

SCIENTIFIC INVESTIGATIONS

## The relationship between smartphone overuse and sleep in younger children: a prospective cohort study

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**Study Objectives:** Younger children and adolescents are exposed to various smart devices in the modern world, and their use of smart devices is rapidly increasing worldwide. Although smart devices have often been considered to have negative effects on sleep of children and adolescents, such effects have not been studied among younger children. Sleep is considered particularly important for learning and memory, and also has implications for emotional regulation and behavior. Therefore, this study was conducted to examine the effects of smartphone overuse on sleep in 5- to 8-year-old children.

**Methods:** Participants were from the Kids Cohort for Understanding of Internet Addiction Risk Factors in Early Childhood (K-CURE) Study, an observational prospective cohort study in Korea. Smartphone screen time and total sleep time were assessed using parental questionnaires. Sleep problems of children were assessed using the Children's Sleep Habits Questionnaire (CSHQ). Analysis of covariance was used to examine the association between smartphone overuse and sleep habits in children. All statistical analyses were conducted using SPSS version 21.0 (IBM Corporation, Armonk, NY).

**Results:** Total sleep time of the smartphone overuse group (smartphone use over 1 hour daily) was shorter than that of the control group ( $F = 6.362, P < .05$ ). Children in the smartphone overuse group showed statistically significant higher scores in the CSHQ total score and nocturnal awakening subscale score ( $P < .05$ ).

**Conclusions:** Excessive smartphone use was related to shorter total sleep time in children. Use of a smartphone was also associated with significant reductions in the quality of sleep in younger children.

**Keywords:** smartphone, sleep problems, younger children

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### BRIEF SUMMARY

**Current Knowledge/Study Rationale:** Although smart devices have often been considered to have negative effects on sleep of children and adolescents, such effects have not been studied in younger children. Therefore, this study was conducted to examine the effects of smartphone overuse on sleep in 5- to 8-year-old children.

**Study Impact:** Excessive smartphone use was related to shorter total sleep time in children. Use of a smartphone was also associated with significant reductions in the quality of sleep in younger children. This study may contribute to designing guidelines for using smart devices in younger children and verifying their future effectiveness.

### INTRODUCTION

Younger children are exposed to various and ubiquitous smart devices in the modern world, and their use of smart devices is rapidly increasing worldwide. Moreover, the first exposure to media devices is occurring at a younger age.<sup>1</sup> In 2006, 90% of toddlers under 24 months had been exposed to screen media worldwide,<sup>2</sup> and 31.3% of children were using smartphones before 24 months in Korea.<sup>1</sup> In fact, it has been reported that excessive use of mobile devices is negatively related to impulse control, executive functioning, flexible thinking, and emotional regulation.<sup>3</sup> Emotional and behavioral problems like anxiety, depression, and somatic symptoms are associated with overuse of mobile devices in elementary-school children.<sup>4</sup> It has also been shown that exposure to media in children causes aggressive behavior that persists into adolescence and adulthood.<sup>5</sup>

In 2-year-old toddlers, an average daily television (TV) watching time of more than 2 hours is related to delay in language development.<sup>6</sup> Considering these negative effects, the American Academy of Pediatrics recommends that the screen time of 2- to 5-year-old children be limited to under 1 hour per day.<sup>7</sup>

Sleep is essential to the development and health of children<sup>8</sup> and is considered particularly important for younger children for learning and memory; it also has implications for their emotional regulation and behavior.<sup>9</sup> Considering that early childhood is a phase of progressive neurocognitive development, the effects of smart devices on sleep are especially concerning.<sup>10</sup> A previous study suggested that excessive screen use was an important determinant of irregular sleep habits and sleep duration.<sup>11</sup> Evidence for a strong association between longer screen time and shorter sleep duration among very young children has also been reported.<sup>12</sup> Despite several previous

reports on negative effects of smart devices on the sleep quality in school-aged children<sup>13</sup> and adolescents,<sup>14</sup> there is still a lack of evidence on the effect of smart device use among younger children because widespread exposure to screen media devices is relatively recent and assessing the use of screen media devices by young children is difficult.

A previous study identified that having a TV set in the bedroom particularly affected several sleep-quality variables.<sup>15</sup> Children can take a smartphone everywhere, even to bed, before going to sleep. This gives rise to a new type of exposure because such devices provide continuous stimulation, anytime and anywhere. Therefore, the use of a smartphone may be more harmful to sleep than traditional screen media such as TV or computer games. Although recent research has shown that TV and smartphones are the most popular digital devices in preschool-aged children,<sup>1</sup> there have only been a few studies that focused on smartphones. Therefore, studying the effects of smartphone use on sleep in younger children is an urgent issue.

The current study is a substudy of a long-term observational prospective cohort study aiming to understand the use of media devices of children in Korea. This study was conducted in part of this cohort to investigate the effects of smartphone overuse on the quality of sleep in younger children. This study was especially focused on 5- to 8-year-old children, and thus may contribute to designing guidelines for the use of smart devices in younger children and verifying their future effectiveness.

## METHODS

### Study sample

The Kids Cohort for Understanding of Internet Addiction Risk Factors in Early Childhood (K-CURE) Study is the first long-term observational prospective cohort study to investigate causal factors associated with internet-related disorders in Korea. This study was conducted as a part of the K-CURE study and utilized data from wave 4. We invited caregivers (mostly mothers) to participate in a self-administered survey on children's usage of various media platforms, as well as the mental health of children and their caregivers. The caregivers made a voluntary visit to a community center for child mental health located in Suwon, Sungnam, or Goyang, all of which are major cities in the most populous province of Korea. The baseline assessment, wave 1, was conducted between December 2015 and July 2016; the follow-up assessment, wave 2, was conducted between January 2016 and September 2017; the follow-up assessment, wave 3, was conducted between May 2017 and June 2018; and wave 4, was conducted between July 2018 and January 2019. In wave 1, 400 caregivers of 2- to 5-year-old children were enrolled. For the current study (wave 4), 350 caregivers participated in the study.

### Measurement of smartphone use

The average amount of screen time that children spent on a smartphone during the past month was assessed using a parental questionnaire. Individuals who reported using their smartphones more than 1 hour daily for more than 5 days per week were classified into the smartphone overuse group. This cutoff

value was in accordance with the current American Academy of Pediatrics screen media-exposure recommendations for children over age 2.<sup>7</sup>

### Measurement of sleep

Child sleep duration and sleep-related habits were assessed using a parental questionnaire. To assess sleep duration, parents were asked to reply to the following open-ended question: "How long does your child sleep per day, excluding naps." Naps were excluded as most children over 5 years of age do not nap. Information was also collected using the Children's Sleep Habits Questionnaire (CSHQ). The CSHQ is a parent-reported, sleep-screening instrument that has been used in a number of studies to examine sleep behavior in young children.<sup>16,17</sup> The subscales in this assessment allow for the measurement of different aspects of sleep, including bedtime resistance, sleep-onset delay, sleep duration, sleep anxiety, night waking, parasomnias, daytime sleepiness, and sleep-disordered breathing.<sup>16</sup>

### Covariates

The age of the child was calculated based on parent-reported birthdate. Familial structure and socioeconomic level were also assessed through parent reports, including details on who was the main caregiver of the child, parental education and employment status, and family income. Smartphone use patterns, such as primary location of smartphone use, smartphone co-user, and age at first use of smartphone, were reported by parents.

### Statistical analysis

Analysis of covariance and Pearson correlation analysis were used for examining the association between smartphone overuse and total sleep time (TST) in children. To determine the sociodemographic factors that were related to smartphone overuse in children, the frequencies of smartphone overuse among various sociodemographic subgroups were compared using chi-square test. Independent *t* test was used to examine the association between items in the sleep-related questionnaire and smartphone overuse. All statistical analysis was conducted using SPSS version 21.0 (IBM Corporation, Armonk, NY).

### Ethics statement

This study was approved by the Institutional Review Board at the Ajou University School of Medicine (AJIRB-SBR-SUR-14-378). Informed consent was obtained from all participants when they were enrolled.

## RESULTS

### Demographic information

Demographic information and screen use status of 350 participants are presented in [Table 1](#). Most of the fathers were employed in clerical or technical jobs, while most of the mothers (50.9%) were stay-at-home mothers. Half of the respondents had a monthly household income of above 4,000,000 South Korean won, which is close to the median household income of 4,222,533 South Korean won in Korea in the same year (2015).

**Table 1**—Characteristics of participants.

	n	%
Sex		
Male	179	51.1
Female	171	48.9
Age		
5 years	42	12.0
6 years	130	37.1
7 years	118	33.7
8 years	60	17.1
Paternal employment status		
Daily labor	7	2.0
Employee	43	12.5
Owner-operator	52	15.1
Office worker	130	37.7
Middle manager	84	24.3
Professional/senior manager	20	5.8
Artist/region worker	7	2.0
Homemaker /no employment	2	.6
Maternal employment status		
Daily labor	4	.9
Employee	26	7.4
Owner-operator	21	6.0
Office worker	73	20.9
Middle manager	11	3.1
Professional/senior manager	24	6.9
Artist/region worker	14	4.0
Homemaker /no employment	178	50.9
Monthly household income		
KRW <4,000,000	112	32.0
KRW ≥4,000,000	238	68.0
Main caregiver		
Parents	332	94.9
Grandparents or other	18	5.1
Starting age of smartphone usage		
0–11 months	19	6.8
12–23 months	62	22.1
24–35 months	41	14.6
36–47 months	39	13.9
48–59 months	25	8.9
≥60 months	94	33.6
Location of smartphone use		
Home	183	65.1
Other	98	34.9
Smartphone co-user		
Parents	113	40.2
Other	168	59.8

n = 350. KRW = South Korean won.

### Characteristics of smartphone usage

Average screen time for participants was 1.46 hours daily (range: 0–12 hours). Boys tended to have a slightly longer use of screen time compared with girls (1.62 vs 1.29 hours daily). Smartphone usage also increased with age, with 5-, 6-, 7-, and 8-year-olds reporting 1.18, 1.08, 1.72, and 1.99 hours of daily smartphone usage. Of all the participants, 28.9% first started using smartphones before 24 months of age, and the main location of use was at home. While 94% of the main caregivers were parents, the smartphone owners of smartphones used by the children in this study were not parents.

### Comparison between smartphone overuse group and control group

The differences between the smartphone overuse group and control group are presented in **Table 2**. The smartphone overuse group (those who used smartphone for over 1 hour daily) formed 21.2% (n = 70) of the cohort. There were no significant differences between the smartphone overuse and control group for age, sex, starting age of using smartphones, and main caregiver. Among the smartphone overuse group and control group, 75.7% (n = 53) and 54.5% (n = 115) of the smartphones used by the children belonged to someone who was not the main caregiver, respectively ( $\chi^2 = 9.83, P = .002$ ). Thus, children in the smartphone overuse group were more likely to be cared for by someone other than the main caregiver compared with the control group. There was a higher proportion of children in the smartphone overuse group (80%, n = 56) compared with the control group (60.2%, n = 127) who used smartphones mainly at home ( $\chi^2 = 9.08, P = .003$ ), indicating that the smartphone overuse group had most of their smartphone use at home.

### Association between smartphone overuse and sleep in children

TST of the smartphone overuse group (9.51 ± .84 hours) was significantly shorter than that of the control group (9.82 ± .77 hours;  $P < .05$ ; **Table 3**). Moreover, when all possible covariates (age, sex, income, and paternal/maternal employment, etc.) were controlled for, the smartphone overuse group showed significantly decreased TST ( $P = .034$ ). In the 2 groups, various sleep parameters were also analyzed, and sleep quality appeared to be poorer in the smartphone overuse group (**Table 4**). Specifically, children who were in the smartphone overuse group reported more frequent nocturnal awakenings ( $P < .05$ ).

Moreover, daily average screen time was positively correlated with sleep latency, sleep duration, and nocturnal awakening, while it was negatively correlated with TST. Smartphone use frequency was positively correlated with CSHQ total score, sleep latency, and nocturnal awakening, while it was negatively correlated with TST (**Table 5**).

## DISCUSSION

### Patterns of smartphone use in children

This study examined the association between smartphone overuse and sleep in younger children. The main patterns of

**Table 2**—Comparison between smartphone overuse group and control group.

	Total	Smartphone Overuse	Control	$\chi^2$	P
All participants, n (%)	330	70 (21.2)	260 (78.8)		
Age					
5 years	41 (12.4)	6 (8.6)	35 (13.5)	6.344	.096
6 years	125 (37.9)	20 (28.6)	105 (40.4)		
7 years	108 (32.7)	28 (40.0)	80 (30.8)		
8 years	56 (17.0)	16 (22.9)	40 (15.4)		
Sex, n (%)					
Female	160 (48.5)	32 (45.7)	128 (49.2)	.273	.601
Male	170 (51.5)	38 (54.3)	132 (50.8)		
Starting age of smartphone n (%)					
<24 months	81 (28.9)	22 (31.4)	59 (28.1)	.284	.594
24 months	199 (71.1)	48 (68.6)	151 (71.9)		
Smartphone co-user, n (%)					
Main caregiver	113 (40.2)	17 (24.3)	96 (45.5)	9.837	.002**
Other	168 (59.8)	53 (75.7)	115 (54.5)		
Location of smartphone use, n (%)					
Home	183 (65.1)	56 (80.0)	127 (60.2)	9.082	.003**
Other	98 (34.9)	14 (20.0)	84 (39.8)		
Main caregiver, n (%)					
Parents	314 (95.2)	64 (91.4)	250 (96.2)		.118 <sup>a</sup>
Other	16 (4.8)	6 (8.6)	10 (3.8)		

<sup>a</sup>Fisher's exact test. \*\*P < .01.

smartphone use in children ages 5–8 years revealed that average use was 1.46 hours daily, which was approximately 1.5 times more than what the American Academy of Pediatrics recommends. Among the sample, 21.2% reported using smartphones more than 1 hour per day for more than 5 days a week. These results are similar to previous studies that studied exposure and use of mobile media in young children. In a study by Kabali and colleagues<sup>18</sup> in 350 children aged 6 months to 4 years in a low-income minority community, 96.6% of all children used mobile devices and started using them before age 1. In addition, there was an increasing trend of media use as children increased in age. Previous studies have also noted that the frequency of daily use of mobile devices significantly increased with age.<sup>19</sup>

Further, this study revealed that there were environmental differences associated with using smartphones in the smartphone overuse group. Among the smartphone overuse group, 75.7% of smartphone co-users represented someone else and not the main caregiver, which was higher than in the control group (54.5%). Moreover, the smartphone overuse group had a higher percentage of children who used smartphones mainly at home (80.0%) compared with those in the control group (60.2%). It should be considered that, when smartphones were used with someone who was not the main caregiver at home, there would have been minimal interaction between the children and the co-user. The smartphone may also be used with little

**Table 3**—Association between TST and children's smartphone overuse.

	Smartphone Overuse		Control		F	P
	n	Mean (SD)	n	Mean (SD)		
TST	68	9.51 (.84)	209	9.82 (.77)	4.554	.034*

Covariates: age, sex, income, paternal and maternal employment status, starting age of smartphone, smartphone couser, smartphone using place, main caregiver. \*P < .05. TST = total sleep time.

supervision. Concerns have been raised about associations between exposure to media devices and interference in the caregiver–child relationship as well as the well-being of children.<sup>20</sup> This is in line with a previous study where increased parental interaction led to a reduction in screen time and TV exposure in infants.<sup>21</sup> Furthermore, 1 previous study in 2,300 parents of children ages 0–8 found that parents' own TV, computer, smartphone, and tablet computer screen time was strongly associated with child screen time, suggesting that interventions to reduce screen time in young children may also need to involve reductions in parental screen time as well.<sup>19</sup> Thus, this may suggest that parental education and early interventions are required for appropriate smartphone use in young children.

**Table 4**—Comparison of sleep quality between the smartphone overuse group and control group.

CSHQ	Control (n = 260)		Smartphone Overuse (n = 70)		t	P
	Mean	SD	Mean	SD		
Total	44.16	5.46	45.93	6.07	-2.345	.020*
Bedtime resistance	11.54	2.66	11.71	2.72	-.478	.633
Sleep latency	1.28	.53	1.43	.58	-1.929	.056
Sleep duration	3.41	.91	3.63	.94	-1.785	.075
Sleep anxiety	6.60	1.79	6.93	2.16	-1.157	.250
Nocturnal awakening	3.65	1.02	4.06	1.41	-2.280	.025*
Parasomnia	8.29	1.27	8.30	1.34	-.044	.965
Daytime sleepiness	10.50	2.48	11.01	2.50	-1.524	.129

\*P < .05. CSHQ = Children's Sleep Habit Questionnaire.

**Table 5**—Correlation analysis between daily average screen time, TST, and CSHQ scores.

	Daily Usage Time	Frequency	TST	CSHQ Total Score	Bedtime Resistance	Sleep Latency	Sleep Duration	Sleep Anxiety	Nocturnal Awakening	Parasomnia	Sleep-Disordered Breathing	Daytime Sleepiness
Daily usage time	1	.621**	-.253**	.099	.011	.127*	.145**	.057	.113*	-.057	.003	.060
Frequency			-.189**	.136*	.031	.108*	.087	.039	.117*	.040	.038	.100

\*P < .05, \*\*P < .01. CSHQ = Children's Sleep Habit Questionnaire; TST = total sleep time.

**Sleep differences in the smartphone overuse group versus controls**

In our study, we identified an association between increased use of smartphones and decreased sleep duration and increased nocturnal awakenings in children ages 5–8 years. Previous studies have reported that screen use in bed has negative effects on sleep duration and sleep–wake patterns.<sup>22,23</sup> One study by Lemola and colleagues<sup>24</sup> investigated 19,299 elementary-school students and found that media use in the bedroom was associated with later bedtimes and wake times, shorter sleep duration, and more sleep disorders. The use of smartphones, similar to the use of traditional media including TV, may also be negatively associated with TST. In the smartphone overuse group in our study, the CSHQ total score and nocturnal awakenings were significantly higher compared with those in the control group. Also, daily average screen time was positively correlated with sleep latency, sleep duration, and nocturnal awakening and negatively correlated with TST. The frequency of smartphone use was positively correlated with CSHQ total score, sleep latency, and nocturnal awakening and negatively correlated with TST. In addition to time spent on the smartphone, frequency of use also had significant effects on TST and sleep quality.

Previous studies have shown that, if media devices are located within the bedroom of young children, there is a negative effect on sleep time and quality.<sup>25–27</sup> Previous studies also have shown that media use at bedtime affects underlying physiological mechanisms affecting sleep. For example, 1 study found that TV use at bedtime increases autonomic activity and may subsequently cause longer sleep-onset latency and difficulty

initiating sleep.<sup>28</sup> In a previous study, 12-month-old infants who were exposed to screen media in the evening showed 28 minutes of decreased sleeping duration than those who were not exposed.<sup>29</sup> As one of several hypotheses on the effects of media on sleep, it has been reported that exposure to bright light in the evening affects the sleep–wake cycle.<sup>30</sup> Another study in adults found that exposure to bright light before bedtime caused inhibition of melatonin secretion, which may also cause sleep disturbance.<sup>31</sup> While the current study did not assess the timing of screen use, it is possible that children who reported increased smartphone use also had increased usage closer to bedtime.

In addition, sleep disturbance caused by increased screen use may be associated with media content. It has been reported that sleep disturbances were significantly increased when children were passively exposed to adult content (stimulatory or violent). This suggests that sleep disturbances are also related to the type of content exposed.<sup>32</sup> Thus, more accurate conclusions can be drawn if additional analysis is done with consideration of the timing and content of smartphone use.

It is well known that sleep is an important mediator of attention deficit, aggressiveness, and obesity caused by media use.<sup>33</sup> Therefore, improvement in sleep is considered an important part in addressing various physical and mental problems. In addition, as a previous study reported, policy interventions are required considering that the family environment can affect children's screen time.<sup>34</sup> This study not only provides a basis for future follow-up studies using the K-CURE cohort but also emphasizes that early intervention in reducing smartphone overuse in young children is important in improving quality of sleep.

## Limitations

There were several limitations of this study. First, smartphone use in children was measured through parental reporting, which is known to be prone to slight overestimation compared with daily logs or direct observations.<sup>35</sup> Several previous studies have used parental reports to estimate screen time in children.<sup>36</sup> Since smartphones can be used more easily, frequently, and repeatedly for shorter durations of time than other media, the study could have been strengthened using objective measurements of smartphone use. Second, it is possible that other elements of poor sleep hygiene, such as lack of bedtime routine, may have been more highly prevalent in the smartphone overuse group. Thus, future studies are needed to address whether smartphone usage directly contributes to decreased sleep in children. Third, screen time in the modern world is not limited to smartphones. While this study exclusively focused on smartphones, adding other media such as tablet PCs and TV should also be considered in future studies. Fourth, objective measures of sleep, such as wrist actigraphy or polysomnography could have made better estimates of sleep in children.

Despite these limitations, this study directs attention to the phenomenon of smartphone use starting at earlier ages in modern society, along with increasing usage of media devices. Despite this widespread phenomenon, the long-term effects of increased screen use on sleep and other domains have been understudied. Subsequent studies based on this cohort are expected to elucidate the trajectory and long-term effects.

## ABBREVIATIONS

CSHQ, Children's Sleep Habits Questionnaire  
 K-CURE, Kids Cohort for Understanding of Internet Addiction Risk Factors in Early Childhood  
 TST, total sleep time  
 TV, television

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