. Pediatrics. 2005; 115(1 Suppl):225–232. [PubMed: 15866856]

Dahl RE. The impact of inadequate sleep on children’s daytime cognitive function. Semin Pediatr Neurol. 1996; 3(1):44–50. [PubMed: 8795841]

Fallone G, Acebo C, Seifer R, Carskadon MA. Experimental restriction of sleep opportunity in children: effects on teacher ratings. Sleep. 2005; 28(12):1561–1567. [PubMed: 16408416]

Fukuda K, Asaoka S. Delayed bedtime of nursery school children, caused by the obligatory nap, lasts during the elementary school period. Sleep Biol Rhythms. 2004; 2(2):129.

Jenni OG, O’Connor BB. Children’s sleep: an interplay between culture and biology. Pediatrics. 2005; 115(1 Suppl):204–216. 115/1/S1/204 [pii]. 10.1542/peds.2004-0815B [PubMed: 15866854]

LeBourgeois, MK. Validation of the Children’s Sleep-Wake Scale. Hattiesburg, Miss: The University of Southern Mississippi; 2003.

Medicine, I. o. Sleep Disorders and Sleep Deprivation: An Unmet Public Health Problem. Washington, DC: The National Academic Press; 2006.

Meltzer LJ, Mindell JA. Sleep and sleep disorders in children and adolescents. Psychiatric Clinics of North America. 2006; 29(4):1059–1076. abstract x S0193-953X(06)00075-X [pii]. 10.1016/j.psc.2006.08.004 [PubMed: 17118282]

Owens J. Sleep in children: cross-cultural perspectives. Sleep and Biological Rhythms. 2004; 2(3)

Owens J. Neurocognitive and behavioral impact of sleep disordered breathing in children. Pediatric Pulmonology. 2009; 44(5):417–422.10.1002/ppul.20981 [PubMed: 19382210]

Russo PM, Bruni O, Lucidi F, Ferri R, Violani C. Sleep habits and circadian preference in Italian children and adolescents. J Sleep Res. 2007; 16(2):163–169. [PubMed: 17542946]

Sadeh A, Raviv A, Gruber R. Sleep patterns and sleep disruptions in school-age children. Developmental Psychology. 2000; 36(3):291–301. [PubMed: 10830974]

Santhi N, Horowitz TS, Duffy JF, Czeisler CA. Acute sleep deprivation and circadian misalignment associated with transition onto the first night of work impairs visual selective attention. PLoS One. 2007; 2(11):e1233.10.1371/journal.pone.0001233 [PubMed: 18043740]

Scheer FA, Hilton MF, Mantzoros CS, Shea SA. Adverse metabolic and cardiovascular consequences of circadian misalignment. Proceedings of the National Academy of Sciences of the United States of America. 2009; 106(11):4453–4458. 0808180106 [pii]. 10.1073/pnas.0808180106 [PubMed: 19255424]

Sitnick SL, Goodlin-Jones BL, Anders TF. The use of actigraphy to study sleep disorders in preschoolers: some concerns about detection of nighttime awakenings. Sleep. 2008; 31(3):395–401. [PubMed: 18363316]

Smaldone A, Honig JC, Byrne MW. Sleepless in America: inadequate sleep and relationships to health and well-being of our nation's children. Pediatrics. 2007; 119(Suppl 1):S29–37. 119/Supplement_1/S29 [pii]. 10.1542/peds.2006-2089F [PubMed: 17272582]

Trejos, N. Washington Post. 2004 Monday, March. Time may be up for naps in pre-K class.

Ward TM, Gay C, Anders TF, Alkon A, Lee KA. Sleep and Napping Patterns in 3-to-5-year old Children Attending Full-Day Childcare Centers. Journal of Pediatric Psychology. 2007; 33:666–672. [PubMed: 17956928]

Weiss AR, Johnson NL, Berger NA, Redline S. Validity of activity-based devices to estimate sleep. J Clin Sleep Med. 2010; 6(4):336–342. [PubMed: 20726281]

Zhang J, Li AM, Fok TF, Wing YK. Roles of parental sleep/wake patterns, socioeconomic status, and daytime activities in the sleep/wake patterns of children. Journal of Pediatrics. 2010; 156(4):606–612. e605. S0022-3476(09)01081-6 [pii]. 10.1016/j.jpeds.2009.10.036 [PubMed: 20022339]

NIH-PA Author Manuscript

NIH-PA Author Manuscript

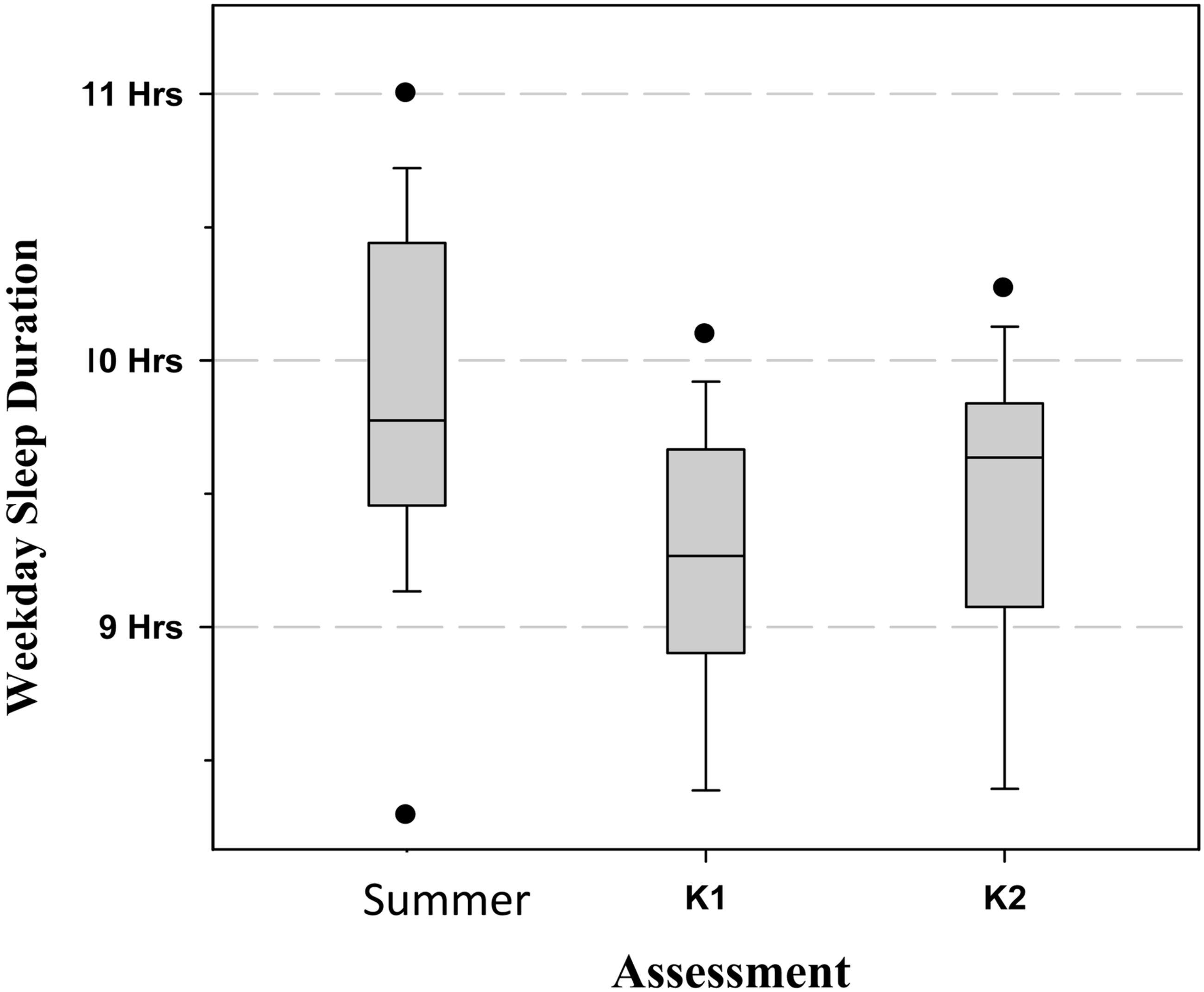

Figure 1.
Boxplots for Distributions of Weekday Total Sleep Duration (Nap plus Nocturnal Sleep Periods) at each Assessment (Summer, K1, K2). Filled circles represent outliers

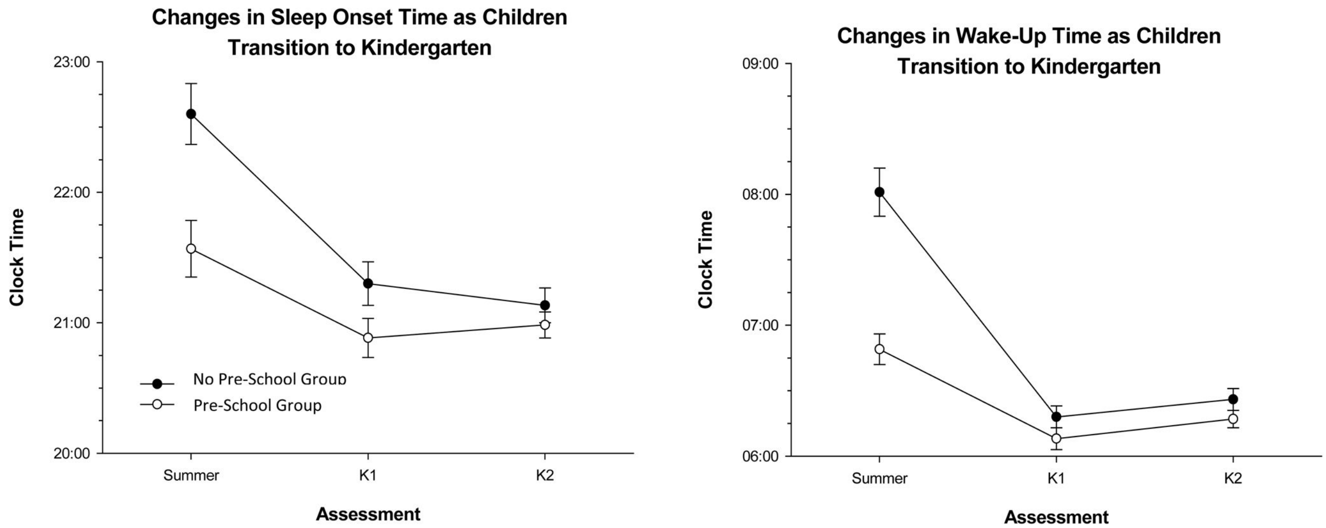

Figure 2.
Changes in Weekday Sleep Timing as Children Transition to Kindergarten

Table 1

Sleep Duration and Timing on Weekdays for Pre-School and No Pre-School Groups at each Assessment. Means (SDs) are presented.

	Summer	K1	K2	Analyses
Total Sleep Duration				
Overall	9 h 53 m (43.1)	9 h 15 m (33.2)	9 h 22 m (37.9)	G: ns
Pre-School	10 h 7 m (41.1)	9 h 22 m (28.4)	9 h 30 m (28.9)	T: $F(2,64) = 5.2$, $p = .008$, $\eta^2 = .14$
No Pre-School	9 h 42 m (42.6)	9 h 10 m (36.2)	9 h 22 m (43.7)	GxT: ns
Nocturnal Sleep Duration				
Overall	9 h 22 m (44.8)	9 h 7 m (35.1)	9 h 14 m (41.9)	G: ns
Pre-School	9 h 11 m (39.5)	9 h 16 m (31.6)	9 h 18 m (28.5)	T: ns
No Pre-School	9 h 26 m (48.7)	9 h 0 m (36.9)	9 h 11 m (49.8)	GxT: ns
Sleep Onset				
Overall	22:10 (65)	21:07 (45)	21:04 (31)	G: $F(1,32) = 5.8$, $p = .022$, $\eta^2 = .15$
Pre-School	21:34 (49)	20:53 (34)	20:59 (24)	T: $F(2,64) = 40.9$, $p < .001$, $\eta^2 = .56$
No Pre-School	22:36 (64)	21:18 (47)	21:08 (35)	GxT: $F(2,64) = 6.1$, $p = .004$, $\eta^2 = .16$
Wake-up Time				
Overall	07:32 (54)	06:14 (23)	06:22 (22)	G: $F(1,32) = 14.9$, $p = .001$, $\eta^2 = .32$
Pre-School	06:49 (26)	06:08 (19)	06:17 (16)	T: $F(2,64) = 81.6$, $p < .001$, $\eta^2 = .72$
No Pre-School	08:01 (49)	06:18 (26)	06:26 (25)	GxT: $F(2,64) = 17.5$, $p < .001$, $\eta^2 = .35$
Sleep Efficiency				
Overall	85.9 (5.0)	88.4 (5.8)	88.3 (5.6)	G: ns
Pre-School	85.9 (7.0)	87.6 (7.2)	87.2 (5.2)	T: $F(2,64) = 3.5$, $p < .05$, $\eta^2 = .10$
No Pre-School	85.9 (5.0)	89.0 (4.6)	89.1 (5.8)	GxT: ns

Note. Total Sleep Duration = mean sleep period duration over 24 hs (nap plus nocturnal sleep duration).