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Explaining the Positive Relationship between Fourth-Grade Children's Body Mass Index and Energy Intake at School-Provided Meals (Breakfast and Lunch)

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Abstract

BACKGROUND—A positive relationship exists between children's body mass index (BMI) and energy intake at school-provided meals. To help explain this relationship, we investigated 7 outcome variables concerning aspects of school-provided meals—energy content of items selected, number of meal components selected, number of meal components eaten, amounts eaten of standardized school-meal portions, energy intake from flavored milk, energy intake received in trades, and energy content given in trades.

METHODS—We observed children in grade 4 (N=465) eating school-provided breakfast and lunch on one to 4 days per child. We measured children's weight and height. For daily values at school meals, a generalized linear model was fit with BMI (dependent variable) and the 7 outcome variables, sex, and age (independent variables).

RESULTS—BMI was positively related to amounts eaten of standardized school-meal portions ($p < .0001$) and increased 8.45 kg/m^2 per serving, controlling for other variables in the model. BMI was positively related to energy intake from flavored milk ($p = .0041$) and increased 0.347 kg/m^2 for every 100-kcal consumed. BMI was negatively related to energy intake received in trades ($p = .0003$) and decreased 0.468 kg/m^2 for every 100-kcal received. BMI was not significantly related to 4 outcome variables.

CONCLUSIONS—Knowing that relationships between BMI and actual consumption, not selection, at school-provided meals explained the (previously found) positive relationship between BMI and energy intake at school-provided meals is helpful for school-based obesity interventions.

Keywords

Child & Adolescent Health; Nutrition & Diet; School Food Services

Childhood obesity has increased dramatically in the US over the last several decades.¹ Data from 2008 showed more than one third of children ages 6 to 11 years had a body mass index (BMI) for age 85th percentile.² Childhood obesity has been linked to adult health problems including cardiovascular disease, type 2 diabetes, and cancer.³

On each school day in the US, millions of children participate in the School Breakfast Program (SBP)⁴ and the National School Lunch Program (NSLP)⁵ which are federally assisted meal programs administered by the United States Department of Agriculture (USDA). Policy makers and researchers have expressed concern that participation in school-meal programs may contribute to childhood obesity.^{6–8} Research concerning the relationship of school-meal participation and childhood obesity has produced conflicting results.⁷ For example, Schanzenbach⁹ found that after 2 years of participating in school lunch, children were 2 percentage points more likely to be overweight than non-participants, whereas Hofferth and Curtin¹⁰ found no relationship between school-meal participation and childhood overweight. In analyses of data from the School Nutrition Dietary Assessment Study III (SNDA-III), Gleason and Dodd¹¹ found no association between NSLP participation and BMI; however, those analyses did show an inverse relationship between SBP participation and BMI.

Analyses by our group have suggested that it is energy intake at school-provided meals, instead of participation in school meals, that is related to obesity. Specifically, in analyses of data from a dietary-reporting validation study¹² (which used direct meal observations of school-provided meals to assess the effects of retention interval on 4th grade children's dietary recall accuracy), Baxter et al¹³ examined the relationship of BMI and school-meal participation as well as the relationship of BMI and energy intake at school-provided meals. Those results, published in 2010,¹³ showed that children's BMI was not significantly associated with school-breakfast participation, school-lunch participation, or combined participation (both meals on the same day). However, there was a significant and positive relationship between children's BMI and energy intake at school lunch, and there was a marginally significant and positive relationship between children's BMI and energy intake at school breakfast.¹³

Aspects of school-provided meals that could influence children's energy intake at those meals include the USDA's "offer-versus-serve" provision, the availability of flavored milk, and trading during school meals. These are briefly discussed below.

The "offer-versus-serve" provision began in elementary schools in 1981; the goals were to reduce food waste at school-provided meals and to allow children to select foods they prefer.¹⁴ Each school district decides whether to implement "offer-versus-serve." Most districts do implement this provision; according to the SNDA-III, during the 2004–05 school year, 78% of elementary schools implemented "offer-versus-serve".¹⁵ In school districts where "offer-versus-serve" is implemented, children may decline one of the 4 required food items offered in the reimbursable breakfast and up to 2 of the 5 required food items offered in the reimbursable lunch.¹⁴ The 4 items that must be offered at breakfast are one serving of juice/fruit/vegetable; one serving of milk; and either 2 servings of grains/breads, 2 servings of meat/meat alternate, or one serving of each. The 5 items that must be offered at lunch are one serving of meat/meat alternative, one serving of grains/breads, 2 servings of vegetables/fruits, and one serving of milk.¹⁴ Depending on which items a child selects and declines, the

meal components (eg, vegetable, beverage) on trays may differ from child to child. As these meal components can vary considerably in energy content, components selected when “offer-versus-serve” is implemented may impact children’s energy intake at school meals.

Flavored milk is a popular choice among children; for example, data from 2005 showed that nearly 70% of children participating in the NSLP selected flavored versus unflavored milk.¹⁶ Data from 2006 showed that 32% to 36% of states required or recommended that schools offer at least 3 different types of milk (eg, 1% chocolate, skim plain) each day for breakfast and for lunch.¹⁷ Because sugars added to flavored milk (eg, chocolate, strawberry) add kilocalories to the milk,¹⁸ it is intuitive that flavored milk has the potential to impact children’s energy intake at school meals.

Trading during school meals, which occurs when children give and/or receive items,¹⁹ may also influence children’s energy intake at school meals. Results from a retrospective analysis of school-lunch observations for 1st grade and 4th grade children indicated that: (1) trading varied by grade, with more 4th than 1st grade children trading and (2) most food items were traded as full servings.¹⁹

The purpose of the current analyses was to identify aspects of school meals that may contribute to the positive relationship between 4th grade children’s BMI and energy intake at school meals that was published in the 2010 article.¹³ It was hypothesized that the following 7 aspects of school meals would be significantly related to BMI: (1) energy content of items selected, (2) number of meal components selected, (3) number of meal components eaten, (4) amounts eaten of standardized school-meal portions, (5) percentage of energy intake from flavored milk, (6) percentage of energy intake received in trades, and (7) percentage of energy content given in trades. The hypotheses were that BMI would be positively related to each of the first 6 variables, and that BMI would be negatively related to the seventh variable.

METHODS

Written parental consent and child assent were obtained. Data collection methods for the dietary-reporting validation study have been described in detail elsewhere;^{12,20} thus, only a summary is provided here.

Participants

Table 1 shows information concerning the sample. Data were collected during the 2004–05, 2005–06, and 2006–07 school years in 17, 17, and 8 elementary schools, respectively, in one school district in Columbia, SC. There were fewer schools during the final school year because data collection needs for the dietary-reporting validation study were less for that year. Of the 1730 children total who agreed to participate in the study, a subset of children was randomly selected for meal observations. The sample for our analyses consisted of 465 4th grade children, who were primarily Black, from the 3 school years combined. All 465 children were observed eating both SBP breakfast and NSLP lunch; these meals were observed on the same day for an individual child, and some children were observed eating both meals on more than one day. As Table 1 shows, across the 465 children, there were 561 observation days. The school district had implemented the “offer-versus-serve” provision, so children could decline some items.

Instruments and Procedure

For direct observation of school-provided meals, researchers (primarily Registered Dietitians) stood close to groups of children during school breakfast and school lunch and recorded items selected and amounts eaten in servings of standardized school-meal portions.

At a school meal, a researcher observed 2–3 randomly selected children, although the researcher appeared to be observing the entire class. Researchers only observed children who obtained school-provided meals because it is difficult to identify contents of meals brought from home.²¹ Observations occurred during entire, regular meal periods with children seated according to the school's typical arrangement. On days when observations were conducted, children wore nametags (created by researchers) that were distributed before meals to all children participating in the study; nametags were collected immediately after meals.

Prior to data collection each school year, researchers conducted practice observations (at least 5 per school) for training purposes and to decrease reactivity. Observer training also included review of the written protocol, modeling, and pre-data-collection inter-observer reliability. Throughout data collection, inter-observer reliability²² was assessed weekly; results showed acceptable levels of agreement between pairs of observers.¹² For any food items that were traded (ie, given away; received), observers recorded the amounts in servings of standardized school-meal portions.

When children selected milk, observers recorded the milk flavor selected as white (ie, plain), chocolate, strawberry, vanilla, or caramel. For the sample of 465 children observed on a total of 561 days, the number of milks selected by flavor at school breakfast and school lunch, respectively, was plain for 114 and 82, chocolate for 48 and 197, strawberry for 14 and 55, vanilla for 15 and 61, and caramel for one and 3. The energy content per 8-ounce milk carton was 102, 140, 180, 190, and 188 kilocalories for plain, chocolate, strawberry, vanilla, and caramel flavor, respectively.

To measure children's weight and height, researchers followed a written protocol and standardized procedures.^{23,24} Each child was weighed and measured after school breakfast but before school lunch in a private location at one point in time at school in the spring of the 4th grade school year. Weight was measured on a digital scale and recorded to the nearest 0.10 pound. Height was measured on a portable stadiometer and recorded to the nearest 0.125 inch. Inter-measurer reliability was assessed daily for pairs of research staff from a random 10% sample of children. Intra-class correlation reliability was >0.99 for weight and for height for each of the 3 school years. Children's measured weight and height were used to calculate BMI as kg/m².

Coding and Data Analysis

Table 1 provides the definition for each of the 7 outcome variables. Energy values (in kilocalories) of standardized school-meal portions were obtained primarily from the Nutrition Data System for Research (Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN), but sometimes from the school district. Amounts eaten of each serving were coded as none=0.0, taste=0.10, little bit=0.25, half=0.50, most=0.75, all=1.00, and the actual number of servings if more than one serving was observed being eaten. Quantified amounts eaten were multiplied by per-serving energy values (in kilocalories) of standardized school-meal portions.

School-meal items were classified as one of 10 meal components (beverage, bread/grain, breakfast meat, combination entrée, condiment, dessert, entrée, fruit, miscellaneous, vegetable). The number of meal components *selected* and the number of meal components *eaten* were 2 distinct variables. For example, on a particular school day, if a child had pancakes, syrup, and orange juice on his or her breakfast tray, and ham, peaches, and chocolate milk on his or her lunch tray, then the number of meal components *selected* for that child over the 2 school meals would be 5 (bread/grain, condiment, beverage, entrée, and fruit). If this child on this day was observed to have eaten pancakes, syrup, and orange juice

at school breakfast, and pizza and chocolate milk at school lunch, then the number of meal components *eaten* over the 2 school meals for that child would be 4 (bread/grain, condiment, beverage, and entrée). Flavored milk was defined as any milk that was not white milk.

Statistical analyses were performed using SAS/STAT ® software (Version 9.2, Copyright © 2002–2008, SAS Institute Inc., Cary, NC). A generalized estimating equation (GEE) method was used to fit a marginal regression model with BMI as the dependent variable; independent variables were the 7 outcome variables, sex, and age in months. The GEE approach²⁵ is common when statistical observations are “clustered” (eg, students within schools); it accounts for the dependence of observations within school and multiple observation days per child. A modified sandwich variance estimator, computed under an independent working correlation assumption, was used to obtain standard errors. For the analyses, BMI was used as the dependent variable (instead of BMI percentile) because the underlying model assumptions were better satisfied when using BMI.

RESULTS

Table 2 provides the means and standard deviations for each of the 7 outcome variables by BMI quartile. Although BMI was treated as a continuous variable in analyses, for ease of presentation, Table 2 shows information by BMI quartiles.

BMI was significantly related to 3 of the 7 outcome variables created concerning aspects of school-provided meals. First, BMI was positively related to the amounts eaten of standardized school-meal portions (one-tailed $p < .0001$); on average, BMI increased 8.45 kg/m² per serving over both school meals, holding other variables constant. As shown in Table 2, children in the fourth BMI quartile consumed a mean of 0.96 serving, whereas children in the first BMI quartile consumed a mean of 0.8 serving.

Second, BMI was positively related to the percentage of energy intake from flavored milk (one-tailed $p = .0041$); on average, BMI increased by 0.347 kg/m² for every 100-kcal consumed, holding other variables constant. As shown in Table 2, children in the third and fourth BMI quartiles consumed nearly 11% of their kilocalories at school-provided meals from flavored milk, whereas those in the first and second BMI quartiles consumed closer to 9% of their kilocalories from flavored milk.

Third, BMI was negatively related to the percentage of energy intake received in trades (our data would yield a one-tailed $p = .0003$ in a test for that negative effect); on average, BMI decreased 0.468 kg/m² for every 100-kcal received, holding other variables constant. As shown in Table 2, children in the second BMI quartile had the highest percentage of energy intake received in trades during school-provided meals, at 11%.

There were no significant relationships between BMI and the remaining 4 outcome variables – the energy content of items selected, the number of meal components selected, the number of meal components eaten, or the percentage of energy content given in trades.

DISCUSSION

Analyses were conducted to investigate 7 aspects of school-provided meals that may contribute to the positive relationship between 4th grade children’s BMI and energy intake at school meals that was published in a 2010 article.¹³ Results for 2 outcome variables were as hypothesized: the result for one outcome variable was opposite to what we had hypothesized, and the results for 4 outcome variables did not support our hypotheses.

The result that BMI was positively related to the amounts eaten of standardized school-meal portions was as hypothesized. Although this result is intuitive, to the authors' knowledge, no other studies have examined this relationship.

Also, the result that BMI was positively related to the percentage of energy intake from flavored milk at school-provided meals was as hypothesized. In contrast to this article's results, previous research has shown that consumption of flavored milk was not associated with adverse effects on BMI among children and adolescents.²⁶ Milk is a source of key nutrients, including calcium and Vitamin D, for children. Results from some studies have shown a negative relationship between calcium intake and children's percent body fat.^{27,28} In recent years, there has been a debate in the US as to whether schools should offer flavored milk. A 2009 study found that elementary and secondary school children drink less milk (and get fewer nutrients) when flavored milk is removed from schools.²⁹

The result that BMI was negatively related to the percentage of energy intake received in trades at school-provided meals was opposite to our hypothesis and counterintuitive. One would expect children with higher BMIs to have a higher percentage of energy intake received in trades, but this article's result showed that children with higher BMIs had a lower percentage of energy intake received in trades at school-provided meals. Perhaps children with lower BMIs were hesitant to give food trades to children with higher BMIs; unfortunately, this could not be investigated using data previously collected for this sample of children because observations usually did not include both "sides" of the trade (ie, the giver and the receiver).

The lack of results concerning positive relationships between BMI and 3 outcome variables concerning aspects of school-provided meals — the energy content of items selected, the number of meal components selected, and the number of meal components eaten — and the lack of a result concerning a negative relationship between BMI and our seventh outcome variable — the percentage of energy content given in trades — did not support our hypotheses. To the authors' knowledge, no other studies with children and school-provided meals have examined the relationship between BMI and these 4 aspects of school-provided meals. However, results from SNDA-III showed that offering elementary school children French fries and desserts more than once a week was associated with higher BMI.³⁰

The 7 outcome variables analyzed for this article were used in part because data had been collected in a school district that had implemented "offer-versus-serve." For example, an outcome variable for the number of items *consumed* within each meal component type was not used because it would have required numerous values of "0" for analyses. Each observed meal did *not* include each meal component type because "offer-versus-serve" was implemented (so children could refuse some meal components), or because of the menu itself. With the "offer-versus-serve" provision, a child was required to select 3 different meal components; for example, a child could not select only 3 milks for breakfast, or only 3 fruits for lunch. Our variable for number of meal components *eaten* was the counterpart to our variable for the number of meal components *selected*. As Table 2 shows, children ate the majority of unique meal components selected; specifically, the number of meal components *eaten* was 88% to 91% of the number of meal components *selected*.

An important strength of these analyses is that data were obtained using direct observation of children eating school-provided meals, rather than relying on self-reported information from children or parental reports of children's school-meal intake. Meal observations are considered the "gold standard" for validating dietary reports, and should be conducted in a cafeteria-type setting (eg, school) that is familiar for children.³¹ Observing children in private homes may cause substantial reactivity, but our school-meal observations were

conducted in a manner that minimized reactivity;³² for example, recent results showed that our implementation of school-meal observations did not influence 4th grade children's dietary recalls.²⁰ Other strengths are the rigorous quality control procedures implemented during all 3 school years for school-meal observations and for weight and height measurements.

Limitations

These were secondary analyses of data collected for a dietary-reporting validation study that was not designed to investigate aspects of school-provided meals that might influence a positive relationship between children's BMI and energy intake at school meals. Weight and height measurements were available for only one time point per child. The sample was homogeneous with respect to grade level and race, and from one school district that had implemented "offer-versus-serve." As data on physical activity were not collected for the dietary-reporting validation study, analyses conducted for this article could not explore what role physical activity may have played in the relationship between children's BMI and energy intake at school-provided meals.

Conclusions

This article's results showed that relationships between 4th grade children's BMI and consumption, not selection, at school-provided meals explained the (previously found) positive relationship between BMI and energy intake at school meals. Specifically, children with greater BMIs (1) ate more of their portions at school meals, (2) had larger percentages of energy intake from flavored milk at school meals, and (3) had smaller percentages of energy intake received in trades at school meals. Additional studies are needed to substantiate these findings and provide further insight towards explaining the relationship between children's BMI and aspects of school-provided meals.

IMPLICATIONS FOR SCHOOL HEALTH

Information and results from this article may help inform school-based health promotion practices and school-based childhood obesity interventions. For example, the result that children with higher BMIs ate more of their standardized school-meal portions could lead to future research to investigate the time duration of eating school meals for individual children to determine whether it differs by BMI. Perhaps children with higher BMIs eat faster than children with lower BMIs, and children could be trained to eat slower and chew longer, thus reducing the number of kilocalories consumed during the time frame allowed for school meals. Also, perhaps children with higher BMIs are more inclined to visual cues such as the amounts remaining on their school-meal trays, than to physiological cues such as satiety, and children could be trained to consider physiological cues, thus reducing the number of kilocalories consumed at school meals. Although these practices could be challenging to implement, educating principals and school staff about them could be helpful for both children and adults, and for both school and non-school meals.

Additional research is needed on the relationship between BMI and energy intake from flavored milk at school-provided meals. It is encouraging that milk processors in the US are reformulating flavored milk to decrease the kilocalorie content, while preserving its nutritional value and taste.¹⁸ It is also encouraging that these lower-kilocalorie flavored milks are acceptable to children. For example, in one study, 3rd through 5th grade children who were offered lower-kilocalorie flavored milk were as likely to drink most of their milk as children who were offered higher-kilocalorie flavored milk.³³ School districts are encouraged to offer lower-kilocalorie flavored milk at school-provided meals.

Although several articles mention trading of foods during school-provided meals,^{12,19,34} to the authors' knowledge, this article's analyses are the first to investigate the relationship between BMI and food trading at school-provided meals. Additional research is needed concerning food trading at school meals.

Future research may consider cohort studies that provide data for groups of children followed throughout grade levels in elementary school. This would provide valuable insight into the relationship over time between BMI and energy intake at school meals.

Human Subjects Approval Statement

The project was approved by the University of South Carolina's institutional review board for human subjects.

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Table 1
Information Concerning the Sample and Definitions for the 7 Outcome Variables

Sample	Detail
Number of schools with data collection by school year	17, 17, and 8 public elementary schools during the 2004–05, 2005–06, and 2006–07 school years, respectively
Total number of 4th grade children	465 (for all 3 school years)
Race	95% Black; 5% White
Sex	49% girls
Age	10.27 years (mean)
Number of days that school-provided meals were observed	Individual children were observed eating school breakfast and school lunch on the same day; across the 465 children, a child had one (N=381), 2 (N=73), 3 (N=10), or 4 (N=1) days of observations for a total of 561 observation days.
Outcome Variable	Definition
Energy content of items selected (in kilocalories)	Sum of kilocalories of food items on a child's tray at school breakfast plus the sum of kilocalories of food items on a child's tray at school lunch for a particular school day
Number of meal components selected	Number of 10 unique meal components (beverage, bread/grain, breakfast meat, combination entrée, condiment, dessert, entrée, fruit, miscellaneous, vegetable) that a child selected at school breakfast and school lunch on a particular school day
Number of meal components eaten	Number of unique meal components that a child was observed eating at school breakfast and school lunch on a particular school day
Amounts eaten of standardized school-meal portions	Average amount eaten at school-provided meals for a child on a particular school day with amounts eaten of each serving coded as none=0.0, taste=0.10, little bit=0.25, half=0.50, most=0.75, all=1.00, and the actual number of servings if >1 serving was observed eaten
Percentage of energy intake from flavored milk	Number of kilocalories from flavored milk (ie, milk that was not white milk) divided by the number of kilocalories eaten at school-provided meals for a child on a particular school day
Percentage of energy intake received in trades	Number of kilocalories from food items received in trades divided by the number of kilocalories eaten at school-provided meals for a child on a particular school day
Percentage of energy content given in trades	Number of kilocalories from food items given in trades divided by the number of kilocalories of items selected at school-provided meals for a child on a particular school day

Table 2

Means (Standard Deviations) for Each of the 7 Outcome Variables^a by Body Mass Index (BMI) Quartile^b in a Sample of 465 4th Grade Children Observed Eating School-Provided Meals on a Total of 561 Days

	BMI Quartile ^b			
	First	Second	Third	Fourth
Number of 4th grade children	141	143	137	140
Energy content of items selected (in kilocalories)	1,014 (207)	1,037 (209)	1,054 (246)	1,033 (218)
Number of meal components selected	5.74 (1.07)	5.56 (1.26)	5.55 (1.13)	5.80 (1.17)
Number of meal components eaten	5.07 (1.25)	5.04 (1.28)	5.01 (1.37)	5.29 (1.22)
Amounts eaten of standardized school-meal portions *	0.80 (0.20)	0.87 (0.18)	0.87 (0.18)	0.96 (0.21)
Percentage of energy intake from flavored milk **	9.40 (12.62)	9.19 (10.82)	10.77 (12.67)	10.56 (11.13)
Percentage of energy intake received in trades ***	6.36 (13.36)	11.00 (16.72)	7.72 (15.86)	6.60 (12.65)
Percentage of energy content given in trades	9.76 (20.31)	7.79 (21.10)	9.33 (25.61)	6.44 (15.85)

^aThe 7 outcome variables are defined in Table 1.

^bFor analyses, BMI was treated as a continuous variable but BMI quartiles were used in Table 2 for ease of presentation.

*BMI was positively related to amounts eaten of standardized school-meal portions (one-tailed Wald large-sample z-test $p < .0001$).

**BMI was positively related to percentage of energy intake from flavored milk (one-tailed z-test $p = .0041$).

***BMI was negatively related to percentage of energy intake received in trades (our data would yield a one-tailed $p = .0003$ in a z-test for that negative effect).