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Effect of experimental change in children's sleep duration on television viewing and physical activity

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Summary

Background: Paediatric observational studies demonstrate associations between sleep, television viewing and potential changes in daytime activity levels.

Objective(s): To determine whether experimental changes in sleep lead to changes in children's sedentary and physical activities.

Methods: Using a within-subject counterbalanced design, 37 children 8–11 years old completed a 3-week study. Children slept their typical amount during a baseline week and were then randomized to increase or decrease mean time in bed by 1.5 h/night for 1 week; the alternate schedule was completed the final week. Children wore actigraphs on their non-dominant wrist and completed 3-d physical activity recalls each week.

Results: Children reported watching more television ($p < 0.001$) and demonstrated lower daytime actigraph-measured activity counts per epoch ($p = 0.03$) when sleep was decreased (compared

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The authors have no conflicts of interests related to this work to disclose.

with increased). However, total actigraph-measured activity counts accrued throughout the entire waking period were higher when sleep was decreased (and children were awake for longer) than when it was increased ($p < 0.001$).

Conclusion(s): Short sleep during childhood may lead to increased television viewing and decreased mean activity levels. Although additional time awake may help to counteract negative effects of short sleep, increases in reported sedentary activities could contribute to weight gain over time.

Keywords

Physical activity; sleep duration; television.

Introduction

Studies consistently demonstrate cross-sectional and prospective associations between sleep and obesity risk in children (1–4), with emerging evidence also demonstrating associations with cardiometabolic outcomes as well. (5) A number of pathways have been implicated in the association between sleep and obesity risk (1), with most studies to date focusing on changes in the neuroendocrine control of food intake. Several experimental studies with adults provide support for this pathway by demonstrating that short sleep results in changes in hunger and satiety signalling hormones, ghrelin and leptin (6–10), as well as changes in ad libitum food intake (11–13). However, findings have not always been consistent (9,10,14), including mixed findings in studies with adolescents (15,16). Although observational studies demonstrate associations between sleep and eating behaviours in children (17–19), less is known about how changes in sleep lead to changes in obesity risk. A recent experimental study with school-age children demonstrated that compared with 1 week of enhanced sleep, when sleep was restricted for 1 week, 8 to 11-year-old children reported consuming 134 kcal/d more and weighed approximately 0.5 lb more (20). Thus, evidence suggests that similar changes in eating behaviours may account, in part, for associations between sleep and weight status in paediatric samples as well.

Fewer studies have assessed how changes in sleep may influence energy expenditure. Results from adult experimental studies have been mixed. Schmid and colleagues (14) found that compared with a rested condition, when sleep was restricted, accelerometer-estimated physical activity under free-living conditions (i.e. outside of the laboratory) decreased. Similarly, Benedict and colleagues (9) found that compared with a rested condition, daytime energy expenditure as measured by indirect calorimetry decreased following 24-h sleep deprivation. In contrast, others have found either no effect of sleep on activity (12), or that sleep restriction leads to increased activity/energy expenditure (11,13) with additional hours awake accounting, in part, for observed increases (13). We are unaware of any such studies with school-age children, yet observational studies suggest that shortened sleep duration is associated with increased sedentary activities, particularly television viewing (21–24). However, similar to findings with adults, associations between sleep and physical activity in children have been mixed (25–27).

The purpose of the present study was to determine whether experimental changes in children's sleep lead to changes in daytime activities. Specifically, we hypothesized that compared with a 1-week increased sleep condition, 1 week of restricted sleep would lead to reported increases in television viewing and decreases in moderate to vigorous physical activity. During the decreased sleep condition, children would also evidence lower activity counts (as measured by actigraphy) during waking hours.

Methods

Participants

Thirty-nine children 8–11 years old who slept approximately 9.5 h per night (i.e. between 9.25 and 9.75 h per night based on parent report) were enrolled. The criterion for sleep duration was chosen, given that national estimates suggest that the mean sleep length for school-aged children is approximately 9.5 h/night (28) and to enable both extension and restriction of sleep duration without reaching a ceiling for what children could sleep and minimizing risks associated with sleep restriction respectively. To ensure that undetected medical conditions would not affect outcomes, children also needed to be at or above the fifth percentile body mass index (BMI) for their age and gender, but no more than 100% overweight (i.e. having a BMI that is no more than twice the mean BMI for a given age and sex). They were considered ineligible if diagnosed with a medical/psychiatric condition or current medication that could affect sleep or weight status. Thirty-seven (95%) children completed the study. Two families chose to discontinue participation because of health concerns associated with sleeping too little during the decreased sleep condition. The mean (SD) age of the participants was 9.6 (1.0) years old. Eighty-one percent were non-Hispanic White, 57% were boys, and 27% were overweight/obese; the mean (SD) BMI z-score was 0.21 (0.89).

Procedures

Families were recruited between March 2009 and December 2011 from southeastern New England through the use of mailers, advertisements and flyers posted throughout the community and on the centre website, which invited participation in a study assessing how changes in children's sleep affect their daytime behaviours. Families were first screened by phone, and those who appeared eligible attended individual orientations, during which written consent was obtained from parents and assent from children. Final eligibility for the study was determined during a baseline assessment of their typical week of sleep. During the baseline week, if the mean reported time in bed (TIB) was approximately 9.5 h/night, and the actigraph was consistent with self-report, children were enrolled. Sleep achieved during this week also served as the starting point for prescribing changes in TIB during the two experimental conditions.

Eligible participants were randomized using a variably sized permuted blocks randomization procedure (stratified by weight status: normal weight vs. overweight/obese) to increase or decrease TIB by 1.5 h/night for 1 week. The alternate schedule was completed in the subsequent and final week of the study, which allowed for a prescribed 3 h/night TIB difference between the increase and decrease conditions. Changes in TIB were achieved by changing bedtimes; wake times remained constant. Naps were not allowed. Throughout the study, the children wore actigraphs on their non-dominant wrist, completed sleep diaries and called the research centre twice daily (to confirm adherence to the prescribed sleep schedule). The families completed 3-d (two weekdays and one weekend day) Previous Day Physical Activity Recalls (PDPARs) (29) each week. They were compensated up to $75 each week ($5 per day for adhering to the sleep schedule and calling the centre; $40 for each in-laboratory assessment). All procedures were approved by the Institutional Review Board at the Miriam Hospital.

Measures

Anthropometrics—Child height and weight were measured by trained staff while the children were in street clothes without shoes. Weight was measured using a calibrated digital scale (Tanita BWB-800; Arlington Heights, IL, USA) to the nearest 0.1 pound. Height was measured to the nearest mm with wall-mounted stadiometers (Perspective Enterprises, Portage, MI, USA). Weight status (normal weight vs. overweight/obese) and BMI z-score were calculated using each child's age-appropriate and sex-appropriate sample from the Centers for Disease Control and Prevention normative data (30).

Sleep—Sleep was measured with Actiwatch 2 actigraphs (AW2; Phillips Respironics, Bend, OR, USA), which the children wore on their non-dominant wrist for 24-h/d throughout the study. AW2s have demonstrated reliability and validity when compared with polysomnography in the children (31). The devices were configured to collect data in 1-min epochs using a medium sensitivity threshold. The data were scored for sleep versus wake using ACTIWARE software, version 5.59.0015. Consistent with recommended procedures, the children completed sleep diaries to help establish sleep onset and wake times (32). Upon downloading the actigraph data using the ACTIWARE software, discrepancies between self-report and actigraph-estimated sleep versus wake (e.g. actigraph demonstrates sleep onset occurring > 15 min earlier than self-report) were reviewed with the families; issues remaining after this review (e.g. families could not remember) were rectified during consensus meeting with the first and fourth authors of this manuscript and the study staff. Sleep onset and wake times were then entered into the ACTIWARE software to establish sleep periods for each night (i.e. the time between estimated sleep onset and wake the next day). All the children had at least five nights of valid actigraph-measured sleep during each experimental condition.

Physical activity—The PDPAR, which has demonstrated reliability and validity (29), was used to assess reported engagement in sedentary and physical activities. During each experimental week, the study staff prescribed two weekdays and one weekend day, for which the families reported on the children's activities in 30-min increments from 06:00–23:30. The staff reviewed the PDPARs with the families to ensure accuracy in completion. Metabolic equivalent values were computed for each 30-min block with reference to the compendium of energy expenditure in youth (33) and categorized into different intensities of activity (i.e. very light, light, medium and hard). Given its association with sleep (21–24) and obesity risk (34), and that the American Academy of Pediatrics provides guidelines regarding television viewing in hours/day (35), total time spent watching television each day was also computed by adding each 30-min block of time devoted to it. Variables of interest included mean percent time in moderate-to-vigorous intensity physical activity (MVPA) and mean hours watching television each week.

To obtain an objective estimate of energy expenditure, daytime activity counts on the AW2s were examined. Two variables were of interest: (i) mean activity counts per epoch and (ii) total daily activity counts. These two different approaches to the data were of interest based on findings with adults, suggesting that decreased sleep is associated with lower average activity levels, yet increased overall energy expenditure (possibly a result of the additional time awake) (11–14,36).

Data analysis

The data were analysed using STATA version 14.0. Tukey's ladder of powers indicated that square root transformations were most appropriate for all study outcomes. The results were unaffected by whether raw or transformed data were analysed. All the participants experienced both increased and decreased sleep conditions, but order was counterbalanced. Cluster sandwich estimators were used to adjust standard errors for repeated measures. The statistical model that was applied adjusted for sleep condition, presentation order and trial, i.e. $y_{it} = b_{0i} + b_1 \times \text{increased sleep} + b_2 \times \text{presentation order} + b_3 \times \text{trial} + e_{it}$. Interactions were not considered because of the incomplete nature of the experimental design. Because the results were identical with raw and transformed data, and with and without adjusting for additional features of the design, the results are reported here based on paired *t*-tests of raw data for greatest ease of interpretation.

Results

The table presents baseline values (i.e. prior to randomization) for reported television viewing and engagement in MVPA as well as average AW2 activity counts/epoch and total AW2 activity counts accrued throughout the day. Overall, the baseline values fall between the values observed during the increased and decreased sleep conditions (Table 1). Supporting the success of the experimental manipulation, the children achieved a mean 2 h 21 min difference in the actigraph-measured sleep period during the increase and decrease conditions, $t_{paired} = 38.00$, $p < 0.001$. Detailed information on experimental differences in actigraph-measured sleep was previously reported (20).

Compared with when the children increased their sleep, when they decreased their sleep, they reported watching an additional hour of television each day ($p < 0.001$) (Table 1). There were no reported differences on the PDPAR for percent time in MVPA ($p = 0.97$). During the decreased sleep condition, AW2 activity counts demonstrated that the children were less active on average (i.e. per epoch) than during the increased condition ($p = 0.03$). However, total activity counts accrued throughout the entire day were higher during the decrease than the increase condition ($p < 0.001$).

Discussion

Findings demonstrate that experimental changes in sleep lead to changes in reported television viewing and objective assessment of activity in school-age children. Specifically, the children reported watching one additional hour per day of television following sleep restriction, and on average, were less active. These findings build upon previous experimental studies by focusing on a paediatric sample and on energy expenditure (as opposed to pathways associated with energy intake) as well as assessing sedentary and physical activities outside of a laboratory setting.

The present findings suggest that compared with a rested condition, when sleep is restricted, objective estimates of daytime activity were, on average, lower. In contrast, we also observed a seemingly opposite effect of sleep restriction for total activity counts accrued throughout the day. Although the children had lower activity counts per epoch during the decreased sleep condition, additional hours awake likely helped to compensate for these lower mean activity levels, such that the children were able to accumulate more activity throughout the day (given that they were awake for almost 2.5 h more during this experimental condition). This observation is consistent with the mixed findings in the adult literature. In general, studies that focused on daytime activity/energy expenditure observed decreased activity/energy expenditure following sleep restriction (9,14). However, studies that assessed energy expenditure throughout the 24-h period and/or during all waking hours generally found that total activity/energy expenditure either did not differ (12) or was greater following sleep restriction than rest (11,13). It is also interesting to note that despite greater observed energy expenditure in some studies, even greater increases in energy intake have been observed, which was associated with weight gain when sleep was restricted (13). This finding is consistent with what we have observed in this sample of school-aged children. Although the children accrued more activity counts throughout the entire day during the decreased sleep condition, they also reported an increase in caloric intake, which resulted in a net increase in how much they weighed (20).

In addition to the children's objectively measured activity level, when sleep was decreased, the children reported watching an additional hour of television each day. We are unaware of any additional experimental studies that have assessed how changes in sleep affect television viewing. However, findings are consistent with extant observational studies, which have demonstrated associations between greater television viewing and both short sleep, (21–24,37) and increased sleep disturbances (37) in paediatric samples. It is important to consider observed reported increases in television viewing reported herein in light of the previously reported findings from the present study, which demonstrated reported increases in caloric intake and higher measured weight following 1 week of sleep restriction (20). Taken together with evidence suggesting that increased television viewing may be associated with weight gain via increased food intake (38), findings from the present experimental study suggest that short sleep may predispose a child to be more sedentary, which in turn may lead to increased food intake. Particularly, given high levels of insufficient sleep and a high proportion of children who exceed current recommendations for television viewing (35), future work should explore how sedentary activities such as television viewing may mediate the effect of short sleep on obesity risk.

The strengths of the study include the use of an experimental study design in school-age children and the high levels of participant adherence to the prescribed changes in sleep, which allows for a valid test of the influence of sleep on activity outcomes. In addition to these strengths, the limitations include use of self-report to measure television viewing and engagement in MVPA. Thus, reporting bias cannot be ruled out. In particular, given research documenting that children accrue MVPA in short bouts (39,40), the 30-min blocks of time used for reporting activity in the present study may have precluded our ability to observe changes in MVPA engagement. Differences in findings in the present study for self-report and objective measures may be due, at least in part, to this limitation. They may also be because the wrist-worn devices used in the present study only provide data on activity counts, which cannot be converted into metabolic equivalents; hip-worn devices are currently considered the best way to assess daytime physical activity (41). Future studies would benefit from the use of hip-worn accelerometers to better capture engagement in MVPA. Given that this is, to our knowledge, the first study to assess changes in activity following experimental changes in children's sleep, the findings nonetheless provide a signal for the effect of sleep on engagement in subsequent daytime activity.

In conclusion, changes in children's nocturnal sleep are associated with changes in reported television viewing and objectively estimated daytime activity. The findings suggest that in addition to changes in the neuroendocrine control of food intake, sleep may also affect activity pathways that could increase children's obesity risk. Thus, sleep may represent a modifiable health behaviour to be considered for public health interventions that are aimed at obesity prevention.

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References

1. Patel SR, Hu FB. Short sleep duration and weight gain: a systematic review. Obesity (Silver Spring, Md) 2008; 16: 643–653.
2. Hart CN, Cairns A, Jelalian E. Sleep and obesity in children and adolescents. Pediatr Clin North Am 2011; 58: 715–733. [PubMed: 21600351]
3. Chen X, Beydoun MA, Wang Y. Is sleep duration associated with childhood obesity? A systematic review and meta-analysis. Obesity (Silver Spring, Md) 2008; 16: 265–274.
4. 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. [PubMed: 18517032]
5. Quist JS, Sjodin A, Chaput JP, Hjorth MF. Sleep and cardiometabolic risk in children and adolescents. Sleep Med Rev 2015; 29: 76–100. [PubMed: 26683701]

6. Mullington JM, Chan JL, Van Dongen HP, et al. Sleep loss reduces diurnal rhythm amplitude of leptin in healthy men. J Neuroendocrinol 2003; 15: 851–854. [PubMed: 12899679]
7. Spiegel K, Leproult R, L'Hermite-Baleriaux M, Copinschi G, Penev PD, Van Cauter E. Leptin levels are dependent on sleep duration: relationships with sympathovagal balance, carbohydrate regulation, cortisol, and thyrotropin. J Clin Endocrinol Metab 2004; 89: 5762–5771. [PubMed: 15531540]
8. Spiegel K, Tasali E, Penev P, Van Cauter E. Brief communication: sleep curtailment in healthy young men is associated with decreased leptin levels, elevated ghrelin levels, and increased hunger and appetite. Ann Intern Med 2004; 141: 846–850. [PubMed: 15583226]
9. Benedict C, Hallschmid M, Lassen A, et al. Acute sleep deprivation reduces energy expenditure in healthy men. Am J Clin Nutr 2011; 93: 1229–1236. [PubMed: 21471283]
10. Schmid SM, Hallschmid M, Jauch-Chara K, Born J, Schultes B. A single night of sleep deprivation increases ghrelin levels and feelings of hunger in normal-weight healthy men. J Sleep Res 2008; 17: 331–334. [PubMed: 18564298]
11. Brondel L, Romer MA, Nougues PM, Touyarou P, Davenne D. Acute partial sleep deprivation increases food intake in healthy men. Am J Clin Nutr 2010; 91: 1550–1559. [PubMed: 20357041]
12. St-Onge MP, Roberts AL, Chen J, et al. Short sleep duration increases energy intakes but does not change energy expenditure in normal-weight individuals. Am J Clin Nutr 2011; 94: 410–416. [PubMed: 21715510]
13. Markwald RR, Melanson EL, Smith MR, et al. Impact of insufficient sleep on total daily energy expenditure, food intake, and weight gain. Proc Natl Acad Sci U S A 2013; 110: 5695–5700. [PubMed: 23479616]
14. Schmid SM, Hallschmid M, Jauch-Chara K, et al. Short-term sleep loss decreases physical activity under free-living conditions but does not increase food intake under time-deprived laboratory conditions in healthy men. Am J Clin Nutr 2009; 90: 1476–1482. [PubMed: 19846546]
15. Klingenberg L, Chaput JP, Holmback U, Jennum P, Astrup A, Sjodin A. Sleep restriction is not associated with a positive energy balance in adolescent boys. Am J Clin Nutr 2012; 96: 240–248. [PubMed: 22760574]
16. Beebe DW, SImon S, Summer S, Hemmer S, Strotman D, Dolan LM. Dietary intake following experimentally restricted sleep in adolescents. Sleep 2013; 36: 827–834. [PubMed: 23729925]
17. Hjorth MF, Quist JS, Andersen R, et al. Change in sleep duration and proposed dietary risk factors for obesity in Danish school children. Pediatr Obes 2014; 9: e156–e159. [PubMed: 25251317]
18. Weiss A, Xu F, Storfer-Isser A, Thomas A, Ievers-Landis CE, Redline S. The association of sleep duration with adolescents' fat and carbohydrate consumption. Sleep 2010; 33: 1201–1209. [PubMed: 20857867]
19. Westerlund L, Ray C, Roos E. Associations between sleeping habits and food consumption patterns among 10–11-year-old children in Finland. Br J Nutr 2009; 102: 1531–1537. [PubMed: 19664303]
20. Hart CN, Carskadon MA, Considine RV, et al. Changes in children's sleep duration on food intake, weight, and leptin. Pediatrics 2013; 132: e1473–e1480. [PubMed: 24190680]
21. Marinelli M, Sunyer J, Alvarez-Pedrerol M, et al. Hours of television viewing and sleep duration in children: a multicenter birth cohort study. JAMA Pediatr 2014; 168: 458–464. [PubMed: 24615283]
22. Magee CA, Lee JK, Vella SA. Bidirectional relationships between sleep duration and screen time in early childhood. JAMA Pediatr 2014; 168: 465–470. [PubMed: 24589672]
23. Cespedes EM, Gillman MW, Kleinman K, Rifas-Shiman SL, Redline S, Taveras EM. Television viewing, bedroom television, and sleep duration from infancy to mid-childhood. Pediatrics 2014; 133: e1163–e1171. [PubMed: 24733878]
24. Falbe J, Davison KK, Franckle RL, et al. Sleep duration, restfulness, and screens in the sleep environment. Pediatrics 2015; 135: e367–e375. [PubMed: 25560435]
25. Williams SM, Farmer VL, Taylor BJ, Taylor RW. Do more active children sleep more? A repeated cross-sectional analysis using accelerometry. PLoS One 2014; 9: e93117. [PubMed: 24695112]

26. Ekstedt M, Nyberg G, Ingre M, Ekblom O, Marcus C. Sleep, physical activity and BMI in six to ten-year-old children measured by accelerometry: a cross-sectional study. Int J Behav Nutr Phys Act 2013; 10: 82. [PubMed: 23800204]
27. Stone MR, Stevens D, Faulkner GE. Maintaining recommended sleep throughout the week is associated with increased physical activity in children. Prev Med 2013; 56: 112–117. [PubMed: 23201000]
28. Foundation NS. Final report: 2004 sleep in America poll. 2004. http://www.sleepfoundation.org/_content//hottopics/2004SleepPollFinalReport.pdf. Accessed 03/05/06.
29. Weston AT, Petosa R, Pate RR. Validation of an instrument for measurement of physical activity in youth. Med Sci Sports Exerc 1997; 29: 138–143. [PubMed: 9000167]
30. Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, et al. CDC growth charts: United States. Adv Data 2000; 314; 1–27.
31. Meltzer LJ, Walsh CM, Traylor J, Westin AM. Direct comparison of two new actigraphs and polysomnography in children and adolescents. Sleep 2012; 35: 159–166. [PubMed: 22215930]
32. Acebo C, LeBourgeois MK. Actigraphy. Respir Care Clin N Am 2006; 12: 23–30 viii. [PubMed: 16530645]
33. Ridley K, Ainsworth BE, Olds TS. Development of a compendium of energy expenditures for youth. Int J Behav Nutr Phys Act 2008; 5: 45. [PubMed: 18782458]
34. te Velde SJ, van Nassau F, Uijtdewilligen L, et al. Energy balance-related behaviours associated with overweight and obesity in preschool children: a systematic review of prospective studies. Obes Rev 2012; 13(Suppl 1): 56–74. [PubMed: 22309065]
35. Council on Communications and Media. Policy statement - Children, adolescents, and the media. Pediatrics 2013; 132: 958–961. [PubMed: 28448255]
36. Benedict C, Brooks SJ, O'Daly OG, et al. Acute sleep deprivation enhances the brain's response to hedonic food stimuli: an fMRI study. J Clin Endocrinol Metab 2012; 97: E443–E447. [PubMed: 22259064]
37. Owens J, Maxim R, McGuinn M, Nobile C, Msall M, Alario A. Television-viewing habits and sleep disturbance in school children. Pediatrics 1999; 104: e27. [PubMed: 10469810]
38. 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. [PubMed: 24001394]
39. Rowlands AV, Pilgrim EL, Eston RG. Patterns of habitual activity across weekdays and weekend days in 9–11-year-old children. Prev Med 2008; 46: 317–324. [PubMed: 18162187]
40. Bailey RC, Olson J, Pepper SL, Porszasz J, Barstow TJ, Cooper DM. The level and tempo of children's physical activities: an observational study. Med Sci Sports Exerc 1995; 27: 1033–1041. [PubMed: 7564970]
41. Trost SG, McIver KL, Pate RR. Conducting accelerometer-based activity assessments in field-based research. Med Sci Sports Exerc 2005; 37(11 Suppl): S531–S543. [PubMed: 16294116]

Table 1

Mean (SD) reported television viewing, MVPA and objective activity counts during the increased and decreased sleep conditions ($N = 37$)[a]

	Baseline	Decreased sleep	Increased sleep	t_{paired}[b]	*p*-value	Cohen's d
Reported television viewing (hours/day)	1.5 (1.1)	2.0 (1.3)	1.0 (0.8)	−6.48	<0.001	−1.06
Reported moderate to vigorous physical activity (percent time/day)	16.9 (10.4)	14.2 (9.0)	14.4 (8.6)	−0.11	0.97	−0.02
Average AW2 activity counts (counts/epoch)	551.0 (113.4)	540.7 (103.9)	561.2 (116.4)	2.33	0.03	0.39
Total AW2 activity counts (total accrued/day)	477 916.2 (101 125.8)	511 449.5 (101 018.2)	454 111.9 (96 436.7)	−7.20	<0.001	−1.20

[a] For Actiwatch 2 activity counts, $n = 36$.

[b] Statistical values report on comparisons between the Decreased and Increased sleep conditions.