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School breakfast and body mass index: a longitudinal observational study of middle school students

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Summary

Objectives: The objectives are to identify breakfast location patterns (frequency and place of breakfast consumption) and explore the association between breakfast patterns and weight status over time among preadolescents.

Methods: Surveys and physical measurements were completed among students from 12 randomly selected schools in a medium-sized urban school district. All students were followed from fifth (Fall, 2011) to seventh grade (Fall, 2013). Latent transition analysis and longitudinal analyses were used in the study.

Results: Six distinct breakfast location patterns emerged at baseline (1) frequent skippers; (2) inconsistent school eaters; (3) inconsistent home eaters; (4) regular home eaters; (5) regular school eaters and (6) *double breakfast* eaters. Results from the longitudinal analyses revealed that there was an increased odds of overweight/obesity among frequent skippers compared with *double breakfast* eaters after adjusting for school, year and students' race/ethnicity (AOR: 2.66, 95% CI: 1.67, 4.24). Weight changes from year to year were similar between *double breakfast* eaters and other students.

Conclusions: Concerns that a second breakfast at school increases risk of excessive weight gain are unsupported. Students who regularly consumed breakfasts at school, including *double breakfast* eaters, were more likely to exhibit a healthy weight trajectory. Additional research is needed to understand the impact of universal school breakfast on students' overall diets.

Keywords: Childhood obesity, *double breakfast*, middle school students, school breakfast.

Introduction

Breakfast consumption has been associated among school children with improved cognitive performance, nutritional adequacy, bone and cardiovascular health (1,2), as well as healthy body weight (3,4). Conversely, skipping breakfast has been associated with obesity (2,5,6). The National School Breakfast Program (SBP) in the United States (US) is a federally funded meal programme designed to provide a nutritious meal to students in public and nonprofit private schools. The programme provides cash assistance to states to operate nonprofit breakfast programmes in >89 000 schools and institutions nationwide, serving nearly 13 million children daily (7).

Currently, there are national advocacy efforts in the US from nonprofit organizations, foundations and corporations to promote higher participation in school breakfast, specifically, to make it easier for low-income communities to serve universal breakfast (i.e. daily breakfast to all students at no cost) (8). One of their recommendations is to use strategies such as

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serving breakfast in the classroom (BIC), or creating 'grab and go' breakfast boxes, to increase participation (9,10). However, a concern is that promoting school breakfast may inadvertently increase the likelihood of students consuming a *double breakfast* – by eating once before coming to school and once at school. The US Department of Agriculture School Breakfast Pilot Study of six school districts found that around 20% of students ate two or more breakfasts; among these students, 46% ate a 'substantive breakfast' at home in addition to the breakfast consumed at school (11). These findings raise the question of whether advocacy for maximum participation in the SBP may conflict with efforts to limit excess calories from school meals. Therefore, research is needed to determine the association between eating breakfast at school and body weight over time (12,13).

The aims of this study are to (1) identify breakfast location patterns (frequency and place of breakfast consumption) and changes in location patterns in a longitudinal sample of middle school students (from Grade 5 through 7); (2) explore predictors of breakfast location patterns; (3) assess the association between breakfast location patterns and weight over time and (4) examine whether students who consume a *double breakfast* have an increased risk of absolute weight gain compared with students with other location patterns.

Methods

Study design

Twelve schools were randomly selected from a total of 27 schools serving kindergarten through eighth grade in a medium-sized urban school district; all 12 schools agreed to participate. Students were eligible to participate if they were enrolled in fifth grade during the 2011–2012 school year. Participants were followed from fifth grade in 2011–2012 to seventh grade in 2013–2014. Student assent and parental consent were obtained prior to data collection.

Measures

Student surveys

Breakfast location patterns were defined by where students are eating and how frequently they are eating at these locations. Two items from the student surveys were used to describe breakfast location patterns (1) average number of days per week they eat breakfast (0–7) and (2) location where they ate breakfast the previous school day (home, school, both home and school or no breakfast).

Physical measurements

Trained research staff measured students' height and weight using the World Health Organization Expanded STEPwise approach to Surveillance protocol (14). Height was measured in inches using a stadiometer (Charder Electronic, Taichung City, Taiwan), and weight was measured in pounds using an electronic flat scale (Seca, Hamburg, Germany). Measured heights and weights were then used to calculate body mass index (BMI) for each student, using the Centers for Disease Control and Prevention sex-specific and age-specific BMI percentile calculator (15).

Administrative data

Students' sex, race/ethnicity and grade were obtained from school district records. Eligibility for free or reduced price school breakfast, set at 130% and 185%, respectively, of the federal poverty line (16), was included as a proxy for family socioeconomic status. Type of breakfast delivery model (BIC or serving in the cafeteria) was collected.

Statistical analysis

Latent transition analysis was used to identify unobserved breakfast location patterns underlying the observed data, and to estimate transition probabilities and movements between the identified patterns over time (17). Frequency and place of breakfast consumption from the two questions in the student surveys were treated as categorical variables and were used as indicators of breakfast location patterns. Akiake information criterion, Bayesian information criterion, likelihood ratio G^2 statistic, model parsimony and interpretability criteria were considered when selecting the best model for the study.

Latent transition analysis allowed estimation of baseline latent status membership probabilities, item-response probabilities conditional on time and latent status membership, transition probabilities and beta coefficients of logistic regression as published elsewhere (17).

Generalized estimating equations (GEE) models for categorical outcomes were used to examine whether the latent statuses membership predicts BMI trajectory over time. BMI values were collapsed into a binary variable: overweight/obese and normal/underweight for ease of interpretation. Students' sex, race/ethnicity, school and study year were incorporated into GEE models. All covariates were chosen *a priori* and were significantly associated with the outcome. In addition, we examined whether latent statuses membership is associated with weight changes over time, adjusting

for year using linear mixed models. Weight changes were calculated as the current year's weight minus past year's weight. All statistical analyses were performed using SAS software (version 9.2, SAS Institute, Cary, North Carolina, USA).

Results

Study participants

Complete data were available for 584 (85.4%) students in fifth grade in 2011, 602 (89.7%) students in sixth grade in 2012 and 539 (77.7%) students in seventh grade in 2013. The main reasons for non-participation were students absent during data collection (6.0% in 2011, 2.5% in 2012 and 15.9% in 2013), or no informed consent (8.6% in 2011, 7.7% in 2012 and 6.5% in 2013). Students who opted out or missed data collection in fifth grade were still eligible to participate the following year, as were students who transferred into participating schools. Students with data for only one of the three study years [11% {$N = 191$}] were excluded.

The final analytic sample is described in Table 1. It included 513 fifth grade, 553 sixth grade and 468

Table 1 Characteristics of the study sample

Characteristic	Grade 5 ($n = 513$)	Grade 6 ($n = 553$)	Grade 7 ($n = 468$)	p for trend
	N (%)	*N* (%)	*N* (%)	
Covariates				
Sex				0.575
Male	236 (46.0)	248 (44.9)	207 (44.2)	
Female	277 (54.0)	305 (55.2)	261 (55.8)	
Race/ethnicity				0.473
Non-Hispanic White	88 (17.2)	99 (17.9)	81 (17.4)	
Non-Hispanic Black	182 (35.5)	195 (35.3)	153 (32.8)	
Hispanic	239 (46.6)	255 (46.1)	229 (49.1)	
Other	4 (0.8)	4 (0.7)	3 (0.6)	
Eligibility for SBP*				—
Free/reduced price	415 (82.8)	—	—	
Full price	86 (17.2)	—	—	
Participate in BIC programme[#]				<0.0001
No	397 (77.4)	350 (63.3)	393 (92.3)	
Yes	116 (22.6)	203 (36.7)	33 (7.8)	
BMI				0.221
Underweight	10 (2.0)	9 (1.6)	9 (1.9)	
Healthy weight	227 (44.8)	241 (43.6)	224 (47.9)	
Overweight	108 (21.3)	119 (21.5)	105 (22.4)	
Obese	162 (32.0)	184 (33.3)	130 (27.8)	
BMI percentile, mean (SD)	73.6 (29.3)	75.0 (28.0)	73.9 (27.7)	0.845
Indicators of latent statuses				
Breakfast frequency				<0.0001
0 day week	14 (2.8)	30 (5.4)	28 (6.1)	
1–3 days week	72 (14.1)	94 (17.0)	101 (22.0)	
4–5 days week	78 (15.3)	89 (16.1)	78 (17.0)	
6–7 days week	346 (67.8)	339 (61.4)	253 (55.0)	
Yesterday's breakfast location				0.045
Did not eat	59 (11.6)	97 (17.6)	107 (23.1)	
Home	302 (59.5)	252 (45.7)	216 (46.7)	
School	85 (16.7)	138 (25.1)	86 (18.6)	
Both home and school	62 (12.2)	64 (11.6)	54 (11.7)	

Dashes indicate missing information. *Eligibility for free or reduced price school breakfast is set at 130% and 185%, respectively, of the federal poverty line. [#]BIC programme serves universal breakfast to students after the opening bell, in the classroom. BIC, breakfast in the classroom; BMI, body mass index; SBP, School Breakfast Program.

seventh grade students. There was no significant difference in sex, age, BMI status and breakfast consumption between students in the final analytic sample and those excluded because of participation in only one study year. However, those excluded with data for only one study year had a lower proportion of Hispanics (32.3% vs. 46.8%) and a higher proportion of students who participated in BIC programme (40.6% vs. 22.7%).

Breakfast location patterns

Using fit indices and model interpretability criteria, a six-class model was selected. Based on values of item-response probabilities (Table S1), the six latent status categories were (1) frequent skippers (71% reported eating breakfast 0–3 times a week and 100% reported not eating breakfast the day before); (2) inconsistent school eaters (97% reported eating breakfast 1–5 days a week and 77% ate at school the day before); (3) inconsistent home eaters (97% reported eating breakfast 1–5 days per week and 100% ate at home the day before); (4) regular home eaters (100% reported eating breakfast 6–7 days a week and 100% ate at home the day before); (5) regular school eaters (100% reported eating breakfast 6–7 days a week and 100% ate at school the day before) and (6) *double breakfast* eaters (100% reported eating breakfast 6–7 days a week and 100% ate at school and home the day before).

Table 2 presents the prevalence of each status for each grade. Overall, breakfast frequency declined over time as students aged, and significantly more students skipped breakfast in seventh grade than earlier. At baseline, the most prevalent status was *regular home* eaters (43.7%), followed by *inconsistent* (home or school combined) eaters (22.6%). Notably, the proportion of students in the *skippers* group progressively increased over time, with 22.9% of the students in this group by seventh grade. Table 2 also presents the likelihood of students transitioning from one breakfast status to another over time. For instance, *regular home* eaters in fifth grade had 41.7% probability of being in the same status in sixth grade, and 15.3% chance of transitioning to *skippers* status. The highest probabilities of transitioning to the *skippers* status was among

Table 2 Class item-response probabilities, prevalence of latent statuses and transition probabilities

	Frequent skippers	Inconsistent school eaters	Inconsistent home eaters	Regular home eaters	Regular school eaters	*Double breakfast* eaters
Prevalence of statuses at (%):						
Grade 5	11.5	6.8	15.8	43.7	11.9	10.1
Grade 6	17.5	9.4	14.4	31.6	16.9	10.3
Grade 7	22.9	12.4	12.9	34.1	9.8	8.0
Transitions from Grade 5 (rows) to Grade 6 (columns) (%)*:						
Frequent skippers	34.7	16.3	22.3	12.7	12.2	1.9
Inconsistent school eaters	14.1	18.5	11.2	20.6	14.0	21.6
Inconsistent home eaters	20.6	11.1	11.7	29.2	11.7	9.6
Regular home eaters	15.3	4.8	11.6	41.7	19.0	7.7
Regular school eaters	13.9	12.1	15.7	17.2	27.5	13.7
double breakfast eaters	9.6	9.8	13.4	37.3	11.3	18.6
Transitions from Grade 6 (rows) to Grade 7 (columns) (%)*:						
Frequent skippers	50.1	15.1	15.7	11.9	3.7	3.5
Inconsistent school eaters	27.2	31.3	15.8	13.4	5.1	7.2
Inconsistent home eaters	28.0	12.0	24.1	21.5	6.6	7.9
Regular home eaters	11.1	7.3	11.2	62.0	5.0	3.5
Regular school eaters	13.9	11.2	8.4	29.9	30.1	6.5
double breakfast eaters	16.4	8.3	2.2	29.2	10.3	33.6

*Transition probabilities are presented here as percentages (by multiplying by 100) for easier interpretation.

students in the *inconsistent* eaters groups. Similarly, *skippers* who changed statuses were most likely to transition to *inconsistent* eaters, and very unlikely to become *double breakfast* eaters over the study period. Overall, there was a higher probability for changes in status membership from fifth to sixth grade compared with sixth to seventh grade.

Predictors of breakfast location patterns

We conducted repeated measurement GEE models to examine predictors of breakfast location patterns. Using the *double breakfast* group as the reference group, significant sex differences in breakfast patterns were identified. Compared with boys, girls were more likely to belong in the *skippers* status (AOR: 3.00, 95% CI: 1.79, 5.02), *inconsistent school* eaters (AOR: 1.40, 95% CI: 0.81, 2.42), *inconsistent home* eaters (AOR: 3.03, 95% CI: 1.84, 5.01), *regular home* eaters (AOR: 1.98, 95% CI: 1.30, 3.03) and *regular school* eaters (AOR: 1.70, 95% CI: 1.03, 2.80) relative to *double breakfast* status, even after adjusting for year, weight status and BIC program.

In addition, significant differences emerged between overweight/obese students and normal weight students. Specifically, overweight and obese students were more likely to be *skippers* (AOR: 2.85, 95% CI: 1.74, 4.69), *inconsistent school* eaters (AOR: 2.51, 95% CI: 1.46, 4.32), *inconsistent home* eaters (AOR: 2.63, 95% CI: 1.61, 4.31) or *regular home* eaters (AOR: 1.74, 95% CI: 1.16, 2.62) than *double breakfast* eaters. We examined whether weight status predicted transition from one breakfast status to another at subsequent year, adjusting for race/ethnicity. We ran models including only baseline weight status and models including the status at each time point. In both models, being obese or overweight at any time did not predict transition from one status to another (all AORs = 1.00).

Association of breakfast location patterns with obesity status

The overall proportion of overweight and obese students in this cohort did not change significantly over time. Weight category was not proportionally distributed across the six latent breakfast statuses (Fig. 1). Notably, the proportion of students classified as *double breakfast* eaters who were identified as healthy

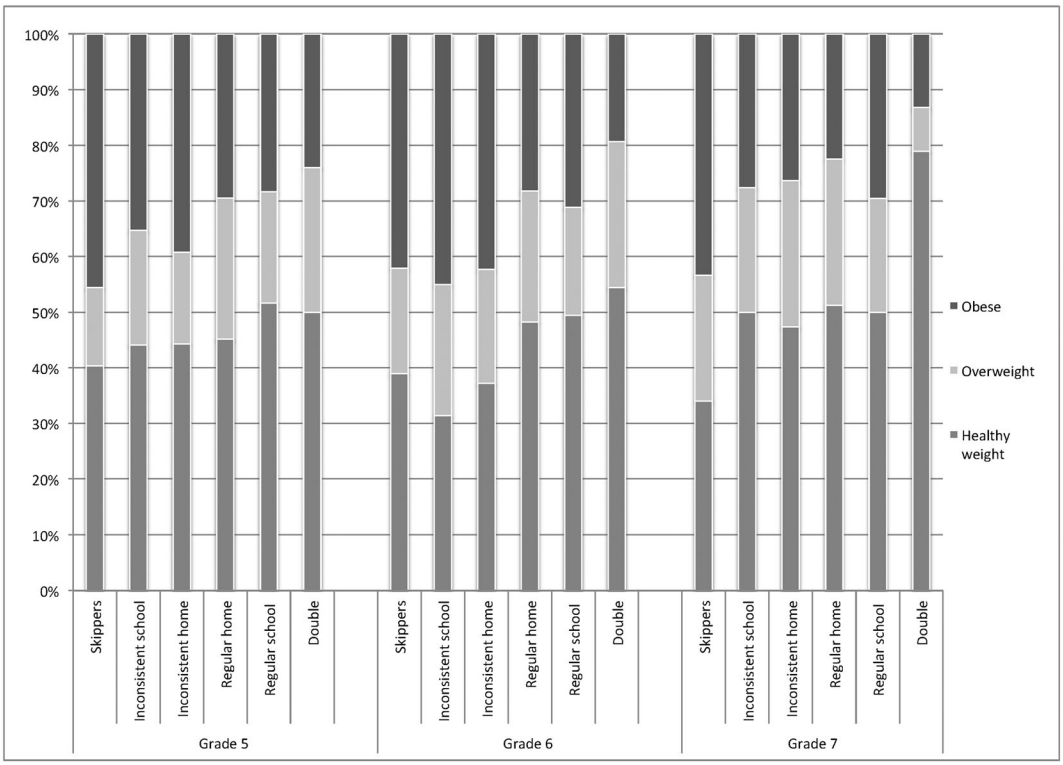

Figure 1 Weight status distribution of the six breakfast location patterns.

weight increased over time (51.9% in Grade 5, 54.4% in Grade 6 and 79.5% in Grade 7).

Because latent transition analysis allows examining the effect of weight status on transition between statuses but does not allow examining the significance of the association with latent status except at baseline, we conducted a longitudinal data analysis to examine whether breakfast patterns are significantly associated with BMI status over time. After accounting for clustering of students within schools and adjusting for year and race/ethnicity, a significant association between latent breakfast class membership and BMI category was revealed ($p = 0.002$) (Figure 1). Odds of being overweight or obese was significantly more likely for students in the *skippers* group compared with *double breakfast* eaters (AOR: 2.66, 95% CI: 1.67, 4.24). Similarly, *inconsistent school* eaters (AOR: 2.11, 95% CI: 1.29, 3.46), *inconsistent home* eaters (AOR: 2.02, 95% CI: 1.27, 3.21) and *regular home* eaters (AOR: 1.70, 95% CI: 1.13, 2.56) all were more likely to be overweight or obese compared with *double breakfast* eaters. Further, Hispanics (AOR: 1.78, 95% CI: 1.14, 2.78) and non-Hispanic black preadolescents (AOR: 1.75 95% CI: 1.10, 2.79) also had higher odds of obesity than non-Hispanic white preadolescents. Finally, to examine the specific question of whether students who consume a *double breakfast* have increased risk of excessive weight gain compared with students in the other breakfast categories, we tested the association between breakfast status and weight change (i.e. difference in BMI from past year) over time. We found that there was no difference between weight changes of *double breakfast* eaters over time compared with any of the other breakfast categories adjusting for year ($F = 0.67$, $p > 0.05$). In other words, there was no evidence of greater weight gain over time among students who consume a *double breakfast* when compared with all other students.

Discussion

To our knowledge, this is the first longitudinal study to explore breakfast location patterns, including *double breakfast*, and obesity risk in the US, using a sample of middle school children in a diverse, urban district. The percentage of students eligible for free or reduced price meal in this study is 83%, which is much higher than the national average of 51% (18). The rate of overweight and obesity in this sample exceeds 50%, well above the national average of 35% for this age group (19). In this high-risk sample, six qualitatively unique patterns of breakfast consumption were identified prevalence of these patterns varied by sex, race/ethnicity and weight status.

Our observation that skipping breakfast increased over the 3-year time period and was more common in female students has been noted in other studies (20,21). The association we found at each time point between breakfast skipping and higher weight status is also consistent with previous cross-sectional studies (2,5,6,22,23). The reason why skipping breakfast is associated with higher weight is not well understood. It may reflect some degree of reverse causality if overweight and obese students think skipping breakfast will help them lower caloric consumption. Another theory is that skipping breakfast leads to overconsumption later in the day due to increased hunger; however, a recent review of the literature on breakfast and weight found that available evidence from randomized controlled trials is not sufficient to draw any causal connection between breakfast skipping and obesity (24). Nevertheless, even if breakfast skipping does not cause weight gain, eating breakfast is recommended because it is associated with a higher diet quality (22). In our sample, the largest increase in breakfast skipping was between fifth and sixth grades, especially among the inconsistent home eaters, suggesting this group may benefit from targeted breakfast promotion interventions.

Our study adds to the literature that has monitored weight and different breakfast location patterns longitudinally (25). Student's weight changes from one school year to the next were similar across all breakfast groups, including the *double breakfast* eaters. A recent study by Vargas *et al.* (26) reported similar findings: although male adolescents in SBP were more likely to be *double breakfast* eaters, there was no association between SBP involvement and the probability of being overweight. The finding that students who eat two breakfasts do not gain significantly more weight than students who eat one breakfast appears paradoxical because they are eating an additional meal. It is possible that the *double breakfast* eaters may be more active and expend more energy during the day, particularly given the male predominance of *double breakfast* eaters found in Vargas *et al*. and in our study. Another possibility is that eating more calories earlier in the day is compensated by lower caloric consumption later in the day. Additional research is needed to examine energy intake over an entire day for children who eat one for children who eat one or two breakfasts, or skip breakfast on school days to better understand the link between morning meals, caloric intake and weight.

This study has several limitations. Our data are observational, not experimental, and the reasons why students have specific breakfast patterns are unknown; therefore, we cannot infer causal associations between breakfast consumption and weight outcomes. We also did not measure the quality or quantity of the breakfast consumed (e.g. did '*double breakfast* eaters' have two small meals or eat twice as much?); thus, there is likely to be great heterogeneity in the caloric consumption among *double breakfast* eaters. Further research using direct observation such as through plate-waste data or accompanied by detailed 24-h recall is necessary to measure breakfast quality and to better understand the *double breakfast* eater consumption pattern. In our cohort, we identified around 10% of students who were *double breakfast* eaters during our study years. This is lower than the 2% reported in a US Department of Agriculture pilot study (11) and the 51% reported in a New York City study of double breakfast eaters when breakfast was served in the classroom (27). A possible reason is that students who were excluded from this study had a higher proportion of students who participated in BIC programme, which may have a positive association with *double breakfast* consumption. We did not explore reasons behind the double eating behavior; further qualitative research and detailed measurement of food security are needed in future research. We recognize that middle school is a period of rapid physical development where students are growing taller and gaining weight. Because growth spurts differ among adolescents and can lead to changes in dietary patterns, BMI may not be the most reliable measure of obesity. Further, research has shown that pubertal onset may differ by weight status, such that obese children enter puberty earlier than normal-weight children (28). Future research should assess students' pubertal stage as well as their possible effects on eating behaviours. Finally, self-reported data are subject to reporting error and social desirability bias. The study sample represents an ethnic and racially diverse low-income school district; findings may not generalize to other types of school districts.

Despite these limitations, there are also several notable strengths. This is the first study to use longitudinal data and latent transition analyses to examine breakfast consumption and obesity risk in a sample of middle school students. Furthermore, this is the first study to examine *double breakfast* eaters and weight status over time. There has been concern about the impacts of promoting school breakfast, as it can lead to *double breakfast* consumption and potential risk of obesity. We found no evidence that this group of students had higher weight status compared with other groups. Given nearly four million households are unable to provide adequate and nutritious food for their children at times during the year, maximizing access to school breakfast is an important strategy to reduce the risk of child hunger (29).

Conflict of interest statement

The authors have no conflicts of interest to report.

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Authors' responsibilities

S. W.: data analyses, data interpretation and manuscript writing; M. S.: study design, data interpretation and manuscript writing; F. S.: data analyses and data interpretation; M. R.: data collection and data interpretation; K. H.: study design and data interpretation; J. I.: study design, data interpretation and manuscript writing. M. S. and J. I. are the multiple principal investigators of the project. All authors contributed to the revision of the manuscript and approved the final manuscript.

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Supporting Information

Additional supporting information can be found in the online version of this article at the publisher's website:

Table S1. Class item-response probabilities