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Hend Alqaderi, BDS, DMSc, J. Max Goodson, DDS, PhD,
S. V. Subramanian, PhD, MPhil, and Mary Tavares, DMD, MPH

Short Sleep Duration and Screen-Based Activities: A Longitudinal Multilevel Analysis

Abstract: Objective. *The aim of this study was to identify lifestyle habits that contribute to night sleep reduction in the Kuwaiti population.* Methods. *Children were 10 to 12 years old and were approximately equally distributed among 138 elementary schools representing the 6 governorates of Kuwait. In the first phase of the study, data were collected from 8317 children. The same data were collected 2 years later from 6316 of the children from the first phase of the study. Calibrated examiners conducted sleep evaluation, lifestyle habits interviews, and body weight measurements. A multilevel random intercept and slope model was conducted to determine the effect of screen-based activities on the daily night sleep hours at 3 levels: within schools, among children, and over time. The primary dependent variable was the number of daily sleep hours. Independent variables assessed were lifestyle habits including screen-based activity variables including TV and video game use. Results. Screen-based activities were significant factors that reduced daily sleep hours ($P < .05$). There were statistically significant variations between schools and children over time. Conclusion. Longitudinal analysis of Kuwaiti*

children revealed that TV and video game use were major risk behaviors contributing to decreased sleep duration with strong clustering effect of the observations within schools across time.

Keywords: sleep; sleep deprivation; pediatric

Similarly, little and disrupted sleep is related to costly metabolic diseases.⁴⁻⁷ Metabolic diseases in Kuwaiti children is a growing problem, where, according to the International Diabetes Foundation, every fourth adult has type 2 diabetes⁸ and by our data every fourth 10-year-old child is obese. Given the high prevalence of obesity in Kuwaiti children, there are

Current evidence shows that children who sleep less at night have a significantly higher risk of becoming obese than children who sleep longer.

It has been recently recognized that healthy sleep patterns play a fundamental role in improving overall health. Current evidence shows that children who sleep less at night have a significantly higher risk of becoming obese than children who sleep longer.^{1,2} Consistent delayed night sleep has been shown to increase the risk and the severity of infectious diseases, cancers, respiratory diseases, and depression.³

serious health implications for these children as they reach adulthood, given the fact that overweight in children is a predictor of obesity in adulthood.⁹ Kuwaiti children had a larger proportion of obese children than American children among the same age groups.¹⁰⁻¹³

The aim of the present analysis was to identify the risk behaviors related to delayed night sleep among a population having the highest prevalence of obesity

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in the world—the Kuwaiti population.¹⁴ Previous work has determined a significant relationship between insufficient sleep and obesity among Kuwaiti children.¹³ This study also demonstrated that screen-based activities (TV and video game use) are major risk factors contributing to diminish sleep time.¹³ However, it is important to keep in mind that this previous analysis used a cross-sectional design, which has its inherent limitations. The prospective longitudinal design of this study allows us to evaluate the changes of behaviors over time, to determine the trend of the observations and their contribution to the outcome. In other words, cross-sectional studies based on one single observation are not appropriate to determine the effect of behavior on changing the outcome. It is essential to follow behavior over time using multiple observations to determine a causal relationship to the outcome.¹⁵ Moreover, multilevel modeling accounts for the clustering effect between schools and the variation between children to provide a more precise and correct inference.¹⁶

Materials and Methods

Study Approval

This prospective cohort study was approved by the Forsyth Institutional Review Board in Cambridge, MA, and the Dasman Institute Human Ethical Review Committee in Kuwait (RA/065/2011 and RA/005/2011). Informed consent forms in Arabic language were provided to parents (or guardians) and assent was required from the children. Assent was obtained on the day of the study visit before participation in the study. Written consent forms were collected and securely stored at the School Oral Health Program in Kuwait.

Study Population

In the first phase of the study, data were collected from 8317 children representing the 6 governorates in Kuwait between October 2011 and May 2012. The Kuwaiti participants were in the fourth and fifth grades, and their

ages ranged between 8 and 11 years in 2012 (visit 1) for this initial screening. The final data collection occurred between October 2014 and May 2015, where the same data were collected from the same cohort of children ($n = 6316$) representing 138 public schools in Kuwait (visit 2). The response rate for the second round was high (95%). There were 2001 children from visit 1 who were unable to follow-up by the second examination visit due to the approaching end of the academic year. In the analysis for this article, we included only the 6316 subjects who had complete measurements at both visits. In this data set, the distribution of participants across the 6 governorates of Kuwait was approximately equal. Students enrolled in these schools represented all socioeconomic levels and ethnic groups among the Kuwaiti population, but did not include expatriate children. All volunteer participants were accepted but selection into the cohort was not randomized across the population.

Data Collection

Subject identification, sleep evaluation interviews, saliva samples, nutrition analysis interviews, and body weight analysis were collected by 2 calibrated teams. Information on these variables was recorded into a programmed iPad (Apple, Cupertino, CA) system for Internet transfer.

Outcome Measure

Sleep Duration. The primary outcome in the present analysis was daily sleep hours. Each child was asked the following: (1) During the past week, at what time did you go to sleep? (2) During the past week, at what time did you wake up? Based on the responses, the number of sleep hours per day was calculated for each child.

Independents Variables. These variables were assessed and obtained from “one-on-one” interviews with each child by calibrated interviewers. Tables 1 and 2 demonstrate the tested variables and their descriptions. Questions about sleep behavior and lifestyle habits were

answered using ordinal responses (never, rarely, sometimes, often), or continuous variables (ranging from 0 to 7) in the multilevel modeling, and answers choices were the following: never, 1 day a week, 2 days a week, 3 days a week, 4 days a week, 5 days a week, 6 days a week, or every day.

Information on these variables was recorded into a programmed iPad (Apple, Cupertino, CA) system for Internet transfer.

Statistical Analysis

Our data had a hierarchical structure composed of time (first level), nested within children (second level), and nested within the schools (third level; Figure 1). Level 3 represented the contextual effect of the school environment on the outcome. We fit the data using multilevel longitudinal linear regression model to determine the linear relationship between sleep duration and the individual-level variables to verify which individual factors were associated with the outcome over a period of 2 years.

Variable selection was based on clinical relevance and potential confounding. We used the stepwise model building strategy. We kept the significant variables in the final model. Beta coefficients for the linear model and their 95% confidence intervals were estimated at a predetermined significance level of $\alpha = .05$. As is often done with multilevel models, we computed the intraclass correlations (ICCs) at each level. ICCs represent the amount of variability in the outcome attributed to each level, after accounting for other variables in the regression models. The statistical analysis modeling was conducted in MLwiN. MLwiN is a statistical software package for fitting multilevel models (Centre for Multilevel Modeling, University of Bristol). Using the prospective longitudinal multilevel design in this study increases the analysis precision by accounting for the clustering within schools, and clustering of the observations between the 2 time points.¹⁶

The final model is shown below:

Table 1.Variables and Corresponding Sleep Quality Questions^a.

Variables' Names in the Analysis	Question Asked to Each Child
Trouble breathing at night	Do you have trouble breathing at night?
Trouble falling to sleep	Do you have trouble falling sleep at night?
TV and video games (VG) before bedtime	Just before bedtime do you play video games or watch TV?
Bed use for TV and VG	How often do you use your bed for watching TV, or playing video games?
Problem with sleepiness	How often do you have a problem with sleepiness during the day?
Falling asleep while watching TV	How often do you fall asleep while watching television?
Fall asleep during class	How often do you fall asleep or get drowsy during class periods?
Fall asleep during homework	How often do you get sleepy or drowsy while doing your homework?
Trouble getting out of bed in the morning	How often do you have trouble getting out of bed in the morning?
Falling back to sleep after being woken up	How often do you fall back to sleep after being woken up in the morning?

^aAnswers of these questions were ordinal responses variables (never, rarely, sometimes, often).**Table 2.**

Variables and Corresponding Questions of Lifestyle Behaviors.

Variables' Names in the Analysis	Question Asked to Each Child
Exercise ^a	How many days a week do you exercise (sports, dance, PE class), bike, skate, or play outside?
Watching TV or playing video games for more than 2 hours ^a	How many days a week do you watch TV, videos, or play computer/video games for more than 2 hours? (Playstation, X-box, Gameboy)?
Eating in front of the TV ^a	How many days a week do you eat in front of the TV?
TV in the bedrooms ^b	Is there a television set in the room where you sleep? The response was binary: "yes" if the child had a TV in the bedroom and "no" if the child did not have a TV in the bedroom
Participation in sports programs ^b	Are you participating in any sports programs outside the school?
Snacking ^b	Do you eat snacks during the day? The response was binary: "yes" if the child ate snacks and "no" if the child did not
Gender ^b	Binary variable consisting of "male" and "female"
Waist circumference (continuous variable)	Was measured at the midpoint between the bottom of the rib cage and the top of the iliac crest at minimal respiration for each participant. Each measurement was conducted using a paper anthropometry tape and the resulting circumference was rounded to the nearest centimeter. A binary variable was created to represent children with abdominal obesity.

Abbreviation: PE, physical exercise.

^aVariables were considered continuous variables (ranging from 0 to 7) in the multilevel modeling; answers choices were the following: never, 1 day a week, 2 days a week, 3 days a week, 4 days a week, 5 days a week, 6 days a week, or every day.^bBinary variables used in the analysis.

Figure 1.

Schematic representation of the 3-level hierarchical structure of the final analytic sample.

$$\begin{aligned}
 Y_{ijk} = & B0 + B1_{\text{time}} \\
 & + B2_{\text{TV_before_bed}} + B3_{\text{TV_before_bed*time}} \\
 & + B4_{\text{use_bed_TV}} + B5_{\text{use_bed_TV*time}} \\
 & + B6_{\text{TV>2h}} + B7_{\text{TV>2h*time}} \\
 & + B8_{\text{trouble_breath}} + B9_{\text{trouble_breath*time}} \\
 & + B10_{\text{WC}} + B11_{\text{WC*time}} + B12_{\text{age}} \\
 & + B13_{\text{sex}} + U_{0jk} + U_{1jk} + V_{0k} \\
 & + V_{1k} + e_{0ijk}
 \end{aligned}$$

$$U_{0jk} \sim N(0,1)$$

$$V_{0k} \sim N(0,1)$$

Results

There were more girls (61.4%) in the study than boys (38.5%). The age of children was tightly clustered around 10 ± 0.008 years in visit 1 and around 12 ± 0.008 years in visit 2. On average, both boys and girls slept 8.8 hours/day, with an average bedtime occurring at 10:00 PM and an average wake up around 6:00 AM.

The population's descriptive statistics for the lifestyle habits are summarized in Table 3. We noticed a considerable increase in the use of screen-based activities over time in this population. A

total of 43.4% of Kuwaiti children in this study have a TV in their bedrooms, with boys more likely to have a TV (56.2%) than girls (35.3%). Most Kuwaiti children (86.7%) watch TV and play video games just before bedtime; once again, this is more commonly found to be a habit of boys (88.7%) than girls (85.5%). Most children (59.5%) watch TV and play video games for more than 2 hours a day (4 days a week or more), more commonly for boys (62.2%) than girls (59.6%). Most children (58.4%) eat in front of the TV (4 days a week or more), with more girls exhibiting this behavior (63.2%) than boys (57.7%). The use of the bed for watching TV and playing video games was reported by 50% of the children, with girls (53.5%) more likely to do so than boys (46.3%). Only 30% of Kuwaiti children reported that they practice exercises 4 days a week or more, with the higher proportion among boys (37%) than girls (24.6%). A small percentage of the children reported having trouble breathing at night (12.4%), which was more common in boys (13.6%) than in girls (12.4%).

At visit 1, 7.7% of the children reported that they had a diabetic mother, and 13.8% reported having a diabetic father. At visit 2, the same children reported that 9.4% had a diabetic mother and 16.8% had a diabetic father. This indicated a 4.7% increase in the prevalence of diabetes in parents over the 2 years. These findings confirm the estimated 24% of diabetic adults in Kuwait reported by the International Diabetes Federation.⁸ Almost all children (95.5%) acknowledged snacking during the day (Table 3). A big increase in the incidence of childhood obesity over time was observed (obesity by waist circumference in visit 1 = 22.4% and in visit 2 = 38.4%, according the World Health Organization guidelines¹⁷).

Results from the multilevel longitudinal linear model showed that the main factors predicting short night sleep duration in children were screen-based activities (Table 4): watching TV or playing video games before bedtime reduced daily sleep hours, with

statistically significant change over time ($P < .05$). Moreover, using the bed for watching TV and playing video games predicted shorter sleep duration over time ($P < .05$; Table 4). Playing video games or watching TV more than 2 hours a day also reduced daily sleep hours, with statistically significant rate of reduction over time ($P < .05$; Table 4). Children with bigger waist circumference had less daily sleep hours over time ($P < .05$), adjusted for age and gender.

For this model, there were statistically significant time variations for both school and children levels, found also in the rate of change in sleep duration across children and schools (Table 5). In the secondary analysis demonstrated in Table 6, we showed that there was a strong clustering effect within schools in the observations of the sleep duration and screen-based activities.

Discussion

Our data showed that the mean sleep duration among Kuwaiti children (8.8 hours/day) was less than the minimum required hours for this age group. According to the Centers of Disease Control and Prevention and the pediatric clinical guide for sleep,¹⁸ 10 to 11 hours of sleep are considered a healthy average sleep duration for 8- to 12-year-old children. This indicates that there is an issue prevalent in Kuwaiti children in terms of short sleep duration. In addition, a recent meta-analysis showed that sleep duration among Kuwaiti children was comparable to the sleep duration in children of other countries.¹⁹

In the present analysis, we showed that children who frequently watch TV or play video games just before bedtime sleep significantly less than children who rarely or never watch TV or play video games before bedtime, with a significant dose-response relationship over time ($P < .05$; Table 4). Similarly, children who mostly use their beds for watching TV and playing video games sleep significantly less than children who rarely or never used their beds for these screen-based activities, with a significant

Table 3.

Summary Descriptions of Lifestyle Habits Stratified by Sex and Visit.

Variables	Visit 1, n (%)			Visit 2, n (%)		
	Boys	Girls	Total	Boys	Girls	Total
TV in bedroom ^a	1079 (51.3%)	1055 (31.4%)	2134 (39%)	1182 (56.2%)	1186 (35.3%)	2368 (43.4%)
TV and VG before bedtime ^b	1865 (88.6%)	2791 (83%)	4656 (85.2%)	1869 (88.7%)	2872 (85.5%)	4741 (86.7%)
Watch TV or play VG >2 hours ^c	1691 (80.2%)	2733 (79.4%)	4424 (80.9%)	1323 (62.2%)	1904 (59.6%)	3360 (59.5%)
Eat in front of TV ^c	1360 (64.5%)	2160 (64.2%)	3520 (64.3%)	1219 (57.7%)	1986 (63.2%)	3205 (58.4%)
Use bed for TV and VG ^b	673 (32%)	1288 (38.4%)	1961 (35.9%)	976 (46.3%)	1777 (53%)	2753 (50%)
Participate in sport program ^a	716 (34%)	470 (14%)	1186 (21.7%)	1088 (51.7%)	864 (25.7%)	1952 (35.7%)
Exercise ^c	1295 (61.5%)	1884 (55.7%)	3179 (58.3%)	801 (37%)	891 (24.6%)	1692 (30%)
Trouble breathing at night ^b	230 (10%)	335 (9%)	567 (10%)	304 (13.6%)	421 (12.4%)	725 (12.4%)
Trouble falling to sleep ^b	432 (19.7%)	625 (17%)	1057 (18.8%)	367 (17%)	631 (18.8%)	1166 (18.2%)
Obese by waist circumference ^a	438 (20.8%)	786 (23.4%)	1224 (22.4%)	746 (35.4%)	1350 (40.2%)	2096 (38.4%)
Diabetic mother ^a	160 (7%)	264 (7.8%)	424 (7.7%)	205 (9%)	310 (9.2%)	515 (9.4%)
Diabetic father ^a	300 (14.2%)	454 (13.5%)	754 (13.8%)	379 (18%)	538 (16%)	917 (16.8%)
Snacking ^a	2051 (97%)	3279 (97.7%)	5330 (97.6%)	2006 (95.3%)	3207 (95.6%)	5213 (95.5%)
Sleep during the day ^a	719 (34%)	1253 (19.3%)	1972 (36%)	795 (45%)	1957 (58.2%)	2932 (53.6%)
Problem with sleepiness ^b	194 (9%)	276 (8.2%)	470 (8.5%)	299 (13.3%)	685 (19.7%)	984 (18%)
Falling asleep while watching TV ^b	1058 (50.4%)	1623 (48.5%)	2681 (49.2%)	1066 (50.6%)	1701 (50.6%)	2767 (50.6%)
Fall asleep during class ^b	537 (25.3%)	947 (28%)	1484 (27.2%)	768 (36.4%)	1366 (40.7%)	2134 (39%)
Fall asleep during homework ^b	443 (20%)	773 (22.7%)	1216 (22.2%)	530 (25%)	1036 (30.4%)	1566 (28.6%)
Trouble getting out of bed in the morning	676 (32%)	1055 (31.4%)	1731 (31.7%)	1116 (53%)	1782 (53%)	2898 (53%)

Abbreviation: VG, video games.

^aBinary variable yes versus no. Obesity by waist circumference (de Onis et al¹⁷).^bOrdinal variable; never, rarely, sometimes, often, the result presented for the sometimes and often versus never and rarely^cOrdinal variable for use during weekdays more than 2 hours 4 days a week or more.

Table 4.

Multilevel Longitudinal Linear Regression Model With Daily Sleep Hours as the Outcome Variable.

Covariate (Fixed Effect)	Estimate	95% Confidence Interval
Watch TV/use video games before bedtime	−0.04 ^a	−0.05, −0.12 [S] ^b
Use bed for watching TV/play video games	−0.06 ^a	−0.01, −0.089 [S]
Watching TV/use video games >2 h/day	−0.03 ^a	−0.05, −0.09 [S]
Trouble breathing at night	−0.05 ^a	−0.03, −0.15 [S]
Waist circumference	−0.11 ^a	0.14, 0.17 [S]
Age	0.6	1.01, 0.22 [S]
Sex (boys vs girls)	0.22	0.02, 0.4 [S]

^aBeta coefficient + interaction term with time to show the effect over time. Variables presented were continuous variables except “sex,” which is a binary variable.

^b[S] = Significant based on 95% confidence intervals; estimated at a predetermined significance level of $\alpha = .05$.

Table 5.

Between School and Children Variation: Random Effect Estimates of the Linear Regression Multilevel Model in Table 4.

Level (Random Effect)	Visit 1, Variation (SE)	Visit 2, Variation (SE)	ICC
Level 3: School	0.05 (0.01) [S] ^a	0.04 (0.03) [S]	2.4%
Level 2: Children	2.2 (0.04) [S]	1.6 (0.09) [S]	97.6%
Total	2.25	1.64	100%

Abbreviation: ICC, intraclass correlation.

^a[S] = Significant value of 95% confidence intervals with significant level of $\alpha = .05$.

dose-response relationship over time ($P < .05$). We also found that children who watch TV or play video games for more than 2 hours most weekdays tend to sleep less during the weekdays than children who spend less time on screen-based activities, with a significant dose-response relationship over time ($P < .05$; Table 4). There is a strong body of evidence showing that screen-based activities have significantly contributed to decrease night

sleep time. Most important, using the prospective longitudinal design in this analysis, we can infer the causal relationship between screen-based activities and little night sleep among those children. In addition, using this longitudinal multilevel modeling increases the precision of the analysis by accounting for the unmeasured confounders as well as accounting for the clustering within schools, and clustering

of the observations between the 2 time points.¹⁶ These findings from the present prospective cohorts ascertain that TV and video games use may be a short sleep duration risk factor that is prevalent in the child population of Kuwait.

Current evidence reported a remarkable decline in night sleep duration in several different populations, with a substantial parallel rise in the prevalence of metabolic diseases in these populations.²⁰

In this study, a substantial rise in the time spent on screen-based activities was observed over the 2 years. We show that 43.4% of the Kuwaiti children in the study have TVs in their bedrooms (Table 3), and 86.7% watch TV or play video games just before going to bed. In addition, 50% of the children are using their beds for watching TV and playing video games, while only 30% engage in physical exercise most of the weekdays (Table 3). These are alarming findings that may explain the general reduction in the sleep duration among these children. Using electronic devices for long periods can suppress melatonin secretion.²¹ It has been suggested that short wavelength light released from electronic devices significantly inhibits melatonin secretion, resulting in both delayed sleep and a diminished quality of the night sleep.²² A randomized study comparing a group of people who used electronic books with a group who used printed books before bedtime found that individuals who used electronic books sleep fewer night hours and have lower levels of melatonin secretion than the group who used the printed book before bedtime.²³ Melatonin plays an important role in carbohydrate metabolism and insulin regulation.⁶ Moreover, it has been shown that short sleep duration and the use of electronic devices are associated with excess body weight.²²

In the present study, screen-based activities were the most significant factors contributing to reduced night sleep duration among Kuwaiti children. Screen-based activity has been considered a major public health issue, associated with unexpected health conditions such as obesity.²⁴ We showed in

Table 6.School-Level Random Effect of Sleep Behavior and Screen Activities Variables^a.

Within Schools Clustering Effect	Sleep Duration	Screen Activities >2 h/day	Screen Activities Before Bedtime	Use Bed for Screen Activities
	2.07 (0.2) [S] ^b	4.8 (0.5) [S]	0.8 (0.09) [S]	1.6 (0.1) [S]

^aValues presented are the between-schools variations and their standard errors.^b[S] = Significant value estimated at a predetermined significance level of $\alpha = .05$.

our analysis that 65.6% of the children reported eating in front of the TV on most weekdays (Table 3). Independent of physical activity, adolescents who spend excessive time on screen-based activities are more prone to obesity.^{21,25} Strong associations have been consistently observed between the presence of the TV in the bedroom and weight gain, mediated by TV viewing time.^{21,26} It has been reported that screen-based activities have the ability to divert children's attention away from the control of food intake, eventually distracting them from signals of satiety,^{27,28} suggesting that screen activities could mediate the relation between sleep and obesity. A previous cross-sectional study using the same data showed that Kuwaiti children of diabetic parents sleep significantly less than children who have nondiabetic parents. Giving the fact that short sleep duration is related to diabetes and metabolic diseases,^{22,26,29,30} this could be attributed to the family lifestyle factor: it is possible that parents who do not value sufficient night sleep may let their children stay up late, and these parents are more susceptible to be diabetic.

Our findings revealed that short sleep duration was significantly associated with increased waist circumference among Kuwaiti children. Short sleep duration plays an important role in the risk of abnormal weight gain and obesity by creating hormonal imbalance,^{6,31} potentially affecting appetite regulation and glucose metabolism, and eventually leading to the development of

cardiometabolic diseases such as diabetes and cardiovascular disease. It has been reported that the association between sleep duration and weight gain is strongest between the ages of 2 and 18 years,^{5,20} suggesting that children and adolescents may be more vulnerable to the effects of inadequate sleep duration.

Another important findings presented in this study is that schools that children attend make a difference in the examined outcome, the sleep duration (Table 5). We also showed strong clustering effect within schools in reducing the sleep duration and increasing the use of screen-based activities over time (Table 6). This indicates that the school context has a substantial influence in shaping children's behaviors and attitude in the Kuwaiti children population.

Children spend a considerable amount of their time at school.³² Fifty percent of a child's waking time is spent in schools; therefore, school is considered a unique social entity that could configure children's health attitudes and behaviors that eventually shape their health outcomes.^{32,33} Studies show that health outcomes of children with high genetic susceptibility to certain health conditions could be improved if surrounded with a healthy protective environment.³⁴ Therefore, most common health intervention programs are school based, because the school can provide the social contextual framework that would support any selected intervention and enhance targeting risk factors for several health conditions.³²

It has been shown that modifying sleep behavior and improving the quality of sleep is efficient and has the potential to support immunity and relief symptoms of chronic diseases.³ Therefore, school health intervention programs should consider behavioral sleep improvement by educating children and parents about the importance of sleep quality on overall health. Children's behaviors may be more easily influenced than adults, resulting in a greater potential to accept and adopt new behaviors if they are exposed to healthy practices. Therefore, targeting children's beliefs and attitudes is an essential step to building healthy behavior that can enhance overall health and prevent chronic diseases. A recent review explored school determinants for optimal health and included the World Health Organization and Centers of Disease Control and Prevention guidelines. This review reported that school health programs could predict children's health outcomes.^{33,35-37} Strong evidence shows that school health programs can effectively change children's health behaviors and decrease symptoms of chronic diseases.³² Therefore, schools can act as an influential instrument to improve child health outcomes. Research in the United States and other developed countries has successfully identified primary school health determinants.³³ Based on this, school health policies and guidelines have been introduced and implemented to ameliorate chronic disease such as obesity.³⁸ This improvement has evolved from the substantial effort to integrate scientific research into practice.

Findings from our prospective longitudinal study might be the first step for future research and policy implementation to advance total health for Kuwaiti children and others who face similar health challenges. The following are recommendations for future work that evolved from our study: (1) introduce school health intervention and awareness programs to educate children and their families about the importance of sleep health and how to improve night sleep quality and limit

screen-based activities and (2) promote public health research to identify healthy school determinants to help designing future cost-effective school intervention and prevention programs.

Study Limitation

The main problem with children responding to survey questions occurs when the questions are complex, ambiguous, or when information needs to be retrieved from memory.³⁹ In this study, we used direct forward questions with clear language. We pretested the questions in the pilot study. All the behavior questions were asked starting with “In the past week” to make it easier for children to remember over a shorter period of time. The study was conducted during the academic year, so the sleep behavior questions and other questions were consistent with the school season. The self-reported habitual sleep duration and other lifestyle habits might be susceptible to reporting bias. There were no contextual school-level variables measured in the analysis that might explain the big variation between schools.

Conclusion

This prospective cohort showed that screen-based activities are a major issue contributing to reduced sleep time, with a statistically significant dose-response relationship over time. Public health intervention programs should target schools and educate children and their families to focus on improving night sleep behavior as well as limit their screen time.

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References

- Cappuccio FP, Taggart FM, Kandala NB, et al. Meta-analysis of short sleep duration and obesity in children and adults. *Sleep*. 2008;31:619-626.
- Knutson KL. Does inadequate sleep play a role in vulnerability to obesity? *Am J Hum Biol*. 2012;24:361-371.
- Irwin MR. Why sleep is important for health: a psychoneuroimmunology perspective. *Annu Rev Psychol*. 2015;66:143-172.
- Narang I, Manlhiot C, Davies-Shaw J, et al. Sleep disturbance and cardiovascular risk in adolescents. *CMAJ*. 2012;184:E913-E920.
- Danielsen YS, Pallesen S, Stormark KM, Nordhus IH, Bjorvatn B. The relationship between school day sleep duration and body mass index in Norwegian children (aged 10-12). *Int J Pediatr Obes*. 2010;5:214-220.
- Srinivasan V, Ohta Y, Espino J, et al. Metabolic syndrome, its pathophysiology and the role of melatonin. *Recent Pat Endocr Metab Immune Drug Discov*. 2013;7:11-25.
- McMullan CJ, Schernhammer ES, Rimm EB, Hu FB, Forman JP. Melatonin secretion and the incidence of type 2 diabetes. *JAMA*. 2013;309:1388-1396.
- International Diabetic Federation. *IDF Diabetic Atlas*. 5th ed. Brussels, Belgium: International Diabetic Federation; 2011.
- Field AE, Cook NR, Gillman MW. Weight status in childhood as a predictor of becoming overweight or hypertensive in early adulthood. *Obes Res*. 2005;13:163-169.
- Ip EH, Leng X, Zhang Q, et al. Risk profiles of lipids, blood pressure, and anthropometric measures in childhood and adolescence: project heartBeat! *BMC Obes*. 2016;3:9.
- Hatipoglu N, Ozturk A, Mazicioglu MM, Kurtoglu S, Seyhan S, Lokoglu F. Waist circumference percentiles for 7- to 17-year-old Turkish children and adolescents. *Eur J Pediatr*. 2008;167:383-389.
- McCarthy HD, Jarrett KV, Crawley HF. The development of waist circumference percentiles in British children aged 5.0-16.9 y. *Eur J Clin Nutr*. 2001;55:902-907.
- Alqaderi H, Goodson JM, Tavares M, et al. Short sleep duration as a risk factor for obesity in Kuwaiti children. *Integr Obes Diabetes*. 2015;1(5):151-156.
- Al Rashdan I, Al Neseef Y. Prevalence of overweight, obesity, and metabolic syndrome among adult Kuwaitis: results from community-based national survey. *Angiology*. 2010;61:42-48.
- Schaie KW. *Longitudinal Studies of Adult Psychological Development*. New York, NY: Guilford Press; 1983.
- Dong G, Harris R, Jones K, Yu J. Multilevel modelling with spatial interaction effects with application to an emerging land market in Beijing, China. *PLoS One*. 2015;10:e0130761.
- de Onis M, Onyango AW, Borghi E, Siyam A, Nishida C, Siekmann J. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ*. 2007;85:660-667.
- Jodi Mindell JO. *A Clinical Guide to Pediatric Sleep*. Vol. 2. Philadelphia, PA: Lippincott Williams & Wilkins; 2003:18.
- Ruan H, Xun P, Cai W, He K, Tang Q. Habitual sleep duration and risk of childhood obesity: systematic review and dose-response meta-analysis of prospective cohort studies. *Sci Rep*. 2015;5:16160.
- Cappuccio FP, D'Elia L, Strazzullo P, Miller MA. Sleep duration and all-cause mortality: a systematic review and meta-analysis of prospective studies. *Sleep*. 2010;33:585-592.
- Arora T, Hosseini-Araghi M, Bishop J, Yao GL, Thomas GN, Taheri S. The complexity of obesity in U.K. adolescents: relationships with quantity and type of technology, sleep duration and quality, academic performance and aspiration. *Pediatr Obes*. 2013;8:358-366.
- Wood B, Rea MS, Plitnick B, Figueiro MG. Light level and duration of exposure determine the impact of self-luminous tablets on melatonin suppression. *Appl Ergon*. 2013;44:237-240.
- Chang AM, Aeschbach D, Duffy JF, Czeisler CA. Evening use of light-emitting eReaders negatively affects sleep, circadian timing, and next-morning alertness. *Proc Natl Acad Sci U S A*. 2015;112:1232-1237.
- Li C, Beech B, Crume T, et al. Longitudinal association between television watching and computer use and risk markers in diabetes in the SEARCH for Diabetes in Youth Study. *Pediatr Diabetes*. 2015;16:382-391.
- Rey-López JP, Ruiz JR, Vicente-Rodríguez G, et al. Physical activity does not attenuate the obesity risk of TV viewing in youth. *Pediatr Obes*. 2012;7:240-250.
- Borghese MM, Tremblay MS, Katzmarzyk PT, et al. Mediating role of television time, diet patterns, physical activity and sleep duration in the association between television in the bedroom and adiposity in 10 year-old children. *Int J Behav Nutr Phys Act*. 2015;12:60.
- Temple JL, Giacomelli AM, Kent KM, Roemmich JN, Epstein LH. Television watching increases motivated responding for food and energy intake in children. *Am J Clin Nutr*. 2007;85:355-361.
- Marsh S, Ni Mhurchu C, Maddison R. The non-advertising effects of screen-based sedentary activities on acute eating behaviours in children, adolescents, and

- young adults. A systematic review. *Appetite*. 2013;71:259-273.
29. Schwimmer JB, Burwinkle TM, Varni JW. Health-related quality of life of severely obese children and adolescents. *JAMA*. 2003;289:1813-1819.
30. Ju SY, Choi WS. Sleep duration and metabolic syndrome in adult populations: a meta-analysis of observational studies. *Nutr Diabetes*. 2013;3:e65.
31. Hanlon EC, Van Cauter E. Quantification of sleep behavior and of its impact on the cross-talk between the brain and peripheral metabolism. *Proc Natl Acad Sci U S A*. 2011;108(suppl 3):15609-15616.
32. Dunn EC, Masyn KE, Jones SM, Subramanian SV, Koenen KC. Measuring psychosocial environments using individual responses: an application of multilevel factor analysis to examining students in schools. *Prev Sci*. 2015;16:718-733.
33. Huang KY, Cheng S, Theise R. School contexts as social determinants of child health: current practices and implications for future public health practice. *Public Health Rep*. 2013;128(suppl 3):21-28.
34. Dunn EC, Masyn KE, Yudron M, Jones SM, Subramanian SV. Translating multilevel theory into multilevel research: challenges and opportunities for understanding the social determinants of psychiatric disorders. *Soc Psychiatry Psychiatr Epidemiol*. 2014;49:859-872.
35. Sellstrom E, Bremberg S. Is there a "school effect" on pupil outcomes? A review of multilevel studies. *J Epidemiol Community Health*. 2006;60:149-155.
36. Maes L, Lievens J. Can the school make a difference? A multilevel analysis of adolescent risk and health behaviour. *Soc Sci Med*. 2003;56:517-529.
37. World Health Organization. *Socio-Environmentally Determined Health Inequities Among Children and Adolescents. Summary of Outcomes, Background Papers, and Country Case Studies*. Geneva, Switzerland: World Health Organization; 2010.
38. Foster GD, Sherman S, Borradaile KE, et al. A policy-based school intervention to prevent overweight and obesity. *Pediatrics*. 2008;121:e794-e802.
39. Borgers N, De Leeuw E, Hox J. Children as respondents in survey research: cognitive development and response quality 1. *Bulletin de methodologie Sociologique*. 2000;66:60-75.