HHS Public Access
Author manuscript
*Pediatr Obes*. Author manuscript; available in PMC 2016 December 01.

Published in final edited form as:
*Pediatr Obes*. 2015 December ; 10(6): 442–447. doi:10.1111/ijpo.12004.

# The role of eating frequency on relative weight in urban school-age children

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## Abstract

**Background—**The role of eating frequency on relative weight in childhood is not well understood.

**Objective—**To clarify this relationship by assessing the cross-sectional and prospective relationships of weekday eating frequency with BMI z-score (BMIz) and change in BMIz in a sample of schoolchildren.

**Methods—**Eating frequency, the average number of reported daily eating occasions, was assessed using two weekday 24-hour diet recalls. BMIz was measured at baseline, 6-months, and 1-year in 155 urban schoolchildren, ages 9-15 years. Multiple linear regression models were used.

**Results—**Cross-sectional analyses at baseline suggest that BMIz was 0.23 units lower for each additional reported eating occasion (regression coefficient=-0.23; 95% CI: -0.44, -0.07). From baseline to 6-months, BMIz increased by 0.03 units for each additional reported eating occasion (regression coefficient= 0.03; 95% CI: 0.01, 0.05). This relationship was no longer statistically significant at 1-year (regression coefficient= 0.01; 95% CI: -0.01, 0.03).

**Conclusions—**Findings suggest that the relationship of eating frequency with BMIz differs from that of change in BMIz. This difference may be due to methodological deficiencies of cross-sectional studies, challenges of dietary assessment, or differences in eating patterns among normal and overweight youth. Controlled trials are needed further clarify this relationship.

### Keywords

Body Mass Index (BMI) Z-score; Childhood obesity; Eating behaviors; Eating frequency; Snacking

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## INTRODUCTION

As childhood obesity prevalence tripled from the 1970's to the present, eating frequency in children increased from 3.0 to 5.0 eating occasions per day (1, 2). At the most basic level, obesity results from an imbalance between energy consumed and energy expended. Given the documented positive association between eating frequency and energy intake in children (3-5), eating frequency represents a potential point of intervention for childhood obesity prevention. Currently, however, there is no consensus as to what role of eating frequency plays in childhood obesity. In 2010, the U.S. Department of Agriculture's (USDA) Dietary Guidelines Advisory Committee concluded that there was insufficient evidence to determine whether the eating frequency affects obesity risk in children (6). Therefore, parents, schools, and practitioners lack guidance as to what role meal and snack patterns play in healthy weight.

Eating frequency and childhood weight has been studied since the 1960's when Fabry and colleagues performed a school-based intervention to test the differences in excess weight gain among schoolchildren consuming three versus seven meals per day. Despite similar energy intake levels across the two groups, children who consumed three daily meals gained more weight compared to those who consumed seven (7). Since this study, prospective and cross-sectional studies have reported both similar (4, 5, 8-10) and conflicting results (11). Specifically, of the two prospective studies to examine this relationship, one reported an inverse association between eating frequency and 10-year mean BMI gains (9), while the other found a positive association between an eating frequency and 6-year change in BMI z-score (BMIz) (11). Most of the analyses undertaken to examine this relationship in children have been cross-sectional in nature. While their results more uniformly support an inverse association, study authors commonly cite methodological limitations, warn against causal inferences, and call for prospective studies (4, 5, 8, 12, 13).

Given the potential for methodological limitations in cross-sectional diet-focused obesity research, this study was undertaken to examine both the cross-sectional and prospective relationships of eating frequency with relative weight in the same sample of schoolchildren. Additionally, given data to suggest that eating frequency and dietary intake patterns change as children gain more autonomy over their eating habits in the transition to adolescence (14), we also examined whether these associations differ between elementary school-age (9-11 year olds) and adolescent participants (12-15 year olds). We hypothesized a positive relationship of eating frequency with baseline BMIz and with change in BMIz over 6-months and 1-year.

## SUBJECTS AND METHODS

### Participant Information

This study was a diet sub-study to the Daily D Study, a randomized trial designed to determine the appropriate level of vitamin D supplementation needed to prevent serum vitamin D inadequacy in schoolchildren. Participants in the diet sub-study were recruited from the 312 currently enrolled fourth through eighth grade students at five public schools in the greater Boston area. The Daily D Study, which ran from October 2011 to December 2012, included four study visits: baseline, 3-months, 6-months, and 1-year. Other than providing a vitamin D supplement to all participants, the Daily D Study protocol did not involve dietary intervention. At the 3-month study visit, 183 students enrolled in the diet sub-study from four of the five schools. We did not recruit from the fifth school given that we met the sample size needed for 80% power, had limited resources, and recruited from a school in the same district which had a student population with similar socio-demographic characteristics. Students were ineligible for the Daily D Study if they were taking vitamin D, multi-vitamin supplements, or oral glucocorticoids, or had rickets, cystic fibrosis, kidney disease, sarcoidosis, irritable bowel syndrome, epilepsy, or HIV/AIDS. Participants were excluded from the diet sub-study if they were missing weight or height measurements at baseline. Parental informed consent and child assent was obtained for both the trial and the diet sub-study. The Tufts University Institutional Review Board approved the protocols for both the Daily D Study and the diet sub-study. The Daily D Study was registered in ClinicalTrials.gov (NCT01537809).

**Dietary Assessment—**Diet was assessed via collection of two non-consecutive, weekday 24-hour diet recalls by trained registered dietitians. The initial 24-hour diet recall was collected in-person during the 3-month study visit using the University of Minnesota Nutrition Data System for Research (NDSR) software (Version 2011, Nutrition Coordinating Center, Minneapolis, MN). This methodology uses a multiple-pass method and a standardized portion-size manual to decrease measurement error. The second recall was collected over the phone 3 to 21 days after the first recall using the same methodology. Dietary data were collected for Monday through Friday only to avoid any additional variation introduced by differences in eating patterns between weekday and weekend day recalls (15). Research suggests that this age group, which ranged in age from 9-15 years, is capable of providing reliable 24-hour diet recalls without the assistance of a caregiver (16, 17).

Within the NDSR protocol, participants identify the name and time of each reported eating occasion. For this analysis, an eating occasion was defined as any distinct time when a participant reported consuming at least one food or beverage item, *excluding water*, regardless of whether the occasion was designated as a meal (breakfast, lunch, dinner/supper or school lunch) or snack. Previous studies of eating frequency have considered eating occasions to be independent if separated by a minimum of 15 minutes (2, 11). Of the 1,574 eating occasions reported by subjects in this sample, only nine occasions (0.05%) were consumed within 15 minutes of each other and were treated as one occasion. Our definition is consistent with previous research and maintains the integrity of how schoolchildren self-report eating occasions.

Statistical methods are not available to estimate usual eating frequency. Analyses were therefore undertaken to determine if eating frequency estimates from the in-person versus over-the-phone recalls yield similar results. No differences in estimates were found, such that average weekday eating frequency was calculated for each participant across the two recalls. Eating frequency categories were created, using nationally representative data as a guide, so as to differentiate between ‘infrequent eaters’ (1.0-3.5 daily eating occasions), 'average eaters' (4.0-4.5 daily eating occasions), and 'frequent eaters' (5+ daily eating occasions).(2)

**Study Outcome—**Height was measured without shoes using a portable stadiometer (Model 214, Seca Weighing and Measuring Systems, Hanover, MD) and recorded to the closest 1/8th inch. Weight was measured without shoes in light clothing on a portable balance beam scale (Healthometer, Boca Raton, FL) and recorded to the closest 1/4 pound. All measures were taken in triplicate. Body mass index (BMI, $kg/m^2$) was calculated from height and weight measurements collected at baseline, 6-months, and 1-year (18). BMI measurements were converted to BMIz using the Centers for Disease Control and Prevention (CDC) Revised Growth reference (19) to provide an age- and sex-specific measure of relative adiposity. Change in BMIz was determined from baseline to 6-months and 1-year, respectively (20).

**Covariates—**Demographic data including age, sex, and race/ethnicity were collected on consent forms. At the baseline visit, parents completed an additional questionnaire on maternal education and eligibility for free or reduced-priced school meals. Physical activity was assessed via the Block Kids Physical Activity Screener (NutritionQuest, Berkley, CA), which was completed by participants at the baseline visit. The screener asks about the frequency and duration of leisure activities, school activities, chores, and part-time employment. It provides relative estimates of total minutes of daily activity and minutes spent in low, moderate, and vigorous activity (21). Using these estimates with guidelines in the 2008 Physical Activity Guidelines for Americans, participants were categorized as 'inactive' if their reported weekly moderate activity totaled less than 150 minutes, 'moderately active' if it totaled 150-300 minutes, and 'active' if it exceeded 300 minutes (1 minute vigorous activity = 2 minutes moderate activity) (22).

**Statistical Analyses—**All statistical testing was done using SAS (Version 9.2, 2008, SAS Institute, Cary, NC) at the two-sided 0.05 level of significance. We used descriptive statistics to examine baseline characteristics of our sample. Separate multivariable models estimated associations of eating frequency with baseline BMIz, change in BMIz at 6-months, and change in BMIz at 1-year. Per *a priori* hypotheses, we tested for the presence of effect modification by age category (elementary school-age (9-11 years) and adolescents (12+ years)), by evaluating the statistical significance of an interaction term in each model. Given differences in snacking policies, the unique food environments, and observed differences in racial/ethnic make-up of the four schools represented in our sample, we controlled for school *a priori* in all models. We also assessed the need to control for age, sex, race/ethnicity, maternal education, eligibility for free and reduced-price lunch and physical activity level in models of each respective outcome measure. Variables were retained in each model if their inclusion induced a change in the point estimate greater than 10% (23). Finally, the relationship between average weekday eating frequency and each outcome was examined using eating frequency categories in which "infrequent eaters" were identified as the reference group.

## RESULTS

A total of 155 participants provided at least one reliable 24-hour diet recall and had complete anthropometric measures at baseline, 6-months and 1-year. Whereas the majority of the sample (n=139) provided two reliable 24-hour diet recalls, we chose to include an additional 16 participants in our analyses who provided only one 24-hour diet recall, as doing so did not result in any meaningful differences in effect size estimates or significance of the examined relationships. **Table 1** displays baseline participant characteristics for the analytical sample. There were no statistically significant differences between the analytic and full diet sub study sample (five participants did not complete an in-person recall, four participants provided an unreliable recall, and 19 participants had missing anthropometrics at one-year). At baseline, the mean age of participants was 11.4 years, 43.9% were non-Hispanic white, 46% were overweight or obese (24), and approximately 64% were eligible for free or reduced-priced school meals. On average, the sample was largely inactive, with 64% participants reporting less than 150 minutes of physical activity per week.

Over the course of the study, while participant BMI increased by 0.2 kg/$m^2$ at 6 months and 0.3 kg/$m^2$ at 1 year, BMIz decreased, on average, as did the percentage of overweight and obese participants (**Table 2**). Relative to baseline, BMIz decreased by 0.03 units over 6 months and by 0.06 units over 1 year, on average. Weekday (Monday – Friday) eating frequency was normally distributed and ranged from 2.0 to 8.5 daily eating occasions. Participants reported a mean weekday eating frequency of 4.5 daily eating occasions.

There was no evidence of effect modification by age category in the baseline, 6-month or 1-year models. As shown in **Table 3**, after adjusting for school and age, the cross-sectional association between reported weekday eating frequency and baseline BMIz was statistically significant and inverse (effect estimate=-0.23; 95% CI: -0.44, -0.07). By the 6-month visit, the relationship was statistically significant and positive. After controlling for school, age and physical activity, each additional reported eating occasion was associated with a 0.03 unit increase in participant BMIz (effect estimate = 0.03; 95% CI: 0.01, 0.05). By 1 year, after controlling for school, sex, age, race/ethnicity, free or reduced-price lunch, maternal education and physical activity, the prospective relationship between reported weekday eating frequency and change in BMIz remained positive; but, it was no longer statistically significant (effect estimate = 0.01; 95% CI: -0.01, 0.03).

To examine differences in BMIz between ‘infrequent eaters’ (1.0-3.5 daily eating occasions), ‘average eaters’ (4.0-4.5 daily eating occasions), and ‘frequent eaters’ (5+ daily eating occasions), a categorical analysis was performed (Table 3). At baseline, BMIz in ‘frequent eaters’ was 0.44 units lower than that of ‘infrequent eaters’ (effect estimate comparing infrequent to frequent eaters = -0.44; 95% CI: -0.75, -0.21). At 6 months, BMIz in ‘frequent eaters’ was 0.09 units higher than in ‘infrequent eaters’ (effect estimate comparing infrequent to frequent eaters = 0.09; 95% CI: 0.04, 0.13). At 1 year, BMIz in ‘frequent eaters’ did not differ from ‘infrequent eaters’. BMIz in ‘average eaters’ did not differ from that of ‘infrequent eaters’ at any time point.

## DISCUSSION

To our knowledge, this is the first study to report on both cross-sectional and prospective relationships between eating frequency and relative weight in the same sample of children. We found a statistically significant, inverse relationship between reported weekday eating frequency and baseline BMIz and a statistically significant, positive relationship between reported weekday eating frequency and change in BMIz at 6 months. Similarly, the analysis by eating frequency categories suggested that ‘frequent eaters’ had a statistically significantly lower BMIz at baseline but experienced a greater increase in BMIz at 6 months compared to ‘infrequent eaters’.

This study uniquely contributes to the body of literature examining the relationship between eating frequency and weight in children. Both cross-sectional and prospective analyses were done in the same sample of schoolchildren and suggest that the nature of the relationship between weekday eating frequency and weight differs between cross-sectional and 6-month prospective analyses. Our cross-sectional findings are consistent with the literature which uniformly supports an inverse relationship (4, 5, 8-10). A recent meta-analysis of ten cross-sectional studies in children concluded that those with the highest reported eating frequency had 22% lower odds of being overweight or obese as compared to those with the lowest reported eating frequency (OR: 0.78; 95% CI 0.66 to 0.94) (12). Similarly, our 6-month prospective analysis is consistent with one of two prospective studies to examine this relationship. In the MIT Growth and Development Study, Thompson and colleagues found that adolescent females with six or more eating occasions experienced a greater 6-year increase in BMIz compared to those with 3.9 or fewer daily eating occasions (11). Our categorical findings mirror Thompson's in that ‘frequent eaters’ experienced larger gains in BMIz at 6-months relative to ‘infrequent eaters’.

One can speculate why cross-sectional and 6-month prospective findings in this study differ. It is possible that overweight and obese youth restrict their eating frequency giving rise to an inverse cross-sectional relationship, whereas, over time, youth who eat more often experience larger BMIz gains yielding the positive, prospective relationship at 6-months (25). It is also possible that these findings are due to methodological deficiencies of cross-sectional analyses. Dietary under-reporting, particularly by overweight and obese children, is well documented and may account for the inverse relationship observed in cross-sectional analyses (26, 27). After examining this relationship in a cohort of 220 free-living adolescents and adults, Summerbell suggested that under-reporting of snacks may be greater in those who are dieting or are highly restrained eaters (28). In a subsequent study in the Longitudinal Birth Cohort Study, Crawley and Summerbell found an initially significant, inverse cross-sectional relationship between eating frequency and BMI in both male and female adolescents. After removing dieting males and weight-conscious females from their analysis, the relationships no longer held up (29). Along with limited prospective analyses that have been done, our findings suggest that increased eating frequency may contribute to weight gain in children. The observed effect size of a change in BMIz of 0.03 units from baseline to six months for each additional reported weekday eating occasion is modest; however, for children who are consistently frequent eaters this could contribute to excess weight gain overtime. To further inform clinical recommendations, randomized controlled trials are needed.

Our study has limitations with respect to the assessment of dietary intake patterns. First, we were only able to assess diet at the 3-month study visit. Our approach assumes that weekday eating frequency does not change over one calendar year. This assumption is reasonable from the baseline to the 6-month visit, given that students in the study remained in the same school food environment over the school year. It is possible, however, that during the summer months, this assumption may be less valid. Such measurement error would lead to random misclassification and may explain why the association between eating frequency and change on BMIz at 1 year is not statistically significant. Further, we took an average across two, nonconsecutive 24-hour diet recalls to measure eating frequency. Intake on two weekdays is not necessarily representative of usual dietary intake patterns (30). However, given that there are currently no statistical methods which model usual eating frequency, an average across two recalls provides more detail on day-to-day variation than a single 24-hour recall. Finally, the two 24-hour diet recalls were collected up to 21 days apart due to difficulty reaching participants by phone. The mean time between recalls was 11.6 + 5.0 days (range 4 to 21), and only 20 participants more than two weeks lapse between recalls.

Our study also has several strengths. First, the prospective study design allowed us to follow the children through an entire calendar year to examine weight gain patterns in the context of eating frequency. Although no conclusions regarding the directionality or causality of the observed associations can be made from our cross-sectional analysis, our 6-month prospective analysis supports such conclusions. Second, our dietary recalls were collected by trained registered dietitians using NDSR's multiple-pass method. This methodology reduces the chance of omitting eating occasions and food items. Finally, our sample is both racially/ethnically diverse as well as low income. Given that childhood obesity affects minorities and low-income children more significantly, this is the ideal population in which to examine this relationship (1).

Preventing childhood obesity is a public health priority. Given that eating frequency represents a potential point of intervention, it is important to understand this relationship to provide guidance to parents, schools, and practitioners. Currently, however, there are no recommendations as to an ideal eating frequency to reduce childhood obesity risk. The findings from this study suggest the inverse relationship observed between reported weekday eating frequency and weight seen in cross-sectional analyses may reflect methodological deficiencies of the study design. Our prospective analysis suggests a statistically significant, positive relationship of reported weekday eating frequency with change in BMIz over 6 months. Additional prospective studies are needed to confirm these findings. Although a logistical challenge, a controlled trial is needed to determine whether reduction in eating frequency can prevent excess weight gain in children in the modern food environment.

## ACKNOWLEDGEMENTS

The authors have no financial relationships relevant to this article to disclose and no conflicts of interest to disclose. This study was funded, in part, by NIH R01HL106160, NIDDK46200 (Boston Nutrition Obesity Research Center), and a National Research Service Award for the NIDDK T32 Research Training Program in Nutrition and Chronic Disease (EWE). EWE developed the research questions, coordinated and supervised data collection at all four schools, analyzed and interpreted the data and wrote the initial draft of the manuscript. PFJ and GED contributed to the study design, statistical analysis, and manuscript preparation. JS was the PI of the Daily D Study and contributed to the study design, helped with manuscript preparation, and approved the final draft of the manuscript as written. AM contributed to the study design, data interpretation, manuscript preparation, and provided study oversight. All authors approved the final version of the manuscript.

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**What's Known on This Subject:** Eating frequency in children has increased, as obesity prevalence has peaked. Despite parallel trends, cross-sectional studies generally suggest an inverse relationship, while prospective studies are equivocal. There is no agreement on what role eating frequency plays in childhood weight.

**What This Study Adds:** Our results uniquely contribute to the equivocal literature by showing that the cross-sectional relationship of eating frequency with baseline BMIz is inverse, whereas the prospective relationship with change in BMIz at 6-months and 1-year is positive.

## Table 1

Baseline characteristics of school-age participants in the Daily D diet sub-study

| | Analytic Sample (n=155) |
|---|---|
| **Female (%)** | 52.3% |
| **Age (mean ± SD)** | 11.4 ± 1.5 years |
| **Race/ethnicity (%)** | |
| White | 43.9% |
| Black | 11.6% |
| Hispanic | 11.0% |
| Asian | 13.5% |
| Other | 20.0% |
| **Overweight/obese (%)** | 45.9% |
| **Maternal education (%)** | |
| No college education | 51.6% |
| Some college, college, and/or graduate education | 48.4% |
| **Free or reduced-price lunch (% Yes)** | 63.9% |
| **Physical activity**[1] | |
| Active (>300 min/week) | 14.2% |
| Moderately active (150 - 300 min/week) | 21.9% |
| Inactive (<150 min/week) | 63.9% |

[1]Minutes of moderate and vigorous physical activity measured using the Block Kids Physical Activity Screener. Categories are based on the 2008 Physical Activity Guidelines for Americans (22)

**Table 2**

Anthropometric measurements and reported eating frequency by study visit for elementary school-age participants in the Daily D diet sub-study

| | Baseline visit (Oct – Dec, 2011) | 6-month visit (Apr – June, 2012) | 1-year visit (Oct – Dec, 2012) |
|---|---|---|---|
| | | *Mean (SD)* | |
| **Weight (kg)** | 50.4 (15.6) | 52.3 (15.8) | 53.4 (15.8) |
| **Height (cm)** | 152.0 (11.0) | 154.4 (10.8) | 155.8 (10.5) |
| **BMI (kg/m$^2$)** | 21.5 (5.0) | 21.7 (5.0) | 21.8 (5.0) |
| **Change in BMI (kg/m$^2$)** | -- | 0.17 (0.9) | 0.25 (1.1) |
| **BMI z-score**[1] | 0.70 (1.2) | 0.67 (1.1) | 0.64 (1.1) |
| **Change in BMI z-score** | -- | −0.06 (0.3) | −0.06 (0.3) |
| **% overweight/obese** | 46.4% | 38.7% | 39.4% |
| **Average Eating Frequency**[2] | 4.5 (1.0) | -- | -- |

[1] BMI z-score determined using CDC Revised Growth Reference (**19**)

[2] Imputed from collection of non-consecutive repeat 24-hour recalls at the 3 month study visit

## Table 3

Multivariable regression effect estimates for reported daily eating frequency with baseline BMI z-score and change in BMI z-score over 6 months and 1 year for school-age participants in the Daily D diet sub-study

| | Sample Size n | Baseline BMI z-score[3] (Cross-sectional) *Effect estimate (95% CI)* | Change in BMI z-score over 6-months[4] (Prospective) *Effect estimate (95% CI)* | Change in BMI z-score over 1-year[5] (Prospective) *Effect estimate (95% CI)* |
|---|---|---|---|---|
| **Eating Frequency[1]** | | | | |
| Average Reported Eating Frequency | 155 | −0.23 (−0.44, −0.07) | 0.03 (0.01, 0.05) | 0.01 (−0.01, 0.03) |
| **Eating Frequency Categories[2]** | | | | |
| *'Infrequent Eaters'*: 1.0 to 3.5 daily eating occasions | 27 | *Ref* | *Ref* | *Ref* |
| *'Average Eaters'*: 4.0 to 4.5 daily eating occasions | 70 | 0.04 (−0.32, 0.40) | 0.04 (−0.01, 0.09) | 0.01 (−0.05, 0.07) |
| *'Frequent Eaters'*: 5+ daily eating occasions | 58 | −0.44 (−0.75, −0.21) | 0.09 (0.04, 0.13) | 0.02 (−0.06, 0.10) |

[1] Coefficients represent the difference in BMI z-score per each additional eating occasion

[2] Coefficients represent the adjusted mean BMI z-score difference from 'infrequent eaters' (referent group)

[3] Multivariable regression model adjusted for school and age

[4] Multivariable regression model adjusted for school, age and reported physical activity

[5] Multivariable regression model adjusted for school, sex, age, race/ethnicity, free or reduced-price lunch, maternal education, and physical activity