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Is there an association between adolescent sleep restriction and obesity

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ABSTRACT

Objective: This is the first prospective study of the reciprocal association between sleep restriction and weight among adolescents. Evidence on sleep duration and obesity in youth is sparse and the results have been equivocal.
Methods: Data are from a community-based, two-wave cohort study. The setting was a metropolitan area with a population of over 4 million. The cohort consisted of 4175 youths 11–17 at baseline and 3134 of these followed up a year later. Obesity was defined as body mass index >95th percentile for children of the same age and sex. Sleep restriction was defined as 6 or fewer hours of sleep per night on weeknights or on both weekends and weeknights. Covariates examined were age, gender, family income and depression.
Results: Results clearly demonstrated that there was no association between sleep restriction and obesity at baseline. In prospective analyses, sleep restriction did not increase future risk of obesity, nor did obesity increase risk of future sleep restriction.
Conclusions: These findings call into question previous research based primarily on cross-sectional data suggesting a positive correlation between sleep restriction and obesity. However, the results for adolescents in this study are supported by one study of adolescents and by studies of adults using prospective designs. At this point, there appears to be little evidence for a temporal relation between sleep duration and obesity among adults or adolescents.

Introduction

Sleep deprivation, or short sleep, is sleep time less than the average basal level of about 9 h per night for adolescents [1]. More recently, the National Sleep Foundation has revised its guidelines for 14–17-year-olds to 8–10 h [2]. Studies indicate that many adolescents do not obtain adequate nocturnal sleep in the U.S. [3–5] as well as in many countries around the world [6]. This latter review found that adolescents slept 7.64 h in Asian studies, 8.44 h in European studies and 7.46 h in North American samples. As many as one-fourth of adolescents report sleeping 6 h or less per night [7]. The National Sleep Foundation's 2006 survey found that only 1 in 5 adolescents gets 9 h of sleep on school nights and 45% sleep less than 8 h on school nights [2]. A typical high school senior sleeps just 6.9 h on school nights.

Available evidence suggests that disturbed sleep and restricted sleep are associated with deficits in functioning across a wide range of indicators of psychological, interpersonal and somatic well-being [7–11]. For example, adolescents with disturbed sleep report more depression, anxiety, anger, inattention and conduct problems, drug and alcohol use, impaired academic performance, and suicidal thoughts and behaviors. They also have been reported to have more fatigue, less energy, worse perceived health and symptoms such as headaches, stomachaches and backaches.

More recent studies have further extended these findings. A prospective, 3-wave study of adolescents found that youths who curtail sleep to study exhibit more cognitive problems at school [12]. In a second prospective study, Kelly and El-Sheikh (2014) found that reduced sleep duration predicted greater depression, anxiety and externalizing symptoms over time [13]. Psychological symptoms also predicted changes in sleep, but less so [13]. A large national, cross-sectional study found that youths who slept less than 8 h per night were more likely to report substance use, have suicidal thoughts, feel sad or hopeless, not being physically active, and drink more soda pop [14].

Laboratory studies in particular have documented impaired cognitive function, daytime sleepiness and fatigue as a consequence of sleep deprivation [8,15,16]. Experimental studies of sleep deprivation and its effects have been rare. One study found combined sleep restriction at home and in the laboratory reduced adolescents' self-ratings of positive affect, increased negative affect and increased negative mood in response to a challenge [17–19]. A more rigorous experiment with adolescents found that sleep restriction resulted in adolescents rating themselves as more tense/anxious, angry/hostile, confused and fatigued and as less rigorous [20].

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There is evidence, albeit limited, that restricted sleep is associated with overweight and obesity in children. Conclusions from 7 reviews published in 2008 concluded that the evidence strongly suggested a consistent relationship between restricted sleep and overweight/obesity among children [21–27]. The association was inconsistent among adults, particularly as age increased.

The strongest evidence for a link between shorter duration of sleep and weight actually comes from studies of children, particularly very young children [28]. Results from both cross-sectional and cohort studies of children indicate that shorter sleep duration is associated with greater odds of overweight or weight gain [29–33]. This is particularly true for preschool children. In fact, for children, the evidence suggests a rather clear dose–response relationship, that is, with each unit decrease in sleep time, there is an increase in weight or weight gain [21, 34]. However, the evidence for adolescents is not clear. One reason is that fewer studies have been done focusing on adolescents. In the 7 reviews published in 2008, only a half-dozen studies were reviewed focusing just on adolescents. All were cross-sectional studies and all found at least some evidence that shorter sleep duration was associated with overweight or weight gain [35–39]. Nielsen et al. reviewed 23 studies not included in the 2008 reviews [28]. This updated review included no new studies of adolescents, either cross-sectional or cohort studies. More recently, Cuypers et al. have reported that insufficient sleep was associated with obesity only in the most extreme sleep range (5 or less hours of sleep) [40].

Thus, while the available evidence suggests an inverse association between restricted sleep and overweight/obesity among both children and adolescents, the evidence is much weaker for the latter age group [21, 28]. First, there have been fewer studies of adolescents and, second, there has been only one cohort study of adolescents. Only one study has examined the prospective association between shortened sleep duration and risk of obesity among adolescents. Calamaro et al. (2010) found no association between sleep duration at baseline and obesity at follow-up in a cohort of over 13,000 adolescents 12–18 years of age at baseline [41]. Studies of young adults suggest that the association between sleep duration and weight may be bi-directional [42]. That is, short sleep increased the risk of obesity and obesity increased the risk of short sleep in a 3-wave cohort (ages 20, 22, and 27). No such reciprocal effects have been examined in studies of children, and none for adolescents.

At this point, there is no evidence for a prospective association between duration of sleep and weight in adolescents other than the study by Calamaro et al. (2010). This is an important gap in the literature, since data from the Whitehall II Study of adults aged 35–55 indicate a cross-sectional association between sleep deprivation and overweight but data from the cohort study found no prospective association between short sleep and weight [43]. Similar results have been reported from the CARDIA study of 18–30-year-olds [44].

In summary, the answer to the question of whether restricted sleep increases the risk of overweight or obesity among adolescents (or weight problems increase the risk of sleep restriction) remains unclear.

Using data from a two-wave cohort study of youth aged 11–17 at baseline, Teen Health 2000 (TH2K), this study examined the prospective association between short sleep or restricted sleep and weight in adolescence. Specifically, the study explored the reciprocal association between restricted sleep and weight, e.g., whether restricted sleep increases the risk for obesity, whether weight increases the risk for restricted sleep, whether the association is asymmetric, or whether there is an association at all.

Method

Sample

The TH2K sample was selected from households in the Houston metropolitan area enrolled in two local health maintenance organizations. One youth, aged 11 to 17 years, was sampled from each eligible household, oversampling for ethnic minority households. Initial recruitment was by telephone contact with parents. A brief screener was administered on ethnic status of the sample youths and to confirm data on age and sex of youths. Every household with a child 11 to 17 years of age was eligible. Because there were proportionately fewer minority subscriber households, sample weights were developed and adjusted by post-stratification to reflect the age, ethnic, and sex distribution of the 5-county Houston metropolitan area in 2000. The precision of estimates are thereby improved and sample selection bias reduced to the extent that it is related to demographic composition [45]. Thus, the weighted estimates generalize to the population 11 to 17 years of age in a metropolitan area of 4.7 million people.

Data were collected on sample youths and one adult caregiver using computer-assisted personal interviews and self-administered questionnaires. The computerized interview contained the structured psychiatric interview (see below) and demographic data on the youths and the household. Height and weight measures were conducted after the completion of the interviews. The interviews and measurements were conducted by trained, lay interviewers. The interviews took on average 1 to 2 h, depending on the number of psychiatric problems present. Interviews, questionnaires, and measurements were completed with 4175 youths at baseline, representing 66% of the eligible households. There were no significant differences among ethnic groups in completion rates. Youths and caregivers were followed up approximately 12 months later using the same assessment battery used at baseline. The cohort consisted of 3134 youths plus their caregivers in Wave 2 (75% of Wave 1 dyads). There clearly was attrition between waves which poses a potential risk of bias.

In a previous paper, Roberts et al. (2009) addressed the issue of bias in the follow-up study in two ways [46]. First, they contrasted status factors for those in the baseline survey and those in the Wave 2 cohort, and found essentially no differences. Second, they then examined the prevalence of psychiatric disorders in the baseline study and in the Wave 2 cohort. Again, there were no differences. They further explored this issue, comparing prevalences between the 3134 at baseline who also were in Wave 2 with those 1041 who were not in Wave 2 (data not shown). There was a slight tendency ($p < 0.05$) for those not in Wave 2 to report a higher prevalence for anxiety and for any DSM-IV disorder. There were no other differences [47]. We have done the same contrasts for weight status and sleep variables (data not shown).

All youths and parents gave written informed consent prior to participation. All study forms and procedures were approved by the University of Texas Health Science Center Committee for Protection of Human Subjects.

Measures

Body mass index (BMI) and weight status

Height and weight were measured using standard field procedures such as a Tanita digital scale [45,48,49]. BMI was defined as weight/height squared (kg/m^2). Weight status was categorized as healthy weight (BMI < 85th percentile for children of the same age and sex), overweight (85th percentile ≤ BMI < 95th percentile) and obese (BMI ≥ 95th percentile) [50–52]. For the overall sample at baseline, 16.5% were overweight and 19.7% were obese. Thus, 36.2% were overweight or obese. Younger youths were heavier, as were males, minority youths and those from lower income families (data not shown).

Sleep restriction

Data on psychiatric disorders were collected using the youth version of the DISC-IV, a highly structured instrument with demonstrated reliability and validity [53]. Interviews were conducted by college-educated, lay interviewers who had been extensively trained using protocols provided by Columbia University. Interviews with the DISC-IV were administered using laptop computers.

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