HHS Public Access

Author manuscript

J Am Coll Nutr. Author manuscript; available in PMC 2016 June 07.

Published in final edited form as:

J Am Coll Nutr. 2016 ; 35(4): 326–333. doi:10.1080/07315724.2015.1048381.

Breakfast Intake and Composition is Associated with Superior Academic Achievement in Elementary School Children

Lauren T. Ptomey, PhD[1], **Felicia L. Steger, MS**[1], **Matthew M. Schubert, MS**[1], **Jaehoon Lee, PhD**[2], **Erik A. Willis, MS**[1], **Debra K. Sullivan, PhD**[3], **Amanda N. Szabo-Reed, PhD**[1], **Richard A. Washburn, PhD**[1], and **Joseph E. Donnelly, PhD**[1]

[1]Cardiovascular Research Institute, Division of Internal Medicine, The University of Kansas Medical Center, 3901 Rainbow Boulevard, Kansas City, KS, 66160 USA

[2]Institute for Measurement, Methodology, Analysis, and Policy, Texas Tech University, 2500 Broadway Street; Lubbock, TX 79409 USA

[3]Department of Dietetics and Nutrition, The University of Kansas Medical Center, 3901 Rainbow Boulevard, Kansas City, KS, 66160 USA

Abstract

Objective—To determine if breakfast consumption or content affects academic achievement measured by standardized tests.

Methods—Baseline data was collected in fall of 2011 from 698 students (50.5% female, age=7.5±0.6 yrs.) living in the state of Kansas. Academic achievement was assessed using three components from the Wechsler Individual Achievement Test (WIAT-III). Prior to taking the WIAT-III, participants completed a breakfast recall of all the foods and drinks consumed that morning, which was analyzed using NDS-R. WIAT-III scores were compared between breakfast and non-breakfast consumers in a sample (n=162) matched for age, sex, race, education level of both parents, household income, BMI, and cardiovascular fitness, and Pearson correlations were calculated from all breakfast eaters (n=617) between test performance and components of the breakfast.

Results—When compared to non-breakfast consumers, the breakfast consumers had significantly higher scores in all three WIAT-III components (all $p<0.05$). In breakfast consumers, servings of fruit juice were negatively correlated with reading comprehension and fluency standard score and mathematics standard score (both $p<0.0001$), and greater servings of whole grains were significantly related to higher scores in reading comprehension and fluency and mathematics (both $p<0.05$).

Conclusion—Both breakfast consumption and the content may be associated with improved standardized test performance in elementary school students.

Corresponding author: Lauren Ptomey, PhD, RD, LD, Postdoctoral Fellow, Cardiovascular Research Institute, Division of Internal Medicine, University of Kansas Medical Center, 3901 Rainbow Blvd, Mail Stop #1007, ATTN: Energy Balance Lab, Kansas City, KS 66160, Phone: 1-913-945-8182, Fax: 1-913-945-8280, ; Email: LPtomey@kumc.edu

Conflict of Interest: No authors report any conflict of interest

Keywords

Breakfast; Academic Achievement; Children; Elementary School; Diet

Introduction

Breakfast is typically the first meal consumed after waking in the morning, and is widely perpetuated as being the most important meal of the day [1]. Breakfast consumption has been linked to a number of positive health benefits, including a more favorable dietary profile [2-4], maintenance of body mass index (BMI) [5, 6], increased physical activity behavior [7, 8], appetite regulation [9], and improved metabolic profiles [10]. Children who skip breakfast are significantly less likely to meet fruit and vegetable recommendations and are more likely to eat unhealthy snack items [11].

Claims for the benefits of breakfast on health and disease risk reduction have encountered recent scrutiny due to a lack of support from randomized-controlled trials [12]. Despite strong associations between BMI and breakfast consumption, the independent effect of breakfast loses some, if not all, significance when accounting for confounding variables, such as total energy intake, parental education, and socioeconomic status [11]. Two major benefits related to breakfast consumption that are often touted are decreased energy consumption later in the day and increased leisure-time physical activity [13, 14]. However, recent evidence has shown that decreased energy consumption by breakfast eaters later in the day does not offset the caloric intake of the breakfast consumed [15]. Further, although modest increases in physical activity may be observed in children who consume breakfast, the evidence is insufficient to support the claim that failing to consume breakfast is detrimental to physical activity levels [7, 8, 13].

Despite criticism that breakfast consumption may not convey the metabolic benefits often claimed, considerable interest has been given to the relationship between breakfast and academic performance [4, 16-18]. Most notably, this relationship is used in support of the provision of breakfast via school-based programs [19-21]. There is reason to believe that the consumption of breakfast may improve cognitive performance and academic achievement [18, 20, 22]; however, most of the previous research did not account for confounding factors such as socio-economic status, parental education, fitness level, and demographic characteristics. Furthermore, most research has simply compared a breakfast to no-breakfast intervention without examining the content or composition of the meal.

The research examining the composition of breakfast mostly focuses on glycemic load (GL) or glycemic index (GI). Postprandial glycemic response and its effects on cognitive performance have been studied, and there is evidence to support a benefit of a low-glycemic load breakfast and/or lower postprandial glycemic response on academic achievement and cognitive performance [3, 19, 22, 23]. A systematic review by Edefonti and colleagues concluded that there is emerging yet insufficient evidence to substantiate claims that breakfast consumption results in improved cognitive performance, and the review reported contradictory results when energy, macronutrient content, and/or GL/GI are manipulated [23]. Specifically, when discussing children and adolescents, the finding that provision of

breakfast by schools increases attendance may confound results from studies on cognitive performance and participation in the Federal School Breakfast Program [21].

Baseline data from the Physical Activity and Academic Achievement Across the Curriculum (A+PAAC) study afforded an opportunity to provide clarification on some of the aforementioned assumptions by examining the effect of breakfast consumption and content (macro nutrient intake and food group servings) on academic achievement while correcting/controlling for confounding variables characteristic of prior study limitations on this topic. Specifically, this investigation aimed to evaluate whether students who consume breakfast perform better on a standardized test (Wechsler Individual Achievement Test, WIAT-III; [24]) than non-breakfast consumers and, among breakfast consumers, whether breakfast content influences test scores.

Methods

Participants

A detailed description of the rationale, design, and methods of A+PAAC has been previously published [25]. Briefly, A+PAAC was a 3-year, adequately powered, cluster-randomized, controlled trial that incorporated 4 school districts. Overall, 17 elementary schools in northeast Kansas were stratified by school district to receive A+PAAC (9 schools) or serve as controls (8 schools). A+PAAC provided academic lessons delivered by classroom teachers using moderate-to-vigorous PA (100 minutes/week, >3 METs, metabolic equivalent of task) in order to increase MVPA while maintaining academic instruction time. The primary outcome was academic achievement measured by WIAT-III. Parents and students provided consent and assent, respectively, prior to initiation of A+PAAC. The investigation was approved by The University of Kansas Human Subjects Committee.

Academic Achievement

Academic achievement was assessed at baseline using the WIAT-III [24]. The WIAT-III was individually administered by research staff who were trained and supervised by a qualified co-investigator. Five WIAT-III subtests (reading comprehension and oral reading fluency, spelling, mathematics, problem solving, and numerical operations) were selected for assessment. The two mathematics subtests and two reading subtests were combined to form composite scores; thus, three component scores were used in this analysis: spelling standard score, reading comprehension and fluency standard score, and mathematics standard score. The test took approximately 40-50 minutes to complete. The WIAT-III has excellent reliability: inter-rater reliability (e.g., 0.92 to 0.99), internal consistency (0.80-0.98), split-half reliability (e.g., by age-range from 0.83 to 0.98), and test-retest reliability (e.g., for children 6 to 12 years of age, 0.87 to 0.96 over 2 to 32 days). Validity is supported via item reviews of curriculum experts and by correlations with other tests, including the WIAT-II (e.g., .62 to .86), and measures of academic achievement (e.g., 0.60 to 0.82) [24]. The WIAT-III was scored by the research staff, and all tests were checked for accuracy by a trained investigator. All scores were entered into the WIAT-III computerized scoring system, which automatically disallows out-of-range values and computes subtest and composite scores

Breakfast Intake

Just before taking the WIAT-III, participants completed a breakfast recall, administered by research staff, of all the foods and drinks they had consumed that morning. Prior to collecting recall data on participants, research staff were required to produce energy and macronutrient intake estimates, within 5% of an RD, from 10 sample breakfast intake recalls. Staff failing to meet this standard received additional training from the RD and were re-evaluated until the standard was achieved. The recall followed the USDA multiple pass method [26] using portion guides to assist participants in estimating portion size. The portion guides used in the breakfast recall were 3-dimensional models that consist of a variety of items intended to provide a reference and improve recall accuracy (i.e., glasses, mugs, bowls, circles, thickness sticks, chip bags, drink bottles, a 12-inch ruler, measuring cups and spoons, a grid, wedges, geometric shapes, and diagrams of chicken pieces) [27]. A separate trained staff member entered all dietary records into Nutrition Data System for Research ((NDS-R) v. 2014) [28] for analysis, and the entry was then reviewed by an RD.

Anthropometrics (Height/weight/waist circumference)

Participants were weighed to the nearest 0.1 kg wearing school clothes without shoes during the first period of the school day on a calibrated scale (Model #PS6600, Befour, Saukville, WI). Standing height was measured with a portable stadiometer (Model #IP0955, Invicta Plastics Limited, Leicester, UK). Body mass index (BMI) was calculated as weight (kg)/ height (m^2). BMI percentile was calculated using the CDC growth charts [29]. Waist circumference served as a surrogate for abdominal adiposity and was assessed using the procedures described by Lohman et al. [30]. Three measurements were taken with the outcome recorded as the average of the closest 2 values.

Cardiovascular Fitness

Cardiovascular fitness was assessed using the Progressive Aerobic Cardiovascular Endurance Run (PACER) used in FITNESSGRAM [31, 32]. The PACER is a multistage fitness test based on a shuttle run that progresses in intensity as participants run 20-meters back and forth with a goal to run as long as possible. The regression method was used to estimate aerobic fitness (VO_2 max) from equivalent 1-mile run time estimated from the total number of laps completed on the PACER [33].

Breakfast Consumers vs. Non-Consumers

Participants were classified as breakfast or non-breakfast consumers. Participants who had consumed food and caloric beverage that morning were classified as breakfast consumers; those who had not consumed any food or caloric beverages were classified as non-breakfast consumers. In order to eliminate any bias due to systematic differences in baseline characteristics, a matched sample of breakfast and non-breakfast consumers was obtained. We matched for age, sex, race, education level of both parents, household income, BMI, and cardiovascular fitness (PACER laps) using the nearest neighbor matching (1-to-1 matching) within a caliper method [34].

Statistical Analysis

Sample baseline characteristics were summarized by descriptive statistics and bivariate tests (i.e., *t*-tests and chi-square or Fisher's exact test). The WIAT-III scores, anthropometrics, and cardiovascular fitness were compared between breakfast and non-breakfast consumers in the matched sample using *t*-tests. The Satterthwaite adjustment was applied when the homogeneity of variance assumption was not met. Pearson correlations were calculated from all breakfast eaters between test performance and components of the breakfast. All analyses were conducted using SAS version 9.3 (SAS Institute Inc., Cary, NC).

Results

Baseline data from 698 participants who completed the breakfast recall were analyzed. 617 participants were classified as breakfast consumers, and 81 were classified as non-breakfast consumers. Baseline characteristics of all breakfast consumers and the matched sample of breakfast and non-breakfast consumers are presented in Table 1.

When comparing non-breakfast consumers to breakfast consumers in the matched sample, breakfast eaters had significantly higher scores in all three WIAT-III scores assessed: spelling standard score ($p<0.05$), reading comprehension and fluency standard score ($p<0.05$), and mathematics standard score ($p<0.01$). Table 2 shows the WIAT-III scores, anthropometric, and cardiovascular fitness differences between breakfast and non-breakfast consumers.

The dietary intake of all breakfast consumers ($N=617$) was analyzed to determine if the quality of the diet had any association with WIAT-III component scores. The percentage of kcals from carbohydrates was positively correlated with spelling standard score ($p<0.05$), but no other aspects of the macronutrient distribution of the diet were significantly associated with WIAT-III scores. Servings of fruit juice were negatively correlated with reading comprehension and fluency standard score and mathematics standard score (both $p<0.0001$), but there was no significant association between fruit juice and spelling standard score. More servings of whole grains were significantly related to higher scores in reading comprehension and fluency ($p<0.05$) and mathematics ($p<0.01$) but not to spelling standard scores. The correlations between diet quality and WIAT-III scores are found in Table 3.

Discussion

The aim of this ancillary study of the A+PAAC trial was to determine if breakfast consumption before a standardized test (WIAT-III) influenced test scores and if individual components of breakfast were related to academic performance. In a population of students matched for gender, ethnicity, race, free/reduced-cost meals, parents' education, and household income, students who consumed breakfast the morning of the test achieved superior scores in all domains of the test compared to those who had not consumed breakfast. Furthermore, servings of whole grains were positively related to test performance and servings of fruit juice were negatively related to test performance.

Children are considered a vulnerable population in which breakfast consumption or omission can have significant metabolic and cognitive consequences [3, 35, 36]. This is largely due to children having a twofold higher utilization of brain glucose compared with adults [37] and a greater depletion of glycogen stores overnight due to increased sleep demands and lower glycogen stores in childhood [38]. Despite this clear physiological need, 20-30% of children are reported to skip breakfast in developed countries [2]. Therefore, it is probable based on our results that children who abstain from breakfast may have more difficulty in the classroom than those who consume it. In the present study, 13% of participants were non-breakfast consumers; however, when looking at a matched sample, we observed a significant ∼5 point improvement in standardized test performance in breakfast consumers. Despite the increase in test performance, there were no differences between breakfast consumers and non-consumers for body composition measurements or physical fitness. Despite controlling for known confounding factors during our analysis (SES, parents' education, etc.), there may be unknown influential factors that were unable to be accounted for.

These study results support previous research indicating that breakfast consumption is associated with improved academic performance. In a study from Spain, adequate breakfast consumers' (≥ 20 % daily energy intake) performance was significantly better on a standardized test than that of those who consumed inadequate breakfasts [39]. Further, a cross-sectional study by Edwards and colleagues [40] found that children, living in North Dakota, who ate breakfast more than 5 days per week achieved better math scores on a standardized assessment (Measures of Academic Progress, MAP) when compared to children who ate breakfast fewer than 5 days per week (227.05 vs. 223.11 p=0.000), but there were no differences in reading scores between the two groups (216.53 vs. 218.53 0=0.086). Finally, a study by Overby and Hoigaard observed a 70% decrease in likelihood of “behavioral problems” in students who regularly consumed breakfast [41]. This is of relevant interest because changes in cognition likely reflect changes in behavior and vice versa [3], although in this present study classroom behavior was not assessed, and some research has suggested this may be a ‘flawed’ variable due to its high subjectivity [3] .

In addition to breakfast consumption, individual breakfast components may impact academic performance. Our results indicate a positive impact of whole grains on reading and math scores, and percent of calories from carbohydrate on spelling scores. Conversely, servings of juice were negatively associated with reading and math scores. The findings of the relationship between whole grains consumed at breakfast and better test performance supports prior research that low GI/GL meals led to improved cognitive performance, better attention, and better memory over the morning [23, 42, 43]. This is likely due to decreased post-meal glycaemia and better maintenance of blood glucose levels with complex carbohydrates compared to simple ones.

Breakfast composition/content and academic achievement is significant since the US school lunch and breakfast regulations have been recently updated. In 2010, the implementation of the Healthy, Hunger-Free Kids Act drastically changed the federal school lunch and breakfast reimbursement regulations, leading to stricter guidelines on the type and variety of foods offered in the program. New guidelines aimed to meet the 2010 Dietary Guidelines by

specifically targeting added sugar, expanding variety and types of fruits and vegetables offered, and requiring that 50% of grains offered are whole-grain or whole-wheat [44]. The findings of a positive relationship between servings of whole-grain and academic performance support the new guidelines promoting whole-grain consumption.

Study Limitations and Strengths

This study is characterized by both strengths and limitations. The sample size was moderately large and robust and from multiple sites. This allowed us to conduct a matched-sample analysis, which ruled out many of the confounders commonly associated with cross-sectional research designs. Furthermore, academic performance was assessed using a valid tool (WAIT-III). Breakfast intake was reported on the same day that academic achievement was collected, so we could study day of intake effects on test scores. Limitations include the lack of assessment of behavior and the recall nature of the dietary assessment. Furthermore, as this was a cross sectional study, we were unable to determine if changing breakfast intake would impact test scores. Future intervention studies are needed to clarify the impact of changing breakfast on test scores.

Conclusion

The results of the present study suggest that breakfast consumption in elementary school students is associated with improved standardized test performance. Servings of whole grains and juice were found to be associated with test performance, with whole grains having a positive effect and juice having a negative effect. The present results suggest that the existing recommendations for consumption of breakfast, high in whole grains and low in added sugars, may be beneficial for academic performance in elementary school students.

Acknowledgments

Disclosure of funding: This study was supported by the National Institutes of Health grant R01-DK085317.

References

1. Turner L, Chaloupka FJ. Continued Promise of School Breakfast Programs for Improving Academic Outcomes: Breakfast Is Still the Most Important Meal of the Day. JAMA pediatrics. 2014
2. Deshmukh-Taskar PR, et al. Do breakfast skipping and breakfast type affect energy intake, nutrient intake, nutrient adequacy, and diet quality in young adults? NHANES 1999-2002. Journal of the American College of Nutrition. 2010; 29(4):407–18. [PubMed: 21041816]
3. Adolphus K, Lawton CL, Dye L. The effects of breakfast on behavior and academic performance in children and adolescents. Front Hum Neurosci. 2013; 7
4. Kleinman RE, et al. Diet, breakfast, and academic performance in children. Annals of Nutrition & Metabolism. 2002; 46:24–30. [PubMed: 12428078]
5. Szajewska H, Ruszczynski M. Systematic review demonstrating that breakfast consumption influences body weight outcomes in children and adolescents in Europe. Critical reviews in food science and nutrition. 2010; 50(2):113–9. [PubMed: 20112153]
6. Rampersaud GC, et al. Breakfast habits, nutritional status, body weight, and academic performance in children and adolescents. J Am Diet Assoc. 2005; 105(5):743–60. quiz 761-2. [PubMed: 15883552]
7. Sandercock GR, Voss C, Dye L. Associations between habitual school-day breakfast consumption, body mass index, physical activity and cardiorespiratory fitness in English schoolchildren. European journal of clinical nutrition. 2010; 64(10):1086–92. [PubMed: 20683459]

8. Vissers PAJ, et al. Breakfast consumption and daily physical activity in 9-10-year-old British children. Public Health Nutrition. 2013; 16(7):1281–90. [PubMed: 21899790]
9. Astbury NM, Taylor MA, Macdonald IA. Breakfast Consumption Affects Appetite, Energy Intake, and the Metabolic and Endocrine Responses to Foods Consumed Later in the Day in Male Habitual Breakfast Eaters. J Nutr. 2011; 141(7):1381–1389. [PubMed: 21562233]
10. Mamerow MM, et al. Dietary Protein Distribution Positively Influences 24-h Muscle Protein Synthesis in Healthy Adults1-3. J Nutr. 2014; 144(6):876–80. [PubMed: 24477298]
11. Affenito SG, et al. Breakfast Consumption by African-American and White Adolescent Girls Correlates Positively with Calcium and Fiber Intake and Negatively with Body Mass Index. Journal of the American Dietetic Association. 2005; 105(6):938–945. [PubMed: 15942545]
12. Levitsky DA. Next will be apple pie. Am J Clin Nutr. 2014; 100(2):503–504. [PubMed: 24965309]
13. Betts JA, et al. The causal role of breakfast in energy balance and health: a randomized controlled trial in lean adults. Am J Clin Nutr. 2014; 100(2):539–547. [PubMed: 24898233]
14. Halsey LG, et al. Does consuming breakfast influence activity levels? An experiment into the effect of breakfast consumption on eating habits and energy expenditure. Public Health Nutrition. 2012; 15(2):238–45. [PubMed: 21729464]
15. Levitsky DA, Pacanowski CR. Effect of skipping breakfast on subsequent energy intake. Physiology & Behavior. 2013; 119:9–16. [PubMed: 23672851]
16. Hoyland A, Dye L, Lawton CL. A systematic review of the effect of breakfast on the cognitive performance of children and adolescents. Nutrition research reviews. 2009; 22(2):220–43. [PubMed: 19930787]
17. Cooper SB, Bandelow S, Nevill ME. Breakfast consumption and cognitive function in adolescent schoolchildren. Physiology & Behavior. 2011; 103(5):431–439. [PubMed: 21439306]
18. Wesnes KA, et al. Breakfast reduces declines in attention and memory over the morning in schoolchildren. Appetite. 2003; 41(3):329–31. [PubMed: 14637332]
19. Benton D, Maconie A, Williams C. The influence of the glycaemic load of breakfast on the behaviour of children in school. Physiol Behav. 2007; 92(4):717–24. [PubMed: 17617427]
20. Richter LM, Rose C, Griesel RD. Cognitive and behavioural effects of a school breakfast. South African medical journal = Suid-Afrikaanse tydskrif vir geneeskunde. 1997; 87(1 Suppl):93–100. [PubMed: 9180808]
21. Leos-Urbel J, et al. Not just for poor kids: The impact of universal free school breakfast on meal participation and student outcomes. Economics of Education Review. 2013; 36:88–107. [PubMed: 24465073]
22. Mahoney CR, et al. Effect of breakfast composition on cognitive processes in elementary school children. Physiology & Behavior. 2005; 85(5):635–645. [PubMed: 16085130]
23. Edefonti V, et al. The effect of breakfast composition and energy contribution on cognitive and academic performance: a systematic review. Am J Clin Nutr. 2014; 100(2):626–656. [PubMed: 24808492]
24. The Wechsler Individual Achievement Test-Third Edition (WIAT III). San Antonio: Pearson; 2009.
25. Donnelly JE, et al. Physical activity and academic achievement across the curriculum (A + PAAC): rationale and design of a 3-year, cluster-randomized trial. BMC public health. 2013; 13:307. [PubMed: 23565969]
26. Conway JM, Ingwersen LA, Moshfegh AJ. Accuracy of dietary recall using the USDA five-step multiple-pass method in men: an observational validation study. J Am Diet Assoc. 2004; 104(4): 595–603. [PubMed: 15054345]
27. Wright JD, et al. Nutrition assessment in the National Health and Nutrition Examination Survey 1999-2002. J Am Diet Assoc. 2007; 107(5):822–9. [PubMed: 17467380]
28. Nurtition Coordinating Center. NDSR 2011 User Manual. University of Minnesota; Minneapolis, MN: 2011.
29. Kuczmarski RJ, et al. 2000 CDC Growth Charts for the United States: methods and development. Vital and health statistics. 2002; 11(246):1–190. [PubMed: 12043359]
30. Lohman, TG.; Roche, AF.; Martorell, R. Anthropometric Standardization Reference Manual. Champaign, Ill: Human Kinetics Books; 1988.

31. Welk, GJ.; Meredith, MD. Fitnessgram/Activitygram Reference Guide. Dallas TX: The Cooper Institute; 2008.
32. Leger LA, et al. The multistage 20 metre shuttle run test for aerobic fitness. J Sports Sci. 1988; 6(2):93–101. [PubMed: 3184250]
33. Cureton K, et al. A generalized equation for prediction of VO2peak from 1-mile run/walk performance. Med Sci Sports Exerc. 1995; 27(3):445–451. [PubMed: 7752874]
34. Rosenbaum PR, Rubin DB. The central role of the propensity score in observational studies for causal effects. Biometrika. 1983; 70(1):41–55.
35. Hoyland A, Dye L, Lawton CL. A systematic review of the effect of breakfast on the cognitive performance of children and adolescents. Nutrition Research Reviews. 2009; 22(2):220–243. [PubMed: 19930787]
36. Pollitt E, Cueto S, Jacoby ER. Fasting and cognition in well- and undernourished schoolchildren: a review of three experimental studies. Am J Clin Nutr. 1998; 67(4):779S–784S. [PubMed: 9537628]
37. Chugani HT. A critical period of brain development: studies of cerebral glucose utilization with PET. Preventive medicine. 1998; 27(2):184–8. [PubMed: 9578992]
38. Thorleifsdottir B, et al. Sleep and sleep habits from childhood to young adulthood over a 10-year period. Journal of psychosomatic research. 2002; 53(1):529–37. [PubMed: 12127168]
39. Lopez-Sobaler A, et al. Relationship between habitual breakfast and intellectual performance (logical reasoning) in well-nourished schoolchildren of Madrid (Spain). European journal of clinical nutrition. 2003; 57:S49–S53. [PubMed: 12947453]
40. Edwards JU, Mauch L, Winkelman MR. Relationship of nutrition and physical activity behaviors and fitness measures to academic performance for sixth graders in a midwest city school district. The Journal of school health. 2011; 81(2):65–73. [PubMed: 21223273]
41. Overby N, Hoigaard R. Diet and behavioral problems at school in Norwegian adolescents. Food & nutrition research. 2012; 56
42. Ingwersen J, et al. A low glycaemic index breakfast cereal preferentially prevents children's cognitive performance from declining throughout the morning. Appetite. 2007; 49(1):240–4. [PubMed: 17224202]
43. Cooper SB, et al. Breakfast glycaemic index and cognitive function in adolescent school children. British Journal of Nutrition. 2012; 107(12):1823–1832. [PubMed: 22017815]
44. Wootan MG. Child Nutrition Act Reauthorization, Part 1. Major highlights of the Healthy, Hunger-Free Kids Act of 2010. NASN school nurse (Print). 2011; 26(3):188–9. [PubMed: 21675302]

Abbreviations

WIAT-III	Wechsler Individual Achievement Test
A+PAAC	Physical Activity and Academic Achievement Across the Curriculum

Table 1

Baseline characteristics of elementary school children who were breakfast eaters as well as the characteristics of the matched sample of breakfast and non-breakfast eaters.

	Breakfast Consumers (*N*=617)		Non-breakfast Consumers (*N*=81)		Matched Breakfast Eaters (*N*=81)		Diff.
Variable	***n***	**%**	***n***	**%**	***n***	**%**	***p***
Age (yr) (*Mean±SD*)		7.58 ± 0.58		7.53 ± 0.61		7.62 ± 0.58	0.360
Gender							0.431
Male	310	50.2%	35	43.2%	40	49.4%	
Female	307	49.8%	46	56.8%	41	50.6%	
Ethnicity							0.409
Not Hispanic/Latino	530	85.9%	64	79.0%	71	87.7%	
Hispanic/Latino	63	10.2%	10	12.3%	7	8.6%	
Unknown	11	1.8%	3	3.7%	2	2.5%	
Refused	1	0.2%	0	0.0%	0	0.0%	
Missing	13	2.1%	4	4.9%	1	1.2%	
Race							0.508
White	505	81.8%	57	70.4%	68	84.0%	
Black/African American	24	3.9%	6	7.4%	4	4.9%	
Native Hawaiian/Pacific Islander	1	0.2%	1	1.2%	0	0.0%	
Asian	8	1.3%	1	1.2%	1	1.2%	
American Indian /Alaska Native	6	1.0%	3	3.7%	1	1.2%	
Two or more races	63	10.2%	8	9.9%	6	7.4%	
Unknown	4	0.6%	2	2.5%	0	0.0%	
Missing	6	1.0%	3	3.7%	1	1.2%	
Free/reduced meals							0.095
Yes	180	29.2%	37	45.7%	27	33.3%	
No	425	68.9%	39	48.1%	52	64.2%	
Missing	12	1.9%	5	6.2%	2	2.5%	
Education level (mother)							0.348
Less than high school	5	0.8%	3	3.7%	1	1.2%	
Some high school	19	3.1%	2	2.5%	3	3.7%	

	Breakfast Consumers (*N*=617)		Non-breakfast Consumers (*N*=81)		Matched Breakfast Eaters (*N*=81)		Diff.
Variable	***n***	**%**	***n***	**%**	***n***	**%**	***p***
Completed high school	64	10.4%	13	16.0%	12	14.8%	
Some college/Associate's degree	198	32.1%	38	46.9%	27	33.3%	
Bachelor's degree	199	32.3%	12	14.8%	20	24.7%	
Advanced degree	127	20.6%	11	13.6%	17	21.0%	
Unknown	1	0.2%	0	0.0%	0	0.0%	
Refused	1	0.2%	0	0.0%	0	0.0%	
Missing	3	0.5%	2	2.5%	1	1.2%	
Education level (father)							0.167
Less than high school	7	1.1%	3	3.7%	2	2.5%	
Some high school	19	3.1%	8	9.9%	5	6.2%	
Completed high school	120	19.4%	21	25.9%	19	23.5%	
Some college/Associate's degree	188	30.5%	30	37.0%	23	28.4%	
Bachelor's degree	162	26.3%	6	7.4%	19	23.5%	
Advanced degree	109	17.7%	7	8.6%	10	12.3%	
Unknown	6	1.0%	3	3.7%	1	1.2%	
Refused	0	0.0%	0	0.0%	0	0.0%	
Missing	6	1.0%	3	3.7%	2	2.5%	
Household income							0.421
<$10,000	29	4.7%	7	8.6%	5	6.2%	
$10,000-$20,000	41	6.6%	9	11.1%	7	8.6%	
$21,000-$30,000	56	9.1%	12	14.8%	9	11.1%	
$31,000-$40,000	51	8.3%	10	12.3%	6	7.4%	
$41,000-$50,000	53	8.6%	10	12.3%	6	7.4%	
$51,000-$60,000	36	5.8%	6	7.4%	6	7.4%	
$61,000-$70,000	46	7.5%	5	6.2%	8	9.9%	
$71,000-$80,000	54	8.8%	5	6.2%	5	6.2%	
$81,000-$90,000	38	6.2%	0	0.0%	4	4.9%	
$91,000-$100,000	53	8.6%	5	6.2%	6	7.4%	
>$100,000	139	22.5%	7	8.6%	16	19.8%	
Refused	16	2.6%	3	3.7%	1	1.2%	

J Am Coll Nutr. Author manuscript; available in PMC 2016 June 07.

	Breakfast Consumers (*N*=617)		Non-breakfast Consumers (*N*=81)		Matched Breakfast Eaters (*N*=81)		Diff.
Variable	***n***	**%**	***n***	**%**	***n***	**%**	***p***
Missing	5	0.8%	2	2.5%	2	2.5%	

Table 2

WIAT-III scores, anthropometric, and cardiovascular fitness differences between breakfast and non-breakfast consumers who were enrolled in the Kansas A+PAAC in 2011

	Non-breakfast consumers (*N*=81)	Breakfast consumers (*N*=81)	Diff
Variable	***Mean*±*SD***	***Mean*±*SD***	***p***
WAIT-III scores			
Spelling standard score	95.85±10.27	100.49±12.73	0.021*
Reading comprehension and fluency standard score	95.16±12.93	100.05±14.25	0.039*
Mathematics standard score	98.19±8.95	103.25±12.86	0.007*
Waist circumference (cm)	57.56±7.65	57.16±7.24	0.745
BMI	17.74±3.32	17.26±3.00	0.347
Pacer laps	13.77±7.39	16.12± 9.04	0.085

*Significant at $p < 0.05$

Table 3

Correlations between diet quality and WIAT-III component scores among breakfast eaters who were enrolled in the Kansas A+PAAC study in 2011

	Spelling Standard Score	Reading Comprehension and Fluency Standard Score	Mathematics Standard Score
% kcals from fat	-0.08	-0.05	-0.06
% kcals from carbohydrate	0.08 [a]	0.05	0.05
% kcals from protein	-0.02	0.01	0.04
Whole fruit servings	0.01	-0.01	-0.01
Juice servings	-0.06	-0.15 [c]	-0.15 [c]
Total vegetable servings	-0.07	-0.04	-0.07
Refined grain servings	0.06	0.06	0.03
Whole grain servings	0.05	0.09 [a]	0.13 [b]
Dairy servings	-0.03	-0.02	-0.01
Total protein servings	-0.04	-0.05	-0.04
Seafood & plant protein servings	0.02	0.05	-0.01
Omega-3 fatty acids (g)	-0.04	-0.03	0.01
Added sugars (g)	0.04	0.03	0.04

[a] $p<0.05$

[b] $p<0.01$

[c] $p<0.001$