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The Association Between Obstructive Sleep Apnea and Dietary Choices among Obese Individuals during Middle to Late Childhood

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Abstract

Objective—Determine whether obstructive sleep apnea (OSA) is associated with the dietary choices of obese individuals during middle- to late-childhood. It was hypothesized that OSA would be associated with increased caloric content of a dinner order, particularly with high carbohydrate food choices. Secondly, we examined the relationships between sleep duration and dietary choices.

Methods—42 obese subjects aged 10–16.9 years participated in a cross-sectional study that involved systematic collection of sleep duration (based on actigraphy), presence and severity of obstructive sleep apnea (obstructive apnea + hypopnea index [AHI] from inpatient polysomnography) and the macronutrient content of dinners ordered from a standardized hospital menu the evening before the polysomnogram.

Results—Primary analyses using Spearman rank-order correlations found that AHI was significantly associated with total calories, as well as grams of fat and carbohydrate, but not protein. These macronutrient variables did not correlate with sleep duration across a week, nor the night before the meal. Findings were unchanged after correcting for age- and sex-adjusted BMI.

Conclusions—More severe OSA appears to be associated with an increased preference for calorie-dense foods that are high in fat and carbohydrate in a manner that is independent of degree of overweight. Although this novel finding awaits replication, it has potential implications for the clinical care of obese youth and individuals with OSA, adds to the limited data that relate sleep to dietary choices, and may have implications for OSA-related morbidity.

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Keywords

children; adolescents; pediatrics; sleep; calories; diet; food; obesity

Introduction

Excessive body weight and obstructive sleep apnea (OSA) are well-correlated in adults, adolescents and, to a lesser degree, young children, but the underlying mechanisms remain uncertain [1–3]. The strongest evidence has been that excessive weight can cause OSA, but recent publications have highlighted mechanisms by which OSA might also maintain excessive weight. OSA has been linked to metabolic aberrations that can contribute to weight gain [2–3]. OSA also disrupts sleep, and inadequate sleep can alter appetite-related leptin and ghrelin levels and result in cravings for calorie-dense sweet and “starchy” foods [4]. OSA can further cause inattention, impulsivity and negative mood, which could contribute to poor food choices [2]. Indeed, a recent report linked OSA with parent-reported diet and activity patterns of 5–9-year old children [5]. The relationship between OSA and excessive weight may be particularly important to understand during middle to late childhood, when the OSA-weight link becomes firmly established, food choices are increasingly self-determined, and weight becomes highly predictive of adult obesity and its morbidity [6].

In the course of a larger study of the neurobehavioral correlates of OSA in obese 10–16 year-old children and adolescents [7], we incidentally collected information on the food chosen by participants for their dinners. In analyzing this food-choice data, we predicted that severity of OSA would be associated with increased caloric content of the orders, particularly to high carbohydrate food choices. Secondly, because sleep duration has been linked to weight status, we examined whether the ordered food would be associated with sleep duration during a week proximal to the food order and, in a subgroup, the night before the order was placed.

Methods

Participants

Obese subjects were recruited from a pediatric weight-management clinic or sleep clinic [7]. All were 10–16.9 years old, had a body mass index (BMI) >95th percentile for their age and sex, and did not have a history of neurological illness or injury, craniofacial abnormalities, neurodevelopmental disorder (e.g., Down Syndrome), or adenotonsillectomy or other treatment for OSA within the past 2 years, nor were they using any psychiatric medication. Procedures were overseen by the Cincinnati Children’s research ethics board, following informed parent consent and subject assent.

Dinner Orders

Subjects arrived for evaluation between 15:30 and 16:30, at which time they placed an order for dinner, to be consumed between 18:30 and 19:30. They were instructed to order only for themselves and could not order caffeinated beverages, but otherwise had no restrictions placed on their orders from a standardized hospital menu that presented options in the following sections: breakfast, bakery, soups, sandwiches, entrees, side orders, condiments, beverages, and desserts. Subjects were not charged for dinner and the menu did not list prices. Orders were made without a lasting record at the initiation of our larger study, but then hospital procedures changed to require a faxed order. The orders for the subsequent 44 subjects were retained and later coded for macronutrient content based upon the hospital

compendium, including total calories and grams of carbohydrate, fat, and protein. The coder was blind to sleep data and recoding of a random sample of 10% of records yielded 100% agreement. Two subjects were considered outliers because their orders reflected fat or protein content ≥ 2.5 standard deviations higher than the remaining sample, and their data were subsequently dropped.

Polysomnography (PSG)

That night, each subject underwent PSG, as detailed previously [7]. Obstructive apneas were defined as a $>80\%$ decline in airflow over two breaths, despite continued chest/abdominal movement. Obstructive hypopneas were defined as an airflow decrease of 50–80% over two breaths that was associated with (a) paradoxical respiration, and (b) oxyhemoglobin desaturation ($>4\%$) or a subsequent arousal. The apnea-hypopnea index (AHI) was computed as the sum of relevant events divided by hours slept. One participant did not tolerate PSG, and is not included in PSG-related analyses.

Actigraphy

Participants were asked to wear an actigraph (Mini-Motionlogger, Ambulatory Monitoring, Inc., NY) during evening and overnight hours for a week. Raw data were compared against a sleep diary to screen for artifacts, then run through a validated sleep scoring algorithm [8]. Actigraphy data were missing for 2 subjects. The remaining 40 wore the unit an average of 5.6 ± 1.4 (mean $\pm$ sd) nights. Most ($n=36$) wore their actigraph the week prior to their hospital stay; in 4 cases data were recorded another week within the same month. We averaged sleep duration across the nights each subject wore the actigraph. For the 27 subjects who wore the unit the night immediately before the hospital visit, we also examined sleep duration that night.

Body Mass Index

Height and weight were measured before dinner, and BMI was converted to an age- and sex-adjusted z-score (zBMI) [9].

Results

The 42 eligible participants were 71% female, 64% African-American, 31% Caucasian, 13.1 ± 1.9 years old (mean $\pm$ sd), and quite obese ($BMI=37.0 \pm 7.1$, $zBMI=2.44 \pm 0.25$). Spearman correlations were used to associate AHI with total calories and grams of protein, fat, and carbohydrate ordered. Secondary analyses substituted AHI with sleep duration. Correlations were first computed on an uncorrected basis, then as a partial correlation corrected for covariates. We *a priori* selected zBMI as a covariate because of concerns that any association between sleep and food choices might be confounded by obesity severity. Beyond this, we considered age, gender, ethnicity, and socioeconomic status (see [7]) as potential covariates, but none contributed to the prediction of our dietary outcome variables beyond zBMI ($p>.10$), so they were trimmed from the final models [10].

As shown in Table 1, AHI significantly correlated with total calories and grams of fat and carbohydrates, but not protein, in each food order. Findings were unchanged after controlling for zBMI. Sleep duration failed to correlate with any of the coded macronutrient variables.

Discussion

To our knowledge, this is the first study of the relationship between OSA severity and the macronutrient content associated with individuals' dietary choices. Severity of OSA

correlated with calories ordered for dinner, and especially with the fat and carbohydrate content of that meal. These relationships persisted after covarying for age- and gender-corrected BMI, so they can not be explained by a confounding relationship with obesity severity.

This novel finding has important potential implications. If OSA induces changes in diet, this would represent a potentially modifiable behavior that could contribute to a spiral of worsening obesity and sleep-disordered breathing [5]. A causal link between OSA and diet also would support aggressive screening and treatment for OSA. An alternative explanation would be a reverse causal sequence, in which dietary choices alter nocturnal respiration, independent of BMI. Acute dietary changes can alter sleep architecture in humans [11] and ventilation control in rats [12]. Such an effect could have implications for the conduct of PSG. Even in the absence of a clear causal sequence, the co-occurrence of OSA with a diet high in fats and refined carbohydrates may increase morbidity. In an animal model, such a diet worsened the impact of intermittent hypoxia on learning and neural tissue [13].

Although links between OSA and carbohydrate content fit with prior reports of increased craving for carbohydrate-rich foods following experimental sleep restriction [4], fat content also was associated with OSA in our sample. Prior research did not specify macronutrient content, and the greatest craving increase was for “salty” foods, including high-fat foods. In our study, similar items (e.g., “french fries”) were ordered by 75% of subjects with an AHI>3, compared to 14% of those with AHI≤3. Methodological factors may also explain the discrepancy between present findings and past reports that (a) sleep duration correlates with weight status [14] or dietary patterns [15] and (b) experimental sleep restriction heightens food cravings [4]. The current study was not well-powered to detect the small correlations that have been reported in epidemiological studies, and experimental work to date has limited sleep to far less than that experienced by our subjects.

Several limitations temper the conclusions that can be drawn from present results, which reflect food *choices*, not food *consumption*. We could not control for activity level or food consumption prior to the appointment, and subjects may have ordered atypically in anticipation of a hospital stay. However, if anything, this unmeasured variability might attenuate correlations, not result in spuriously inflated findings. Our sample size did not allow us to explore gender as an effect moderator, and the study lacked the hunger ratings and physiological measures needed to address the mechanisms that might underlie a relationship between OSA and food choices. Detailed PSG data were available, but no variable surpassed AHI as a correlate of dietary data; the rate of destitution events correlated with fat grams only ($r=.32$, $p=.04$; all others $p>.05$), and frequency of arousals, average O_2 , and nadir O_2 failed to correlate with any dietary index ($p>.05$). As an additional limitation, BMI does not index fat distribution on the body. Finally, our recruitment of obese subjects ensured a broad range of breathing functioning during sleep, but the generalizability of findings to other populations, including non-obese individuals, remains to be seen. Taken together, these limitations suggest that findings be viewed as intriguing, but preliminary, warranting replication and extension in future work.

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Table 1

Correlations of Macronutrient Content of Dinner Orders with AHI, Typical Sleep Duration, and Sleep Duration the Night Before the Order.

	Bivariate		Corrected for zBMI		
	N	Rho	P	Rho _p	p
Correlations with Obstructive Apnea ± Hypopnea Index (AHI = 5.7 ± 10.9; mean ± sd)					
Total Calories (608 ± 275; mean ± sd)	41	.40	.009	.42	.007
Grams of Fat (26.5 ± 15.1)	41	.39	.011	.36	.020
Grams of Carbohydrate (72.4 ± 31.0)	41	.39	.013	.40	.010
Grams of Protein (21.3 ± 13.0)	41	.29	.063	.25	.121
Correlations with Sleep Duration Across Entire Actigraphy Recording Period (7.7 ± 0.9 hr)					
Total Calories	40	.15	.364	.19	.238
Grams of Fat	40	.15	.386	.23	.158
Grams of Carbohydrate	40	.18	.276	.17	.291
Grams of Protein	40	.19	.247	.28	.086
Correlations with Sleep Duration the Night Before Visit (8.3 ± 1.5 hr)					
Total Calories	27	.03	.875	.03	.875
Grams of Fat	27	-.07	.730	-.08	.698
Grams of Carbohydrate	27	.17	.399	.18	.367
Grams of Protein	27	.05	.797	.08	.683

Rho = Spearman's rank-order correlation; rho_p = rank-order correlation after partialling out variance related to age- and gender-adjusted BMI; AHI = Apnea + Hypopnea Index.