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Original Research Article

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Dietary Intake and Eating-Related Cognitions Related to Sleep Among Adolescents Who Are Overweight or Obese

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Abstract

Objective To examine associations of sleep duration and regularity with dietary intake and eating-related cognitions among adolescents who are overweight/obese. **Methods** Participants were 315 adolescents being evaluated through Healthy Kids, Healthy Weight. Outcomes were reported sleep duration and regularity (bedtime shift, wake-time shift, sleep duration shift). Major predictors were dietary intake (e.g., consumption of calories and sugar-sweetened beverages) and eating-related cognitions (food preoccupation, eating self-efficacy). **Results** Findings were that staying up (i.e., bedtime shift) and sleeping in later (i.e., wake-time shift) on weekends compared with weekdays significantly relates to drinking more sugar-sweetened beverages, the latter for males. Sleeping in on weekends was related to greater food preoccupation. **Conclusions** Sleep regularity was the most important variable in its relationships with dietary intake. Evaluating sleep patterns and improving them with behavioral interventions should be considered as an additional weight loss strategy to promote dietary adherence.

Key words: dietary intake; eating self-efficacy; food preoccupation; obesity; sleep; sleep regularity; sugar-sweetened beverages.

Because sleep duration and regularity are associated with weight status in pediatric populations, even among adolescents who are overweight or obese (Chuang et al., 2015), research on dietary intake and eating-related cognitions as potential mechanisms is vitally important. Emerging evidence exists for short sleep to relate to increased or less healthy food intake in children and adolescents. A study of 1,106 young children (6–7 years old) in Canada found that short sleep related to diet quality in boys and girls, and eating behaviors such as the timing of eating and the quantity or speed of eating mediated the sleep duration/obesity relationship among boys (Tatone-Tokuda et al., 2012). In a large study of adolescents from the National Longitudinal Study of Adolescent Health ($N = 13{,}284$), short sleep duration related to reduced odds of vegetable and fruit consumption compared with the recommended sleep duration in adjusted models (Kruger, Reither, Peppard, Krueger, & Hale, 2014). Also, experimental sleep restriction in adolescents has been linked to consumption of a higher glycemic index and load, more servings of sweets/desserts, and to the perceived appeal of sweet/dessert foods versus other foods (Beebe et al., 2013; Simon, Field, Miller, DiFrancesco, & Beebe, 2015). One mechanism for these relationships is hormonal. Sleep restriction has experimentally and cross-sectionally been related to lower leptin levels in children (Boeke, Storfer-Isser, Redline, & Taveras, 2014; Hart et al., 2013), although these relationships likely differ by sex and age, for example, associations are stronger in adolescent males and in children with higher adiposity. Therefore, when sleep is not optimal, biological factors may play a role in altering perceptions of hunger and satiety as well as food preferences.

Cognitive variables, such as impaired executive control that relate to sleep duration or regularity, have been proposed as being worthy of investigation as potential contributing factors to children's food consumption choices (see a review by Lundahl & Nelson, 2015; Riggs, Chou, Spruijt-Metz, & Pentz, 2010). Specific eating-related cognitive variables involved in behavioral nutrition as they relate to sleep have only received limited examination in children, with no studies that we could locate with adolescents. In a sample of 56 normal-weight children ages 5–12 years, short sleep duration was associated with higher levels of reported external eating behaviors that have been shown to be related to increased food intake (Burt, Dube, Thibault, & Gruber, 2014). In the present study, we are extending this work to the examination of relationships of sleep with additional eating-related cognitions: eating self-efficacy (i.e., confidence in overcoming barriers to making healthy eating choices) and food preoccupation. This is particularly relevant among children or adolescents who are overweight or obese because these cognitions are associated with weight gain and disordered eating behaviors (Maloney, McGuire, & Daniels, 1988). In addition, worsened mood and decreased ability to regulate negative emotions have been shown to relate to sleep deprivation (Baum et al., 2014), which could also contribute to less healthy dietary intake, greater food preoccupation, and lower eating self-efficacy. Identifying sleep and eating-related cognition associations among adolescents with obesity could further support the important role of behavioral sleep medicine interventions for pediatric weight loss.

Another novel contribution of the present study is the consideration that irregular rather than short sleep duration may relate to dietary intake and eating-related cognitions. A recent study in Japan with adults evaluated dietary intake as it related to participants' reports of their subjective sleep–wake regularity for the past year (e.g., whether the time of falling asleep at night and waking in the morning was mostly regular or irregular; Yamaguchi et al., 2013). Findings were that after adjusting for sleep duration, low intake of protein, high intake of carbohydrates, and skipping healthier foods at breakfast were associated with poor sleep–wake regularity. Likewise, in a sample of 305 adolescents, He and colleagues (2015) found that dietary intake of total calories, fat, and carbohydrates were significant mediating factors in the relationship between habitual sleep variability, but not duration, and abdominal obesity. The authors noted that sleep variability may impact health behaviors via multiple mechanisms, including increased fatigue, stress, and lower psychological well-being. Further research is needed to continue to investigate sleep regularity and dietary intake associations in children and adolescents. Our study is designed to investigate the sleep/diet association based on regularity and not solely on duration for adolescents who are overweight/obese and to consider eating-related cognitive variables as well.

The goal of this study was therefore to evaluate sleep and dietary intake/eating-related cognition relationships among treatment-seeking adolescents who were overweight or obese. Hypotheses were that shorter and more irregular sleep would relate to consumption of a less healthy diet and to lower eating self-efficacy and greater food preoccupation. When gender was a significant correlate of the sleep outcomes, interactions with gender were explored because of the existing literature of different findings in gender-stratified models of sleep with health or biological parameters (e.g., weight status, leptin) (Baum et al., 2014; Chuang et al., 2015; Tatone-Tokuda et al., 2012). Based upon initial bivariate associations, selected mediator models were also considered with eating-related cognitions as potential mediators between sleep and dietary intake variables.

Methods

Participants were adolescents and their caregivers being evaluated for the Healthy Kids, Healthy Weight (HKHW) clinical research program at Rainbow Babies & Children's Hospital, University Hospitals Case Medical Center. The principal investigators of the HKHW clinical research program are two pediatric endocrinologists and a licensed clinical psychologist, and the staff includes exercise physiologists, psychology assistants, and registered dietitians. This study was approved by the hospital's institutional review board. Before participation, parents went through the informed consent process and signed a consent form, and adolescents signed assent forms. Medical insurance was charged for the medical evaluation conducted by a pediatric endocrinologist, and all other aspects of the evaluation and the later group treatment or individual sessions were provided at no cost to families.

Procedure

Data were collected from adolescents and their parents/legal guardians during their outpatient evaluation clinic visit. Participants' heights and weights were measured by staff. Children and their parents completed self-report measures just before or during the clinic visit.

Measures: Outcomes

Sleep Duration and Regularity

The sleep variables for the present study were obtained from select questions on the Children's Sleep Habits questionnaire (Owens, Spirito, and McGuinn, 2000), which has been validated for children and with adolescents (Chuang et al., 2015). Parents reported their children's typical week day and weekend sleep (time falling asleep and waking up on week days and weekends). Parent-reported sleep data have demonstrated validity with actigraphy, indicating that it may be reasonably used in determining sleep duration and variability (Sekine et al., 2002; Tikotzky & Sadeh, 2001). Sleep duration was measured as the weighted average number of hours slept on both week days and weekend days [(5 × typical weekday sleep) + (2 × typical weekend sleep)]/7. Sleep regularity measures included sleep duration shift (weekend minus weekday sleep duration), wake-time shift (weekend minus weekday wake time), and bedtime shift (weekend minus weekday bedtime).

Measures: Predictors

Demographics

Parents provided the demographic information for their child and family. Information on child age, gender, race (dichotomized as White vs. non-White), and parental education (dichotomized as high school education/higher education) were obtained.

Weight Status

A medical evaluation included measurement of the participants' heights and weights. Body mass index (BMI) was calculated, and BMI z-score was derived for age and gender on the basis of the charts published by the Centers for Disease Control in 2000 (Kuczmarski et al., 2000). To be eligible for participation in the HKHW program, participants must have a BMI above the 85th percentile for age and sex.

Dietary Intake Variables

The Rapid Eating Assessment for Patients (REAP) total score is a 24-item healthy eating index used as the measure of participants' dietary intake (Gans et al., 2003, 2006; Segal-Isaacson, Wylie-Rosett, & Gans, 2004). The REAP was initially developed to efficiently assess diet quality in patients in primary care and evaluates typical weekly consumption of whole grains, fruits and vegetables, calcium, fat, saturated fat, cholesterol, sugary beverages, and sodium with the same stem "In an average week, how often do you…." Responses are coded as 1 = usually/always, 2 = sometimes, and 3 = rarely/never, with higher REAP scores reflecting better eating habits. While the REAP survey was originally developed to be completed directly by the patient or administered by a provider via a brief interview (Gans et al., 2006), in our study, one of the registered dietitian nutritionists completed the REAP after a 45-minute interview of the child participant and parent/caregiver. The food record was reviewed if available, and a nutrition assessment, including a meal pattern assessment, was completed. For the present study, the REAP total score was used as a predictor variable as an indicator of healthy eating. Additionally, a 14-item subscale for calories, a 15-item subscale for total fat, and an 11-item subscale for saturated fat were used as predictors. Some individual questions that are REAP subscores were analyzed separately, including fruit intake ("…eat less than 2–3 servings of fruit a day?"), vegetable/potato intake ("…eat less than 3–4 servings of vegetables/potatoes a day?"), and sugar-sweetened beverage intake ("…drink 16 ounces or more of non-diet soda, fruit drink/punch or Kool-Aid a day?"). There is evidence for validity and reliability of the REAP, including with the Healthy Eating Index (HEI), a metric of dietary quality validated for use in a sample representative of the U.S. population including children as young as 2 years of age, and with food frequency questionnaires (Gans et al., 2006; Segal-Isaacson et al., 2004). In a sample of young adults (medical students), the total REAP score was significantly associated with the total HEI score ($r = .49$, $p < .0007$); REAP subscores included in the present study were related to the corresponding HEI subscores for total fat ($r = .55$, $p < .0001$), saturated fat ($r = .41$, $p < .0055$), and fruit ($r = .50$, $p < .0006$) (Gans et al., 2006). In a sample including young adults aged ≥18 years, the subscores of the REAP related significantly to a food frequency questionnaire developed by the Fred Hutchinson Cancer Research Center, including for calories ($r = -.44$, $p < .0001$), percent calories as fat ($r = -.47$, $p < .0001$), percent calories as saturated fat ($r = -.44$, $p < .0001$), fruit ($r = .30$, $p < .0038$), vegetables ($r = .45$, $p < .0001$), and sucrose (including a question on frequency of sweets in addition to sugary beverages) ($r = -.43$, $p < .0001$) (Gans et al., 2006). A validation study with medical students with a shortened version of the REAP with the Block 1998 Semi-quantitative Food Frequency Questionnaire found significant correlations for the single-item REAP subscores of servings of fruit ($r = .506$, $p < .0001$) and vegetables ($r = .503$, $p < .0001$) and of sweetened drinks with sugar intake ($r = -.267$, $p < .005$) (Segal-Isaacson et al., 2004).

Eating-Related Cognitions: Food Preoccupation and Eating Self-Efficacy

Food preoccupation, an eating-related cognitive variable, was measured via a 5-item subscale from the

Children's Eating Attitude Test (ChEAT). The ChEAT is a modified version of the Eating Attitudes Test used to screen for disordered eating habits in children (Maloney et al., 1988) and has demonstrated reliability and concurrent validity (Maloney et al., 1988). The ChEAT item responses are on a 6-point Likert scale (1 = *always* and 6 = *never*) but were coded for analyses based on validity testing into three categories. For the present study, coding was "usually" = 0, "often" = 1, and the least symptomatic answers ("never," "rarely," "sometimes") = 2. The food preoccupation subscale of the ChEAT was determined via a factor analysis conducted with a sample of children and adolescents who are overweight or obese (Ranzenhofer et al., 2008). A second eating-related cognitive construct included as a predictor is child-reported eating self-efficacy. This construct was measured with the Weight Efficacy Life-style Questionnaire (WEL), a 20-item validated questionnaire used to measure degree of confidence in resisting overeating in a variety of settings and situations with the stem of "I am confident that..." (e.g., "I can control my eating on the weekends") (Clark, Abrams, Niaura, Eaton, & Rossi, 1991). The item responses include a 5-point Likert scale (1 = *no confidence at all*, 5 = *complete confidence*) with higher scores indicating greater self-efficacy. The WEL includes five 4-item situational factors with adequate to excellent reliabilities obtained in clinical settings with Cronbach alpha coefficients ranging from .70 to .90 (Clark et al., 1991), including Negative Emotions, Availability, Social Pressure, Physical Discomfort, and Positive Activities. This measure has been used with adolescents who are overweight or obese in a weight loss trial (Walpole, Dettmer, Morrongiello, McCrindle, & Hamilton, 2013).

Data Analytic Plan

Spearman Rank Order correlations, *t* tests or analysis of variance tests were performed to determine relationships between the outcomes (sleep duration and regularity variables) and potential predictors (dietary intake and eating-related cognition variables). For the multiple regression models, *p*-values of $< .05$ were required for a regression to be conducted for that outcome and predictor pair. For each of the sleep outcomes significantly related to a predictor variable, correlations or *t* tests were carried out between those outcomes and potential covariates to determine which would be included in those particular regression models. These covariates were conservatively included in the adjusted models if they were related at $p < .10$ with the sleep outcome. Separate multiple regressions were conducted for each outcome, controlling for the identified relevant covariates if applicable. Participants with missing data on a measure requiring computation of a total rather than a mean score were not included in analyses with that variable in the model; the sample size for each regression is included in Table III. To further check on our findings using list-wise deletion, all regressions were rerun using "full-information" maximum likelihood method (FIML) in PROC CALIS Advantage: Single procedure using SAS 9.4.

To initially test for interactions, follow-up regressions were conducted to explore the possible moderator of gender with dietary intake/eating-related cognitive variables. For these moderation analyses, any other relevant covariates were entered first, followed by gender, then the dietary intake or eating-related cognitive variable, with an interaction term of gender and the dietary/eating cognition variable entered in the final step. Specific mediation models were considered with eating-related cognitive variables as potential mediators based on whether significant bivariate relationships existed with the independent variables.

Results

Participant Characteristics

Data from 315 participants, ranging in age from 13 to 18 years with a mean of 14.50 years ($SD = 1.35$), were included in the present study. The majority of this sample was female (64.13%); the race/ethnic makeup was approximately half White (49.21%) and half non-White. For parental education, almost three-quarters (75.99%) reported having more than a high school education. The sample was primarily obese with 95.18% having BMI-for-age percentiles at the 95th percentile or above ($M = 98.27$, $SD = 1.68$), and the BMI z-scores mean was 2.38 ($SD = 0.39$). See Table I for psychometric properties of the predictors, and Table II for psychometrics of the sleep outcomes.

Bivariate Relationships

See Table II for the relationships between sleep and dietary intake/eating-related cognition variables; the significant ones ($p < .05$) are described as follows. Shorter sleep duration was significantly related to less healthy dietary intake as measured by the total REAP score, calories, and fat. For bedtime shift, sugar-sweetened beverage consumption was higher for adolescents with later weekend compared with weekday bedtimes. More wake-time shift was significantly related to a less healthy diet assessed by the REAP total score, calories, fat, and sugar-sweetened beverage consumption. For sleep variables related to eating-related cognitions, lower eating-related self-efficacy and more difficulty overcoming negative emotions to make healthy dietary choices were significantly related

Table I. Psychometric Properties of Predictors

Variable	*N*	*M*	*SD*	Potential range	Actual range
Child age (years)	315	14.50	1.35	13 to 18	13 to 18
Body mass index z-scores	314	2.38	0.39	NA	1.07 to 3.60
REAP total score[a]	314	47.36	7.47	24 to 72	30 to 67
Calorie intake[b]	314	29.00	5.15	14 to 42	14 to 42
Total fat intake[c]	314	30.37	5.52	15 to 45	17 to 44
Saturated fat intake[d]	314	21.77	3.99	11 to 33	11 to 30
Food preoccupation[e]	279	1.09	1.97	0 to 10	0 to 9
Weight Efficacy Lifestyle (WEL) questionnaire total score[f]	227	71.82	17.60	20 to 100	20 to 100
Negative emotions[g]	268	13.85	4.56	4 to 20	4 to 20
Availability[g]	266	12.55	3.85	4 to 20	4 to 20
Social pressure[g]	265	14.16	4.23	4 to 20	4 to 20
Physical discomfort[g]	255	15.48	3.78	4 to 20	4 to 20
Positive activities[g]	259	14.85	3.58	4 to 20	4 to 20

REAP = Rapid Eating Assessment for Patients.

[a]The REAP total score consists of 24 items coded on a 3-point Likert scale from 1 (usually/always) to 3 (rarely/never) to the item stem, "In an average week, how often do you. . ."; higher scores indicate healthier eating habits.

[b]A 14-item subscore of the REAP.

[c]A 15-item subscore of the REAP.

[d]An 11-item subscore of the REAP.

[e]A 5-item subscale from the Children's Eating Attitude Test; lower scores indicate greater food preoccupation.

[f]The WEL questionnaire is a 20-item measure scored on a 5-point Likert scale, with higher items meaning greater self-efficacy in controlling overeating.

[g]WEL situational factors – 4 items each scored on a 5-point Likert scale.

Table II. Mean Scores, Standard Deviations, and Correlations With Predictors for Sleep Duration and Regularity Outcomes

	Sleep duration	Bedtime shift	Wake-time shift	Sleep duration shift
Mean	8.26	1.38	3.21	1.83
SD	1.16	1.26	1.93	1.88
Range	4.79 to 13.00	−4.00 to 6.00	−5.50 to 9.00	−8.00 to 8.00
Demographics				
Child age	**−0.21*****	−0.01	0.04	0.07
Body mass index z-scores	−0.05	0.07	0.06	−0.001
Dietary intake				
REAP total	**0.13***	−0.07	**−0.12***	−0.08
Calories	**0.13***	−0.07	**−0.12***	−0.07
Total fat	**0.15***	−0.07	**−0.12***	−0.06
Saturated fat	0.10†	−0.07	−0.08	−0.02
Eating-related cognitions				
Weight Efficacy Lifestyle (WEL) questionnaire total	0.04	**0.16***	0.08	−0.03
Negative emotions	0.05	**0.15***	0.05	−0.06
Availability	0.06	0.07	0.05	0.01
Social pressure	0.08	0.03	0.02	−0.01
Physical discomfort	0.06	0.12†	0.06	−0.01
Positive activities	0.10	0.10	0.01	−0.06
Food preoccupation	0.11†	**−0.19****	**−0.13***	−0.02

REAP = Rapid Eating Assessment for Patients.

†$p < .10$,

*$p < .05$,

**$p < .01$,

***$p < .001$.

Significant findings are indicated with asterisks and with bolded text.

to staying up later on the weekends compared with weekdays (i.e., bedtime shift). Finally, more food preoccupation was significantly related to greater bedtime and wake-time shifts.

Multiple Regressions

Based on the bivariate analyses, 10 follow-up multiple regressions were conducted (Table III). In separate models, greater sugar-sweetened beverage consumption

Table III. Multivariate Regressions: Sleep Duration, Bedtime Shift, and Wake-Time Shift

	β	*SE*	*t*	*p*	Cohen's f-square effect size (f^2)[a]
DV = sleep duration					
Covariate: age	−0.16	0.05	−3.39	**<.001*****	0.052
Covariate: race	0.20	0.13	1.54	.12	
REAP total score	0.01	0.01	1.17	.24	
n = 314					
Covariate: age	−0.16	0.05	−3.44	**<.001*****	0.056
Covariate: race	0.20	0.13	1.51	.13	
Calorie consumption	0.02	0.01	1.68	.09	
n = 314					
Covariate: age	−0.16	0.05	−3.45	**<.001*****	0.060
Covariate: race	0.17	0.13	1.33	.19	
Total fat intake	0.02	0.01	1.72	.09	
n = 314					
DV = bedtime shift					
Covariate: age	−0.05	0.05	−0.97	.33	0.026
Sugar-sweetened beverage consumption	−0.23	0.08	−2.77	**.006****	
n = 315					
Covariate: age	−0.00	0.06	−0.07	.94	0.021
Food preoccupation	−0.09	0.04	−2.35	**.02***	
n = 279					
Covariate: age	−0.00	0.06	−0.06	.95	0.013
Negative emotions (eating self-efficacy subscale)	0.03	0.02	1.87	.06	
n = 315					
DV = wake-time shift					
Covariate: education	0.44	0.26	1.70	.09	0.039
Covariate: gender	−0.46	0.23	−2.05	**.04***	
REAP total score	−0.02	0.01	−1.69	.09	
n = 303					
Covariate: education	0.44	0.25	1.75	.08	0.040
Covariate: gender	−0.48	0.23	−2.12	**.04***	
Calorie consumption	−0.04	0.02	−1.91	.057	
n = 303					
DV = wake-time shift					
Covariate: education	0.44	0.26	1.74	.08	0.038
Covariate: gender	−0.46	0.23	−2.03	**.04***	
Total fat intake	−0.03	0.02	−1.63	.10	
n = 303					
Covariate: education	0.41	0.25	1.62	.11	0.055
Covariate: gender	−0.53	0.23	−2.36	**.02***	
Sugar-sweetened beverage consumption	0.59	0.26	2.28	**.02***	
n = 304					

REAP = Rapid Eating Assessment for Patients.
*$p < .05$,
**$p < .01$,
***$p < .001$.
[a]Cohen's f^2_B effect sizes of 0.02 are considered to be small, 0.15 are medium, and 0.35 are large.
Significant findings are indicated with asterisks and with bolded text.

(beta estimate = −0.23, p = .006) and food preoccupation (beta estimate = −0.09, p = .02) were significant predictors of going to bed later on weekends compared with week days (i.e., bedtime shift). For the sleep regularity outcome of wake-time shift, all five models controlled for parental education and gender, and gender was a significant predictor in all of them (p's = .02–.04). Sugar-sweetened beverage consumption was a significant predictor of wake-time shift (beta estimate = 0.59, p = .02). Note that effect sizes for all of the regression models were small. Our findings rerunning all of these regressions using FIML were similar and confirmed our results. Just one additional dietary variable reached statistical significance; calorie intake was a

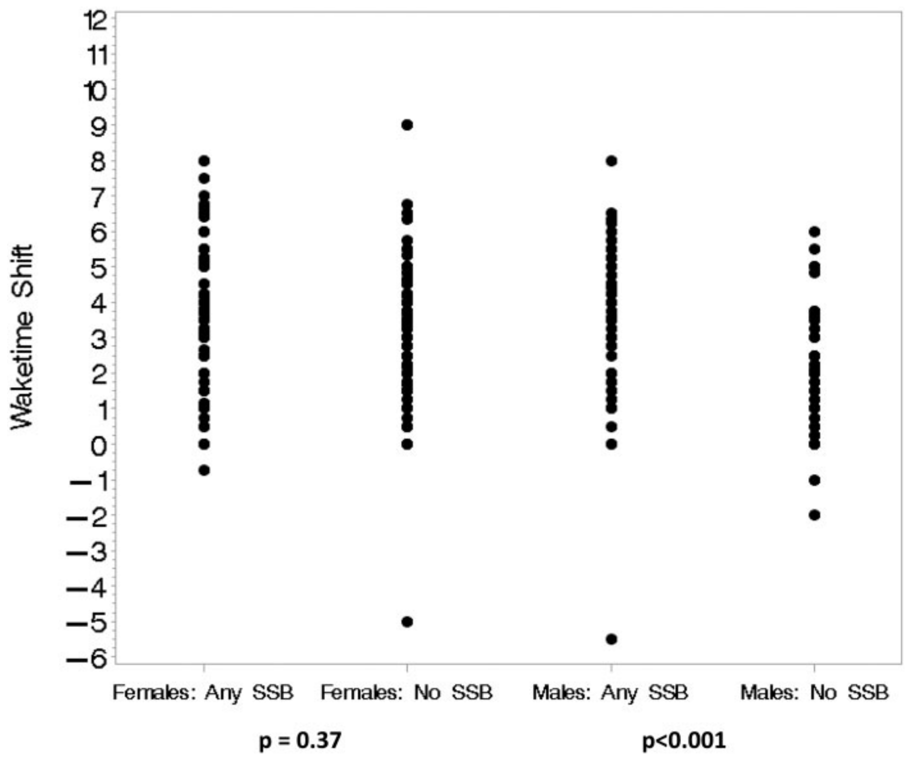

Figure 1. Moderation finding: The significant relationship of wake-time shifts with sugar-sweetened beverage consumption by males; the nonsignificant relationship between these variables for females. $p = .37$; $p < .001$.

significant predictor of wake-time shift (beta estimate = 0.06, $p = .03$). All data in the text and tables therefore reflect the original analyses using list-wise deletion.

Moderator Analyses

In separate adjusted models (not shown) with the sleep regularity outcome of wake-time shift, a model controlling for education and gender as relevant demographics found sugar-sweetened beverage consumption to be a significant predictor (beta estimate = 2.35, $p = .003$) with a signification interaction of sugar-sweetened beverage consumption by gender (beta estimate = −1.06, $p = .02$). For males, a significant relationship exists between waking up later in the morning on weekends compared with weekdays and drinking more sugar-sweetened beverages; this relationship was not significant in females (Figure 1). No other moderator analyses with gender were significant in any of the multiple regression analyses with wake-time shift as the outcome.

Mediator Analyses

Based on testing prerequisites for the hypothesized specific mediation models, potential mediator models to be tested included the outcome sleep variable of bedtime shift and the potential mediators of weight efficacy total, negative emotions, and food preoccupation. The only potential dietary-related variable that could serve as an independent variable was sugar-sweetened beverages. As none of the above potential mediators related to the independent variable (in this case, sugar-sweetened beverage consumption), results were that none of the eating-related cognitive variables served as significant mediators of the relationships between sugar-sweetened beverage consumption and bedtime shift in the present sample.

Discussion

This study was the first to examine models of eating-related cognitions and sleep regularity in a relatively large sample of 315 adolescents who were overweight/obese. Our results extend the existing literature on sleep and dietary intake among children by exploring novel correlates (eating self-efficacy and food preoccupation) and by including sleep regularity in a population at high risk for multiple early morbidities. For these treatment-seeking adolescents who are overweight or obese, having later bedtimes and sleeping in more on weekends compared with week days significantly relates to drinking more sugar-sweetened beverages. Particularly for males, wake-time shift relates to consuming sugar-sweetened beverages. An additional finding from the present study is that the eating-related cognition of food preoccupation is significantly related to bedtime shift.

Of particular interest is that sleep regularity, in particular shifts in bedtime and wake time between week days and weekends, was the most important sleep variable in its relationships with dietary intake and eating-related cognitions. This fits with prior research demonstrating that shifts in the sleep period affecting circadian rhythms are associated with dietary intake behaviors more so than is sleep duration among adults (Yamaguchi et al., 2013). We have duplicated this finding in a population for whom dietary intake is of particular importance. A potential moderating variable to investigate is chronotype, that is, diurnal preference of morningness versus eveningness (Olds, Maher, & Matricciani, 2011). Adolescents with an evening-type chronotype would be expected to have more irregular schedules because of adopting their preferred schedule on weekends. Also, eveningness types engage in less healthy dietary behaviors, consuming more caffeinated drinks and eating more fast food and fewer dairy products, but no differences were found for eating sweets (Fleig & Randler, 2009). The confluence of chronotype and sleep irregularity on dietary intake/eating-related cognitions should be studied further, particularly for adolescents who are overweight/obese.

More research is warranted on the finding that staying up later on weekend nights *and* sleeping in more on weekend days is related to drinking more sugar-sweetened beverages. We found this in a sample of children who are already overweight/obese, but this finding also has potential implications for prevention of pediatric obesity among at-risk groups. The sleep regularity variables of bedtime and wake-time shift are moderately correlated ($r = .335$, $p < .0001$), that is, adolescents who stay up later are more likely to sleep in later on weekends. Parenting rules/regulations/supervision pertaining to health behaviors may be a potential mediator to explore to better understand why these behaviors (staying up later/sleeping in later and drinking sugar-sweetened beverages) co-occur. Another possible mediator may be children's or even their parents' executive skills, that is, the ability to make plans and be organized (Lundahl & Nelson, 2015; Riggs et al., 2010). Consuming significantly higher amounts of sugar-sweetened beverages has been found among Japanese female nurse shift workers versus day workers, with a proposed mechanism being abnormal timing of meals (Tada et al., 2014). It is also possible that sleep variability promotes consumption of sugar-sweetened beverages among adolescents because of increased fatigue, stress, or lower psychological well-being (He et al., 2015). The significant interaction found for wake-time shift and consumption of sugar-sweetened beverages by gender is a novel finding that merits further study. Males who sleep in more on the weekends compared with the weekdays drink more sugar-sweetened beverages; females' sleeping in did not relate significantly to their consumption of sugar-sweetened beverages. It is difficult to know why this gender difference exists. Because males are more likely to be evening types, this might play into this particular finding (Fleig & Randler, 2009).

Finally, the finding that adolescents who stay up late on the weekends endorse more food preoccupation merits further study. This fits with research from Baum and colleagues that sleep deprivation worsens mood and emotion regulation in adolescents (2014). Note that the items in the food preoccupation subscale of the ChEAT include a symptom of binge-eating disorder, that is, loss-of-control eating, "I have gone on eating binges where I feel that I might not be able to stop." Knowing that adolescents who are overweight/obese who stay up later on weekends may be at increased risk for binge eating is of immense value to psychologists and other health care providers.

It is notable that in this study BMI z-scores were not related to any of the sleep variables, although our own data suggest that irregular sleep relates significantly to higher BMI z-scores in gender-stratified samples (Chuang et al., 2015). A notable difference between these two studies is that the Chuang et al. (2015) study was focused directly on the BMIz/sleep relationship, and the present study was designed to investigate relationships of sleep with dietary and eating-related cognition variables.

Limitations

The present study's findings should be interpreted with consideration of the following limitations. This study was conducted on adolescents presenting at a hospital-affiliated weight control program clinic for evaluation because of being overweight or obese and therefore results cannot be generalized across the entire weight range. These findings are cross-sectional, and it is not known whether shifts in circadian rhythm cause alterations in dietary behaviors/eating-related cognitions or whether these co-occur because of some other important variable such as a chaotic home environment or permissive parenting. Despite our significant findings, the effect sizes were small and warrant further investigation. The measure of dietary intake, the REAP, has limited established validity with adolescents and was completed by a registered dietitian based on multiple sources of dietary information provided by child patients and parents rather than by patients as in the validation studies. Some of the dietary intake variables were assessed by one-item subscores of the REAP. Another measurement issue is that food preoccupation was fairly high with somewhat limited variability in this sample, which may have reduced our ability to assess the relationship between sleep and this eating-related cognitive variable. Finally, this study was conducted with variables from an ongoing clinical research program not originally set up to explore sleep/dietary intake relationships and potential mediators. Thus, we did not have access to objective sleep data (just parent report) or to measures of executive function, the latter to test as potential mediators.

We also used raw difference scores for sleep regularity in the analyses, and the use of raw difference scores has been associated with some weaknesses.

Future Directions

Our findings provide an initial framework that may be built upon to better understand which variables to include in longitudinal models or experimental studies for investigating the effects sleep may have on dietary behaviors and eating-related cognitions within a population of at-risk adolescents. Additional experimental studies to alter sleep patterns and measure dietary intake as well as eating-related cognitions could be designed to better answer these questions (e.g., similar to Beebe et al., 2013; Simon et al., 2015), or longitudinal studies could be conducted to track these behaviors for greater insight into the directionality of these relationships and to better assess mediation. Future research should use objective sleep measures and also test these models with additional racial/ethnic groups. If circadian rhythm changes contribute to dietary behaviors not consistent with weight loss, devising effective interventions to regularize sleep schedules or address dietary challenges for those with these schedules should be empirically evaluated as part of a standard program. Testing a variety of different methods for regularizing sleep and determining whether they are feasible with adolescents who are overweight/obese and if more regularized sleep relates to better health outcomes are reasonable next research steps that have also been recommended in the literature on the relationship of sleep with higher BMI z-scores (Chuang et al., 2015; Sallinen et al., 2013). Based on the present study's findings, clinically it is recommended that professionals affiliated with pediatric weight loss programs should interview all potential participants and their parents/legal guardians about relevant sleep behaviors with enough specificity to determine whether there are significant issues related to sleep irregularity. Programs could also consider more objectively measuring sleep duration/regularity with the use of wrist actigraphy as part of the initial evaluation phase to provide individualized feedback to families regarding their child's sleep habits with behavioral recommendations for improvements as necessary. Consultation with or referrals to psychologists or other professionals certified in behavioral sleep medicine through the American Board of Sleep Medicine (http://www.absm.org/BSMSpecialists.aspx) may be necessary if providers affiliated with the weight management program do not currently have this expertise. The implications of participants' sleeping habits on dietary intake/eating-related cognitions should then be considered as these may relate to potential success in weight loss programs.

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