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Background media exposure prolongs nighttime sleep latency in Thai infants

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BACKGROUND: Less is known about the effect of screen time and sleep at a younger age on current sleep outcome in infants. Therefore, we examined whether sleep parameter at a younger age and daily exposure of electronic media could predict sleep outcomes in 12-mo-old Thai infants.

METHODS: There were 208 typically developing infants enrolled since 6 mo old. Each main caregiver completed a sleep questionnaire and was interviewed for the infant's screen exposure at 6 and 12 mo of age. Nighttime sleep latency and sleep duration were calculated. Electronic media and sleep outcomes were analyzed using multiple linear regressions and path analysis.

RESULTS: Longer sleep latency at age 12 mo was predicted by longer daily duration of media exposure and longer 6-mo-old sleep latency. Infants who were exposed to electronic media above the median at both ages had longer 12-mo-old nighttime sleep latency compared with those who were exposed to the screen below the median at both ages.

CONCLUSION: Six-month-old nighttime sleep latency and 12-mo-old electronic media exposure could predict 12-mo-old nighttime sleep latency. Relative changes in media exposure over time can provide a better prediction of nighttime sleep latency in Thai infants than screen exposure at either time point.

Electronic screen media have become an important part of the daily lives not only of older children, adolescents, and adults, but also of younger children with and without developmental problems (1–3). In the United States, 90% of children younger than 2 y watch some form of electronic media with an average of 1–2 h of televised programs daily (1,2). Likewise, >90% of Thai infants have been exposed to at least one form of electronic screen media at the age of <12 mo (4). Unsurprisingly, these children have begun to be exposed to any screen media since birth, particularly background television where programs on the television are intended for adults and always on. As a result, young individuals are unattended by their caregivers (4). Moreover, duration of all electronic screen media the Thai infants aged 6–12 mo have been exposed to, is >4 h per day (5). This earlier and heavy media exposure has been documented to be associated with violence (2), obesity (2), sleep problems (1,6), decreased parent-child interactions (7,8), delayed language development (9–11), impairments in cognitive function (11,12), and behavioral problems (4,6,13,14).

Although sleep is essential for normal neurocognitive functioning of children, optimal sleep of each individual can be affected by exposure to electronic screen media (15). The association between screen time and various sleep variables was observed mostly in school-aged children and adolescents (16,17). Such sleep variables that exhibited consistent results among studies included shorter total sleep time, longer sleep onset latency, and later bedtime (16,17). On the other hand, there are very few studies demonstrating such association in younger individuals. One example is the study conducted by Xu *et al.* where they showed that screen time was related to decrease nighttime sleep duration, prolonged sleep latency, and later bedtime in preschoolers (18). Another study by Thompson and Christakis also found that duration of television viewing per day was associated with irregular schedules in both naptime and bedtime in infants and toddlers aged 4–35 mo (19). Apart from total duration of screen media, the time and program content to which children were exposed on the screen particularly evening media use and violent media content during daytime were significantly associated with sleep problems in preschool-aged children (20). The association between sleep and media has been shown to be bidirectional in the following prospective study in that preschool- and school-aged children who spent more time on screen media at age 4 and 6 appeared to have shorter sleep duration at age 6 and 8 (21). Conversely, children who had shorter sleep duration at age 4 and 6 tended to be exposed to more media at age 6 and 8, respectively (21). However, most studies mentioned above have failed to predict individual variability in sleep variables of interest since they did not use such sleep variables at an earlier age as a predictor as demonstrated by Vijakkhana *et al.* study (5). In that study, they found that nighttime sleep duration of each individual at two time points were moderately correlated (5). Although the relationship between electronic screen media and sleep has been documented in previous studies, most of

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them focused solely on the influence of screen viewing time on sleep duration or problems in preschool- and school-aged children in cross-sectional studies without taking background media variable and sleep parameters at a younger age into consideration. Moreover, little is known whether the effect of screen time on sleep has any impact or emerges during infancy period, particularly in a longitudinal construct and broader sleep parameters. Therefore, we examined the associations between total daily duration of electronic media exposure at 6 and 12 mo of age and sleep parameters including bed time, sleep onset time, nighttime sleep latency, duration of night awakening, wake-up time, nighttime sleep duration, naptime duration, and daily sleep duration in 12-mo-old Thai infants.

METHODS

Study Participants

Parents of typically developing infants, who brought their child in for health supervision visits before the age of 6 mo at our centers were invited to participate in this study. Important information about the study was provided to each parent who was initially interested in our study. Parents who finally decided to participate in this study; their child was scheduled to visit our centers when he or she was 6 mo and 12 mo old according to the study protocol. From August 2012 to October 2013, there were 221 participants originally enrolled in this study. Thirteen participants (5.9%) did not come for the follow-up visit at 12 mo of age. As a result, there were a total of 208 typically developing infants, who were enrolled since 6 mo old and brought in for the follow-up visit at 12 mo of age. The following criteria were used to define "typically developing" for this study: singleton full-term birth (37–42 wk gestation) weighing ≥ 2,500 g; no prenatal, perinatal, and postnatal complications; no congenital malformations; normal growth pattern (weight, length, and head circumference were proportional between the third and the 97th percentiles); no underlying medical illnesses; and typical development documented by Cognitive Adaptive Test/Clinical Linguistic & Auditory Milestone Scales (CAT/CLAMS) at age 6 mo (22). This study was approved by the Institutional Review Boards of the Faculty of Medicine, Chulalongkorn University. Parents provided written informed consent.

Study Protocol

All participants' parents provided relevant information about sociodemographic characteristics of study participants as listed in **Table 1**.

Study Variables and Assessments

The independent variables were (i) total media exposure which was total daily duration of all electronic screen media (both background and foreground media) the infant had been exposed to (min); (ii) estimated media watching which was the duration of screen media parents estimated that the infant actually watched daily (min); and (iii) media content which was primary content of electronic media exposure (adult, noneducational, and educational) at age 6 and 12 mo. The dependent variables were nighttime sleep latency, duration of night awakening, nighttime sleep duration, naptime duration, and daily sleep duration at age 12 mo. We also assessed sociodemographic characteristics including the child's age, gender, birth weight, full scale developmental quotient at age 6 mo, birth order, mode of delivery, primary caregiver, number of family members, father's and mother's age, education, occupation, and income which are demonstrated in **Table 1**.

Media Exposure

Electronic screen media exposure in each participant was assessed by interviewing in depth with the main caregiver using a 24-h recall diary adapted from Mendelsohn *et al.* (8,11). All electronic screen media in which the infant had been exposed to on the most recent typical day, starting from the time the infant awoke in the morning until sleep onset at night, including name and duration (min) of each program were ascertained. Total media exposure (min) the infant had, during awake time at both 6 and 12 mo of age, been then calculated. Each main caregiver was also asked to estimate the total time that the infant actually watched all electronic screen media daily (min). Evening (after 7:00 p.m.) and bedroom media use were also obtained since these variables tended to be associated with sleep parameters in previous studies (20,23). Media content including adult, noneducational, and educational programs was classified based on previous studies by Mendelsohn *et al.* (8,11) and the Office of the National Broadcasting and Telecommunications Commission (NBTC) in Thailand. In brief, educational programs were programs intended for 2-to-6-y-old children such as animated programs, i.e., Dora the Explorer. These were broadcast in a very limited number in Thailand compared with other types of the programs. Noneducational programs had little educational content, but were intended as entertainment programs for 2–6-y-old children, such as cartoons. Older child/adult programs were those that are not suitable for children younger than 7 y since they contained violent content. Therefore, this program category includes cartoons for older children and adults, news, games, music videos, talk shows, sports, variety, drama, and comedy.

Table 1. Sociodemographic characteristics of study participants

Variables	Value[a]	*N*
Birth weight (g)	3,153.4 ± 338.2 (2,500–4,405)	204
Father's age (y)	35.8 ± 6.1 (17–55)	203
Mother's age (y)	33.5 ± 4.9 (16–45)	208
Father's education at least bachelor degree	147 (72.1%)	204
Mother's education at least bachelor degree	171 (82.6%)	207
Median number of family members in the household	4 (3–15)	203
Median monthly father's income[b]	30,001–50,000 Baht	203
Median monthly mother's income[b]	10,001–30,000 Baht	207

[a]Continuous variables are presented as mean ± SD (range) and ordinal variables as median. Dichotomous variables (father's and mother's education) are shown as number and percentage (in parentheses). [b]Monthly father's and mother's income consisted of a six-point scale as follows: 1 = < 10,000, 2 = 10,000–30,000, 3 = 30,001–50,000, 4 = 50,001–100,000, 5 = 100,001–200,000, 6 ≥ 200,000 (Baht/mo).

Sleep Parameters

The main caregiver who raised the child and was with him/her during naptime and bedtime, at home completed a sleep questionnaire. The questionnaire had information about sleep variables in a recent typical week for both the weekdays and the weekend at both 6 and 12 mo of age including bedtime, sleep onset, frequency and duration of night awakening, wake-up time, naptime, and naptime duration. Nighttime sleep latency was then computed based on total duration between bedtime and actual sleep onset. Nighttime sleep duration was calculated based on total duration between sleep onset and wake-up time, excluding duration of night awakening. Daily sleep duration was then computed by adding naptime duration to the nighttime sleep duration.

Statistical Analysis

Continuous variables of electronic media exposure and sleep parameters at age 6 and 12 mo (**Table 2**) were compared using either paired *t*-test or Related-Samples Wilcoxon Signed Rank Test, depending upon the assumption of normality and the equality of variance in each group. Categorical variables such as cosleeping, evening and bedroom media use at two time points were compared by Chi-Square test. Pearson or Spearman correlations between media and sleep data were used based on the normality assumption of these variables. Moreover, associations between media variables, especially bedroom media use at age 12 mo and total media exposure at both 6 and 12 mo of age, and sleep parameters in particular nighttime sleep latency at

age 12 mo, were analyzed using Pearson correlations and multiple linear regressions in unadjusted and adjusted analyses, respectively. In adjusted analyses, age, gender, cosleeping status, evening media use at age 12 mo, maternal education, and household income were included in the final regression models as covariates. Additional multiple regression analyses were performed to investigate whether total daily duration of each media program category was associated with nighttime sleep latency at age 12 mo, while accounting for the same adjusted variables. In each of these multiple regression models, standardized regression coefficients (Beta) and unstandardized regression coefficients (B) were calculated, which are presented in **Table 3** with SE of each independent variable and 95% confidence interval (CI). The distribution of total media exposure was nonlinear according to the Kolmogorov–Smirnov *Z*-value ($P < 0.05$), such that natural log transformations of total media exposure were performed by adding a constant of 1 to each value to account for the values of 0 as demonstrated in the previous study (11). A path analysis and sensitivity analyses were finally conducted to adjust for multiple correlations and various confounding factors as well as to explore effects for both the direct and indirect pathways. All *P*-values documented are two-tailed and the significance level is 0.05.

RESULTS

Sociodemographic Characteristics of Study Participants

The mean age at the 6- and 12-mo-old assessment was 191 d (SD = 7) and 374 d (SD = 8), respectively. The mean full scale developmental quotient of participants at age 6 mo was 103.13 (SD = 5.57).

Of 208 participants, 134 (64.4%) were the first child, 131 (63%) were delivered by cesarean section, 98 (47.1%) had a mother as a primary caregiver followed by 47 (22.6%) with a maternal grandmother. Of 201 fathers who reported their occupation, 95 (47.3%) worked as company employees and 47 (23.4%) worked as government officers. Of 206 mothers, 82 (39.8%) worked as company employees and 56 (27.2%) worked as government officers. As such, our participants were generally middle class, residing in a metropolitan area of Bangkok. Additional sociodemographic details of participants are displayed in **Table 1**.

Electronic Media Exposure at Both 6 and 12 mo of Age

Two hundred and five (98.6%) infants were regularly exposed to at least one kind of electronic screen media prior to 6 mo of age with an average age of onset of 1.43 mo (SD = 1.65). There was an increased trend of total media exposure from a median of 245 min at age 6 mo to a median of 271.5 min at age 12 mo ($P = 0.056$). There was a significant increase in estimated daily media watching from a median of 22 min at age 6 mo to a median of 38.75 min at age 12 mo ($P < 0.001$). Six-month-old infants who spent more time exposed to all electronic media tended to be exposed to more media at age 12 mo with Spearman correlation (r) of 0.55 ($P < 0.001$). With regard to media content, total media exposure were categorized as adult programs for 87.0% and 86.0% at age 6 and 12 mo, respectively and were categorized as noneducational programs for 12.6% and 13.5% at 6 and 12 mo of age, respectively.

Table 2. Sleep parameters at 6 and 12 mo of age

Sleep parameters[a]	6 mo	12 mo	*P*
Nighttime sleep latency in min (weekday)	31.8 ± 25.9, *30.0 (15.0–30.0)*, (0–150.0)	32.5 ± 28.8, *30.0 (15.0–30.0)*, (0–180.0)	0.880
Nighttime sleep latency in min (weekend)	31.7 ± 24.5, *30.0 (15.0–36.0)*, (0–150.0)	31.8 ± 28.7, *30.0 (15.0–30.0)*, (0–180.0)	0.783
Night awakening duration in min (weekday and weekend)	24.5 ± 36.1, *17.5 (8.5–30.0), (0–420.0)*	15.4 ± 18.0, *10.0 (5.0–20.0)*, (0–180.0)	< 0.001
Nighttime sleep duration in h (weekday)	9.2 ± 1.3, *9.3 (8.5–10.0)*, (4.0–12.7)	9.4 ± 1.0, *9.3 (8.8–10.1)*, (6.5–11.8)	0.020
Nighttime sleep duration in h (weekend)	9.4 ± 1.3, *9.5 (8.6–10.2)*, (3.0–12.8)	9.7 ± 1.0, *9.7 (8.9–10.3)*, (6.6–12.5)	0.009
Naptime duration in h (weekday)	3.39 ± 1.50, *3.25 (2.13–4.25)*, (1–10)	2.83 ± 1.02, *3.00 (2.00–3.50)*, (0.5–6)	< 0.001
Naptime duration in h (weekend)	3.3 ± 1.4, *3.0 (2.0–4.0)*, (1.0–10.0)	2.7 ± 1.1, *2.5 (2.0–3.5)*, (0.5–6.0)	< 0.001
Daily sleep duration in h (weekday)	12.6 ± 1.9, *12.4 (11.4–13.6)*, (8.0–20.2)	12.2 ± 1.3, *12.1 (11.4–13.1)*, (9.0–16.0)	0.009
Daily sleep duration in h (weekend)	12.7 ± 1.8, *12.5 (11.5–13.7)*, (7.0–20.2)	12.3 ± 1.4, *12.2 (11.4–13.3)*, (8.8–16.2)	0.003

[a]Data are presented as mean ± SD, *median (interquartile range, 25th–75th percentile)*, and the range (minimum–maximum values) for each variable.

Table 3. The impact of 6-mo nighttime sleep latency, total electronic media exposure, and bedroom media use at 12 mo on nighttime sleep latency on the weekend and the weekday at 12 mo of age

Variables in the final model	Unstandardized coefficients B (SE)	95% CI	Standardized coefficients β	*P*
Nighttime sleep latency on the weekend at 6 mo of age[b] (min)	0.41 (0.08)	0.25–0.56	0.35	< 0.001
Ln[a] of total electronic media exposure at 12 mo of age[b] (min)	5.00 (2.13)	0.82–9.20	0.17	0.020
Bedroom media use at 12 mo of age[b]	7.77 (4.11)	– 0.34–15.88	0.14	0.060
Nighttime sleep latency on the weekday at 6 mo of age[c] (min)	0.37 (0.07)	0.22–0.51	0.33	< 0.001
Ln[a] of total electronic media exposure at 12 mo of age[c] (min)	4.77 (2.18)	0.48–9.06	0.16	0.030
Bedroom media use at 12 mo of age[c]	7.88 (4.18)	– 0.36–16.13	0.14	0.061

[a]LN = Natural Log transformation. [b]Dependent variable: nighttime sleep latency on the weekend at age 12 mo, Adjusted $R^2 = 0.169$. [c]Dependent variable: nighttime sleep latency on the weekday at age 12 mo, Adjusted $R^2 = 0.141$. Adjusted analyses based on multiple linear regression models including chronological age, gender, cosleeping status, evening media use at 12 mo of age, maternal education in y, and household income (Baht) as covariates.

Of 208 participants, 201 had data on evening media use (after 7:00 p.m.) at the age of 6 and 12 mo, 145 (72.1%), and 149 (74.1%) participants were exposed to media in the evening at age 6 and 12 mo, respectively. Two hundred of 208 participants had data about bedroom media use at both time points, 119 (59.5%) and 95 (47.5%) infants had been exposed to at least one kind of the media in the bedroom at age 6 and 12 mo, respectively. Among sociodemographic characteristics, mother's education was significantly negatively associated with total media exposure ($r = -0.25$, $P < 0.001$ for 6 mo and $r = -0.19$, $P = 0.005$ for 12 mo), estimated media watching ($r = -0.21$, $P = 0.003$ for 6 mo and $r = -0.15$, $P = 0.039$ for 12 mo), evening media exposure ($r = -0.18$, $P = 0.009$ for 6 mo and $r = -0.29$, $P < 0.001$ for 12 mo), and bedroom media use ($r = -0.23$, $P = 0.001$ for 6 mo and $r = -0.21$, $P = 0.003$ for 12 mo), but was significantly positively associated with the age of media onset ($r = 0.22$, $P = 0.001$). Although father's education was also associated with electronic media exposure variables mentioned above, Spearman correlation coefficients among those variables were weaker when compared with mother's education.

Sleep Parameters at both 6 and 12 mo of Age

At age 6 mo, the average time that the caregivers generally put their infants to bed (bedtime) was at 20:05 (SD 2:12) and 20:12 (SD 2:14) on the weekdays and the weekend, respectively. The average time of the sleep onset was at 20:37 (SD 2:14) and 20:38 (SD 2:39) for the weekdays and the weekend, respectively. Infants at this age normally awoke twice at night with the average duration of 11.82 (SD 12.41) minutes. They usually awoke in the morning with the average time of 6:28 (SD 1:05) and 6:47 (SD 1:11) on the weekdays and the weekend, respectively.

At age 12 mo, the average bedtime of these infants was at 20:31 (SD 1:04) and 20:42 (SD 1:05) and the average sleep onset was at 20:57 (SD 1:44) and 21:00 (SD 2:16) during the weekdays and the weekend, respectively. They still awoke the average of 1.7 (SD 0.98) times at night with the average duration of 9.08 (SD 10.42) minutes. Twelve-month-old infants generally awoke in the morning with the average time of 6:39 (SD 1:12) and 7:04 (SD 1:13) on the weekdays and the weekend, respectively. These sleep parameters were significantly different between the 6 and 12 mo old. With regard to cosleeping, 182 out of 204 (89.2%) and 186 out of 207 (89.9%) infants coslept with their parents at age 6 and 12 mo, respectively. Other sleep parameters in particular, dependent variables of interest are presented in **Table 2**.

Associations Between Electronic Media Exposure and Sleep Parameters at Age 12 mo

Longer sleep latency at age 12 mo was significantly associated with longer total electronic media exposure at age 12 mo and longer sleep latency at 6 mo of age for both the weekdays and the weekend using multiple linear regression analyses with adjustment for various confounding factors (**Table 3**). To simplify the results from **Table 3**, infants who had a 1-min increase in nighttime sleep latency at age 6 mo was associated with ~0.4-min increase in nighttime sleep latency at age 12 mo for both the weekdays and the weekend. Due to the fact, that total media exposure was natural log transformed, a unit of Ln (Natural log) of total media exposure at age 12 mo was ~2.72 min since Ln 2.72 = 1. As such, this result can be interpreted as a 2.72-min increase in total media exposure at age 12 mo was associated with ~5-min increase in nighttime sleep latency at 12 mo of age for both the weekdays and the weekend, or it means that a 50.0% increase in total media exposure at age 12 mo was associated with ~2-min increase in nighttime sleep latency at 12 mo of age. There were interesting trends toward associations between bedroom media use and nighttime sleep latency at age 12 mo (**Table 3**). With regard to media content, as expected, longer daily duration of only adult programs at age 12 mo was associated with longer nighttime sleep latency at age 12 mo in separate multiple regression analyses since these programs were the majority of all electronic media the infants were exposed to. However, other media parameters including the onset of media exposure, total media exposure at age 6 mo, estimated media watching, and evening media use for both 6 and 12 mo of age did not relate to nighttime sleep latency at age 12 mo. Apart from nighttime sleep latency, other sleep parameters at age 12 mo were not associated with the onset and duration of electronic media exposure at both 6 and 12 mo of age. To better illustrate the relationships among various relevant variables, path analysis was performed to account for multiple correlations among factors and to best investigate relative contributions of maternal education (years), the onset of media exposure, total media exposure at both 6 and 12 mo of age, and nighttime sleep latency at age 6 mo to 12-mo-old nighttime sleep latency. According to the path analysis presented in **Figure 1**, nighttime sleep latency on the weekend at age 6 mo had a direct relationship with the nighttime sleep latency on the weekend at age 12 mo. Total media exposure at age 12 mo had a direct relationship with the nighttime sleep latency on the weekend at age 12 mo. Unsurprisingly, total media exposure at age 6 mo had a moderate to strong direct relationship with total media exposure at age 12 mo. There was an interesting trend toward a direct relationship between total media exposure and the nighttime sleep latency on the weekend at age 6 mo, but total media exposure at age 6 mo did not have any direct relationship with the nighttime sleep latency on the

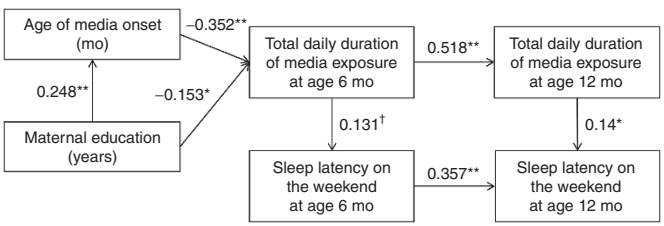

Figure 1. Effects of maternal education (y), age of media onset, total daily duration of all electronic media exposure at age 6 and 12 mo, and nighttime sleep latency at age 6 mo on 12-month-old nighttime sleep latency on the weekend; Chi-square = 3.862 (df 8), $P = 0.869$, Comparative Fit Index = 1.000, Root Mean Square Error of Approximation < 0.001, Normed Fit Index = 0.975; †$P < 0.1$, *$P < 0.05$, **$P < 0.001$, $N = 208$.

weekend at age 12 mo. Maternal education appeared to have a positive direct relationship with the onset of media exposure, but it was negatively correlated to total media exposure at age 6 mo. This model showed excellent goodness of fit indicators. Moreover, we thoroughly performed sensitivity analysis controlling for other potential confounding factors including chronological age, gender, full scale developmental quotient, household income, cosleeping, bedroom, and evening media use; the results on nighttime sleep latency did not significantly change after controlling for these confounders. Moreover, our primary model on the path analysis showed better and excellent goodness of fit indicators than the models, which included all of these confounders.

Factors that could predict nighttime sleep latency on the weekdays at age 12 mo were similar to predictors for the nighttime sleep latency on the weekend presented in **Figure 1**, but the path coefficients of these relationships were relatively weaker when compared with the path analysis for the nighttime sleep latency on the weekend.

Although there was no direct relationship between total media exposure at age 6 mo and the nighttime sleep latency on the weekend at age 12 mo, relative changes in electronic media exposure from age 6 to 12 mo might have an impact on nighttime sleep latency on the weekend. Therefore, we examined 12-month-old nighttime sleep latency on the weekend with respect to changes in total media exposure from age 6 to 12 mo. A median split of total media exposure at each age was used to categorize infants as having relatively lower or higher electronic media exposure for each age. The participants were divided into three groups as the following: (0) low–low, (1) low–high or high–low, and (2) high–high media exposure at age 6 and 12 mo, respectively. As shown in **Figure 2**, infants who had been exposed to all electronic media above the median at both ages had longer nighttime sleep latency at age 12 mo compared with those who had been exposed to relatively lower media exposure at both ages (mean ± SD = 35.84 ± 30.24 min for high–high media exposure, N = 75 and 22.93 ± 15.37 min for low–low exposure, N = 75, P = 0.011). The low–high or the high–low media exposure groups had longer 12-month-old nighttime sleep latency on the weekend compared with those in the low–low group (mean ± SD = 36.63 ± 33.39 min for low–high or high–low media exposure, N = 54 and 22.93 ± 15.37 min for low–low exposure, N = 75, P = 0.014).

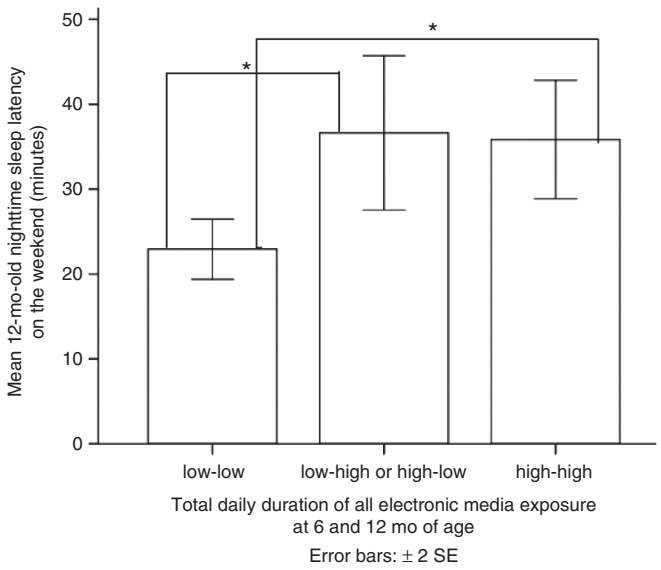

Figure 2. Mean 12-mo-old nighttime sleep latency on the weekend (min) depending on relative changes in total daily duration of all electronic media exposure from age 6 to 12 mo and categorized infants as having relatively lower or higher electronic media exposure based upon the median of media exposure at each age; *P < 0.05.

DISCUSSION

To our knowledge, this is the first study documenting the effect of total electronic media exposure particularly background media and sleep parameters at a younger age on nighttime sleep latency of 12-month-old infants. The impact of electronic media exposure on nighttime sleep latency is consistent with previous studies (16–18), however, most of those studies documented such effect in preschool-, school-aged children, and adolescents and considered nighttime sleep latency as categorical data by determining whether there was a sleep latency problem based on the sleep questionnaire. Considering the lack of normative data on nighttime sleep latency in typically developing children, to categorize the participants as having sleep-onset latency problems in healthy individuals during infancy period was challenging. As a result, the duration of nighttime sleep latency could be used as an outcome measure during infancy as demonstrated in this study. Moreover, our finding could imply that the effect of screen time on sleep may emerge during or has an impact starting in the infancy period.

With respect to the amount of sleep, our participants had an average of nighttime sleep and naptime duration very similar to the age of typically developing infants reported in previous study (15). However, the relationships between electronic media exposure and nighttime, or daily sleep duration were not documented in this study as displayed in preschool- and school-aged children in previous studies (20,21,23–26). The difference in this finding may be due to screen time alone not being significant enough to affect the nighttime and daily sleep duration in children at this younger age compared with preschool- and school-aged children recruited in previous cohorts (21,24). Furthermore, sleep structure and sleep-wake patterns in infants are quite different from preschool- and school-aged children, as the central nervous system of infants is less mature and these varying patterns of neurodevelopmental maturation may lead to the differences in findings between studies. Infants' sleep is primarily much more influenced by feeding schedules and parenting practices than media exposure so that they tend to depend on their caregivers during bedtime. Moreover, infants have less control of their media exposure when compared with older children. As a result, many of these assumptions could explain why nighttime and daily sleep duration of these infants were not predicted by electronic media exposure in young individuals in this study.

The model on path analysis displayed in **Figure 1** was the most robust with respect to goodness of fit indicators although thorough sensitivity analyses were further performed. The results on nighttime sleep latency did not significantly change after controlling for other confounding factors including chronological age, gender, full scale developmental quotient, household income, cosleeping, bedroom, and evening media use. However, there might be other intermediate factors particularly sleep routines and practices that were not measured in this study which may have relationships with sleep outcome of interest. Therefore, such factors should be taken into consideration in future studies.

Our main findings could plausibly extend the results of an increased risk of having an irregular sleep schedule in infants and toddlers who viewed more television, as reported by Thompson and Christakis (19). Those who were exposed to all forms of electronic media were more likely to have irregular bedtime from day to day, whereby later bedtime generally tended to be reported by main caregivers, leading to longer sleep latency in infants with more media exposure, as documented in our study. Furthermore, longer nighttime sleep latency may be related to increased bedtime resistance, anxiety, delayed sleep onset, and melatonin suppression with more screen time exposure as documented in previous reports (1,23,27). With respect to media content, longer daily duration of adult programs, which apparently contained content that is more violent could predict longer nighttime sleep latency in 12-mo-old infants in this study. Bedroom media use and nighttime sleep latency were almost related, whereas evening media use was not, although these variables were associated with increased sleep problems in the studies by Garrison *et al.* (20) and Owens *et al.* (23) .

Although, total media exposure at age 6 mo did not have a direct relationship with the nighttime sleep latency on the weekend at age 12 mo, total media exposure at age 6 mo may have an indirect effect on the nighttime sleep latency on the weekend at age 12 mo, plausibly mediated through the nighttime sleep latency on the weekend at age 6 mo and total media exposure at age 12 mo. According to the longitudinal nature of this study, we were able to underscore the importance of relative changes in total daily duration of electronic media exposure from age 6 to 12 mo on nighttime sleep latency and the strength of longitudinal cohort could enhance the associations observed here. Trends of media exposure over time appeared to provide a better prediction of the nighttime sleep latency in infants than screen exposure at either time point. Therefore, changes in media use across time in addition to the same sleep variables at a younger age should be incorporated into the main objectives of future research with regard to the effects of screen time changes on sleep.

Infants in this cohort had been exposed to electronic media very early in their lives, mostly after birth and spent a relatively longer time on the screen, possibly more than any other leisure activity during the day. Consistent with previous studies (11,28), maternal education appeared to be a protective factor for rational media use in this study. Later media onset and decreased screen time exposure were the two main variables that had relationships with higher maternal education documented in the path analysis where the final model could provide a better illustration of how these relevant variables interacted with one another and ultimately contributed to longer nighttime sleep latency. Although maternal education was a protective factor against inappropriate media use, most infants in this study were at risk of having inadvertent electronic media exposure with earlier onset and unnecessarily prolonged duration of background media use by caregivers. As such, parents should be cognizant of possible deleterious effects of media use in young infants and children, including the impact of media exposure on sleep quantity, quality as well as on other developmental and behavioral problems.

Regarding the limitations of this study, the data on electronic media exposure and sleep parameters were based on only parent reports. However, this method of data ascertainment is generally accepted in the field of media research and widely used in previous studies (11,20,21,24). Moreover, main caregivers were not aware of any associations between these variables since media use was thoroughly interviewed in depth in person with each main caregiver, whereas sleep data were obtained by sleep questionnaires completed by main caregivers before the interview. There were also relatively moderate correlations between the data of media and sleep variables at two time points of each participant so it could be implied that main caregivers provided the data consistently at both 6 and 12 mo of age. As a result, the data obtained from the main caregivers of the same participants over time were relatively reliable. Objective sleep measurements particularly actigraphy, however, should be considered to document more accurate sleep time variables including nighttime sleep latency in future studies. Even though media exposure could predict nighttime sleep latency in our study, how this main finding contributed to clinical relevance or had an impact on sleep quantity and quality of these typically developing infants remains unknown. This issue should be elucidated in future longitudinal studies.

In conclusion, 6-mo-old nighttime sleep latency and total daily duration of all electronic media exposure at age 12 mo could predict 12-mo-old nighttime sleep latency. Relative changes in total daily duration of media exposure from age 6 to 12 mo can provide a better prediction of nighttime sleep latency in Thai infants than screen exposure at either time point. General pediatric practitioners should be aware of the impact of screen time on sleep so that appropriate anticipatory guidance can be provided early to promote optimal sleep for young individuals during health supervision visits.

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