Journal of Behavioral Health
www.scopemed.org
DOI: 10.5455/jbh.20160216105917

Original Research

Screen time, sleep, and overweight among low-income 8-12 years old youth

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Received: November 08, 2015
Accepted: January 30, 2016
Published: ***

ABSTRACT

Objective: To examine the joint association of sleep duration and screen time (ST) on overweight (including obesity) in low-income 8-12 years old children from Grand Rapids, Michigan. **Methods:** Participants included 237 third-through fifth-grade children. Sleep duration and daily ST were determined via self-report and classified as meeting or not meeting recommendations. Odds of overweight in each group were compared using logistic regression. **Results:** 47% of subjects were at least overweight, 74% did not meet ST recommendations, and 52% slept <10 h per night. Compared to children meeting recommendations for sleep and ST, the odds of overweight were similar among those meeting only one recommendation (sleep or ST), and among those meeting neither sleep nor ST recommendations. **Conclusions:** Results indicate that there is a lack of association between ST and sleep with overweight in this sample.

KEY WORDS: Overweight, obesity, screen time, sleep, television viewing

INTRODUCTION

The current epidemic of pediatric overweight and obesity in the United States, as well as its risk factors and consequences, are well-documented [1]. Two main lifestyle risk factors for child overweight on which researchers usually focus are habitual physical activity and diet. However, other factors are likely to be important as well. Screen time (ST; television [TV] viewing, computer use, and video games) has also received considerable attention [2,3], and more recently, the relationship between sleep duration and overweight has become recognized as a risk factor [3,4]. With regards to overweight and these lifestyle behaviors, there are clear disparities among socio-economic and ethnic groups. Low-income Hispanic and African-American children and adolescents have an increased prevalence of overweight [5] and are less likely to meet recommendations for ST and sleep [6,7]. Thus, it is important to determine the relationship between these lifestyle habits and overweight within these groups.

The proposed mechanisms by which ST influences overweight include reduced energy expenditure, and/or displacement of physical activity, and increased energy intake of calorically dense food during these sedentary pursuits [3]. Pathophysiologically, sleep deprivation could influence the development of overweight through several pathways including increased sympathetic

activity, elevated cortisol and ghrelin levels, decreased leptin, and/or impaired glucose tolerance [8,9]. Indirectly, ST may interfere with sleep duration by delaying bedtime or increasing sleep onset latency [10,11]. Although the independent associations between ST and overweight, as well as sleep duration and overweight, have previously been shown, there is little information on the joint association of sleep and ST with overweight in a low-income, minority population. Therefore, the purpose of this study was to examine the independent and joint association of sleep and ST on overweight (including obesity) in 8-12 years old children residing in low-income neighborhoods in Grand Rapids, Michigan.

METHODS

Subjects

Five elementary schools located in the Grand Rapids, MI (2010 census population 188,040) public school district were selected to be part of Project FIT, a community- and school-based intervention to prevent child obesity and improve physical activity and dietary habits [12]. These schools were chosen since they serve primarily low-income neighborhoods (e.g., 90% of the students qualifying for the Free or Reduced Lunch Program). Data were collected in October and November of 2009. Since the data were collected prior to subject knowledge of randomization into control or treatment groups (e.g., baseline), the analysis in this paper reflects a cross-sectional, observational study design. A total of 434 children were enrolled in the study (57% participation rate). Participation rates were similar among schools. For this analysis, 237 children (age 8-12 years; 106 boys, 131 girls) (9.2% Caucasian, 33.3% African-American, 50.6% Hispanic, 2.5% multi-racial, and 4.2% did not report; reported for each child by the school) with complete data for anthropometry, sleep duration, and ST were included. Participants with incomplete data did not differ from the final included sample with regard to any demographic characteristics. The Michigan State University Institutional Review Board and the Grand Rapids Public School District approved the study protocol. All parents provided written consent and children provided written assent prior to testing. Data collection procedures were reviewed with the child on the day of testing, and trained study staff assisted children with survey completion to improve validity.

Anthropometry

Stature was measured without socks and shoes to the nearest 0.1 cm using a Shorr board (Shorr Production, Olney, MD), and body mass was determined using the Tanita BC-534 InnerScan body composition Monitor (Tokyo, Japan; US Service Center Arlington Heights, IL). Body mass index (BMI) was calculated from measured stature and mass, and weight status (normal weight, overweight, and obese) was classified using CDC growth chart age- and sex-specific cut points (underweight $<5^{th}$ percentile, overweight = 85-94.9^{th} percentile; and obese $\geq 95^{th}$ percentile) [13].

Lifestyle Behaviors

ST (TV viewing, video games, and computer usage) and sleep duration were determined by self-report questionnaire. Children were asked to indicate the number of hours they watched/played on weekdays and weekends for each of the three screen media types. Daily ST (h/d) was calculated, and children were classified as meeting or not meeting the recommendation of 2 h per day of ST [14]. Test-retest reliability of self-reported ST ranges from low to moderately high (r = 0.25-0.80) depending on the length of the retest period [15]. For sleep duration, children were asked to indicate their usual bedtime and waking time on weekdays and weekend days and average daily sleep was calculated. Children were also classified as meeting or not meeting the recommended amount of sleep - 10 h per day [16]. 10 h per night was chosen as the sleep duration cut-point in this study because it represents the median of current recommendations (9-11 h) and closely approximates the mean sleep time in the current sample. Physical activity was self-reported using the same question used in the Youth Risk Behavior Survey and is reported as days per week of physical activity. Trained members of the research staff assisted the children with survey completion to improve validity.

Statistical Analysis

Descriptive statistics were calculated for the total sample and by sex. Partial correlation analysis, controlling for age and sex, was conducted to examine the associations between ST, sleep duration, and the BMI percentile. Differences in sleep duration and ST between normal weight and overweight/obese children were examined using analysis of covariance (ANCOVA), adjusted for age, sex, ethnicity, school, and self-report physical activity. Logistic regression was used to initially assess the utility of the current ST and sleep duration cut-off points independently. Following children were categorized into four groups based on whether they met the ST and/or sleep duration recommendations: (1) Do not meet sleep/do not meet ST, (2) meet sleep/do not meet ST, (3) do not meet sleep/meet ST, and (4) meet sleep/Meet ST. The frequency of overweight and obesity were calculated for each of these groups. Finally, logistic regression was used to calculate the odds of combined overweight and obesity and obesity alone (results not significant, not shown) for each grouping of sleep and ST. The group not meeting sleep and ST recommendations was considered the referent for all analyzes. Models were adjusted for age, sex, ethnicity, and school. All statistical analyzes were performed using SPSS Statistics version 19.0.

RESULTS

Descriptive characteristics are shown in Table 1. In the total sample, the mean percentile for height was 52.5% (boys 47.1% and girls 56.6%), weight was 66.4% (boys 67.9% and girls 65.1%), and BMI was 70.9% (boys 75.1% and girls 67.5%). Of the total sample, 47% were overweight (18.1%) or obese (29.2%). Approximately 74% of the sample did not meet ST

Table 1: Descriptive characteristics of the sample. values are mean (SD) unless otherwise indicated

Variable	Group 1	Group 2	Group 3	Group 4	*P*
	n=38	*n*=77	*n*=24	*n*=98	
Age (y)	9.4 (0.9)	9.7 (0.9)	9.8 (0.8)	9.8 (0.9)	0.154
Height (cm)	135.9 (8.3)	137.9 (9.2)	137.2 (7.0)	138.9 (8.8)	0.364
Weight (kg)	38.6 (13.3)	37.3 (11.0)	39.4 (13.9)	408 (13.4)	0.356
BMI (kg/m^2)	20.6 (5.3)	19.4 (4.0)	20.5 (5.4)	20.7 (4.9)	0.257
Overweight (%)	10.5	23.4	12.5	18.4	
Obese (%)	36.8	22.1	29.2	31.6	
Daily ST (h)	1.2 (0.4)	5.4 (2.7)*	1.1 (0.5)	5.5 (2.8)*	*P*<0.0001
Daily sleep (h)	10.8 (0.7)	10.5 (0.5)	9.3 (0.6)*	8.9 (0.8)*#	*P*<0.0001
PA (d/week)	3.7 (0.4)	3.7 (0.3)	4.2 (0.5)	4.1 (0.3)	0.626
Percent black	31.6	29.9	29.2	37.8	
Percent hispanic	52.6	53.2	54.2	46.9	
Percent multi-racial	2.6	1.3	8.3	2.0	

*Denotes statistical significance (*P*<0.05) compared to Group 1. #Denotes statistical significance (*P*<0.05) compared to Group 3. Group definitions: Group 1=Meet sleep/meet ST; Group 2=Meet sleep/not ST; Group 3=Not sleep/meet ST; Group 4=Not sleep/not ST. Sleep recommendation ≥10 h/day; ST recommendation <2 h/day. Overweight=BMI 85-94.9th percentile; Obese=BMI≥95th percentile, ST: Screen time, BMI: Body mass index, SD: Standard deviation

recommendations (mean = 4.4 ± 3.0 h/day) and 52% slept <10 h per night (mean = 9.8 ± 1.1 h). 41% were classified as not meeting either sleep or ST recommendations [Table 2].

Partial correlation analyzes among sleep duration, ST, and BMI percentile indicate a small but significant negative association between ST and sleep duration ($r = -0.18$, $P = 0.006$) but no significant relationship between both ST or sleep duration and BMI percentile ($r = -0.07$, $P = 0.32$ and $r = 0.03$, $P = 0.66$, respectively). Results from the ANCOVA indicated that there was not a significant main effect for sleep or ST on BMI percentile (results not shown). In addition, there was no significant interaction between sleep duration and ST on BMI percentile. Physical activity did not differ between sleep/ST groups or between normal weight and overweight participants.

The odds of overweight (including obesity) in boys and girls meeting ST recommendations were similar to those not meeting recommendations (odds ratio [OR] = 1.0, 95% confidence interval [CI] = 0.55-1.86). Similarly, the odds of overweight in boys and girls not meeting sleep duration recommendations were similar to those meeting recommendations (OR = 1.1, 95% CI = 0.65-1.92). The percentage of overweight and obese children in each combined sleep duration-ST category is shown in Table 1. The results of the logistic regression examining the joint association of sleep duration and ST are shown in Table 2. The odds of overweight among children not meeting recommendations for sleep duration and ST were not significantly different from those among the other three groups (i.e., range for OR = 0.82-0.98; 95% CI = 0.33-2.18; Table 2). *Post-hoc* analysis using 9 h as the sleep duration cut-point did not change these results (not shown).

DISCUSSION

The current study was unique in that we expanded upon previous studies by considering the joint association of total daily ST and sleep duration on overweight among low-income, primarily minority children living in an urban area.

Table 2: Association of screen time and sleep duration on the odds of overweight and obesity (combined) in 8-12 years old children

Meet sleep recommendation (10 h/d)	Meet screen time recommendation (2 h/d)	No. of sample (%)	Adjusted OR*	95% CI
No	No	98 (41.4)	Referent	-
Yes	No	77 (32.5)	0.82	0.44-1.53
No	Yes	24 (10.1)	0.84	0.33-2.14
Yes	Yes	38 (16.0)	0.98	0.44-2.18

*Adjusted for age, sex, ethnicity, and school, CI: Confidence interval, OR: Odds ratio

Our data show an inverse correlation between ST and sleep duration, indicating those who reported longer ST tended to sleep less ($r = -0.18$, $P = 0.006$). 41% of the sample did not meet recommendations for sleep duration and ST combined. Regardless, we did not find evidence for a joint association between sleep duration and ST on overweight. However, 29% of the sample was obese, 74% did not meet ST recommendations, and 52% slept <10 h per night. In addition, 41% were classified as not meeting either sleep or ST recommendations while only 16% met both recommendations. Days of physical activity per week did not differ between groups or by weight status and only 30% reported being physically active 7 days per week. These prevalence rates are a cause for concern due to the well-established links between these variables and the immediate and future health outcomes [1,2,17].

The null findings indicate that the prevalence of overweight is similar across the four cross-tabulated groups [Table 1], which indicates that just as many normal weight children have poor ST and sleep habits as overweight children. These results may have been observed for a number of reasons. Most obviously, measurement error due to the self-report of lifestyle behaviors may result in misclassification of ST and/or sleep duration. As seen in Table 1, a higher proportion is obese in the group that meets both recommendations compared to the other three groups. It is possible that these obese children may be self-reporting more socially desirable behaviors.

When examining the independent association between sleep duration and odds of overweight, our results do not indicate any differences between those meeting and not meeting sleep recommendations. Similarly, the correlation between sleep duration and BMI percentile was null ($r = 0.03$, $P = 0.66$). Although about half of the current sample slept <10 h/night, only 19.4% slept <9 h/night and 5.1% slept <8 h/night. This lack of variability at the lower end of the sleep duration spectrum reduces our ability to determine the cut-off for increased obesity risk with shortened sleep duration. Furthermore, the lack of variability in sleep duration limits comparability to results of previous studies, especially those including reasonably large samples of children who slept < 8 h and/or < 5 h/night. In addition, we did not assess the previous sleep practices of our participants and did not know whether the sleep duration measured in this study reflects their lifelong habits. The lack of such knowledge should not negate the importance of examining children's sleep duration because previous studies have shown shorter sleep duration in younger children influences BMI over time [18,19].

In general, short sleep is related to overweight and/or obesity as shown in a meta-analysis of 11 studies where the pooled odds ratio for short sleep duration was 1.58 (95% CI = 1.26, 1.98) [4]. Besides the cross-sectional associations between sleep duration and overweight, sleep duration predicts the development of overweight over time. Lumeng *et al*. [18] found that longer sleep duration in the 3rd grade was associated with significantly reduced odds of obesity in 6th grade (40% reduction for each additional hour of sleep). These results are supported by those of Landhuis *et al*. [19] who found that sleep duration at ages 5, 7, 9, and 11 years predicted BMI at 32 years of age. There remains a possibility that normal weight youth who are not meeting sleep recommendations in our sample will develop overweight as they move through puberty; unfortunately, it is not possible to determine this with the available data.

The positive relationship between ST and overweight is well-documented. In a 2004 meta-analysis [2], mean effect size between TV and body fatness was 0.066, which may be too small to be clinically significant. In general, our results are in contrast to previous studies. In similar aged children, Laurson *et al*. [20] found a weak correlation between ST and BMI (0.22 in boys 0.13 in girls). In addition, boys exceeding the recommendation for daily ST (i.e., > 2 h of total ST) were 1.69 times more likely to be overweight. Similarly, in a study of over 4,000 Brazilian 10-12 years old, those watching <2 h of TV per day were 1.3 times more likely to be overweight or obese [21].

Few studies have utilized a similar approach to study the combined relationships of sleep and ST. The Brazilian study discussed in the previous paragraph [21] included analyzes of sleep duration and TV, both independently and jointly. In that study, the highest BMI was found in children who slept the least and watched the most TV, while the lowest BMI was found in those who slept the most and watched the least TV. However, these results did not reach statistical significance, and unfortunately, the values are not reported in the paper. More recently, sleep duration has been shown to be a modest predictor of child weight status (daily sleep 33 min greater among normal weight than overweight/obese children), while ST was not a significant predictor [22]. A 2014 analysis by Laurson *et al*. supports a joint association between sleep, ST, and physical activity on the odds of obesity. Their results demonstrate that children who fail to meet sleep and PA recommendations are more likely to be obese, but again, ST was not a significant independent predictor. Unsurprisingly, children who met all three recommendations were least likely to be obese [23]. The lack of association between ST and odds of obesity in these two studies are consistent with our findings; however, our data do not support a relationship between sleep time and odds of overweight (including obesity). It is important to note that sleep and ST in the Laurson's study were assessed similarly to our methods while behaviors were reported jointly by children and parents in the Appelhans study. Furthermore, Laurson's study population was mostly white, though the sample in the Appelhans study was 77% black and 76.6% fell below the federal poverty level.

Despite the null associations, the prevalence of overweight and obesity in this sample is alarming. NHANES 2011-2014 data indicate that 17% of children age 2-19 years are obese, while rates are highest among non-Hispanic black (19.5%) and Hispanic (21.9%) youth [5]. In contrast, the prevalence of obesity in the current study was 29.2% in the total sample (12.7% black, 39% Hispanic, and 50% multi-racial). More so, 6.8% of children had a BMI-for-age > 99th percentile. Furthermore, 6.8% of the current sample had a BMI ≥ 99th percentile, with the highest prevalence among blacks (3.8%), Hispanics (6.7%), and multi-racial students (16.7%). These rates are higher than national data that suggest that 2.1% of children 2-19 years old exhibit Class 3 obesity, with corresponding rates highest among blacks (3.2%) and Hispanics (1.8%) [24]. Thus, a considerable attention needs to be devoted to the prevention and treatment of pediatric obesity in Hispanic and African-American children from low-income households.

In addition to high rates of obesity, the mean ST in this sample was 4.4 h/day, with 74% of the children failing to meet the recommendation of <2 h of total ST per day. Marshall *et al*. [25] reviewed trends in TV, video game, and computer use and estimated that the prevalence of watching ≤2 h per day of TV for boys and girls aged 7-12 years was 66%. 58% of the current sample watched ≤2 h of TV per day, and 13.5% watched 4 h of TV per day. In addition, Marshall *et al*. estimated the average time spent playing video games and working on a computer was 40 min/day and 34 min/day, respectively. In comparison, the current sample averaged 64 min/day on the computer and 98 min/day playing video games. It is important to remember that these data were collected in 2009; thus, it could be expected that the use of smartphones, tablets, and other handheld electronic media was limited. This may limit the generalizability of our results to current trends. Understanding the influence of different media types on overall ST patterns may lead to a better understanding of the association between ST and sleep and outcomes such as weight status.

This study is limited by the cross-sectional design and self-report measures of lifestyle variables. Most, if not all, of the studies examining the relationship between sleep duration and overweight in children have used self-report [4]. In the case of sleep, the parental report is commonly used, but this may not accurately record the time the child is in bed but not yet asleep. With the increased prevalence of TV in the bedroom and the use of other electronic devices, the amount of sleep (and ST) may not be reported accurately, again leading to an error in measurement. In contrast to other studies, we included weekday and weekend sleep habits in our measures. Accelerometry and other new technologies are being developed to better objectively measure sedentary pursuits such as sleep [26] and ST viewing. Many accelerometers that are currently available can measure ambient light exposure, which may allow for objective evaluation of electronic device usage after bedtime. As these technologies become more commonly used, the ability to better measure these behaviors and compare across cohorts will allow better determination of their influence with childhood overweight and obesity. Further research incorporating objective measures is required to better characterize the role of sleep quality/quantity in child obesity.

In summary, no association between ST, sleep, and overweight/obesity was found in this sample of 8-12 years old children. However, the high prevalence of overweight and low proportion meeting recommendations for sleep and ST is concerning. The null findings in the current study suggest that other factors (i.e., prenatal and early life influences, chronic stress, and food insecurity) may be significant determinants of overweight in this sample. Longitudinal investigations are warranted to gain further understanding of these relationships.

ACKNOWLEDGMENTS

The school component of Project FIT is a partnership among Michigan State University, Grand Rapids Public Schools, YMCA of Greater Grand Rapids, and Michigan State University Extension. It is supported by Blue Cross Blue Shield of Michigan and USDA's Supplemental Nutrition Assistance Program - Nutrition Education program by way of the Michigan Nutrition Network at Michigan State University Extension in partnership with the Michigan Fitness Foundation. This material is based on work supported in part by the Michigan Department of Human Services, under contract number ADMIN-10-99010.

HUMAN SUBJECTS

The Project FIT study protocol was approved by the Michigan State University Institutional Review Board and the Grand Rapids Public School District.

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Source of Support: Nil, Conflict of Interest: None declared.