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Regular breakfast consumption is associated with increased IQ in kindergarten children

Jianghong Liu, PhD^{1,*}, Wei-Ting Hwang, PhD², Barbra Dickerman³, and Charlene Compher, PhD⁴

¹Faculty, School of Nursing, University of Pennsylvania, Philadelphia, PA 19104

²Faculty, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA 19104

³BSN Candidate, School of Nursing, University of Pennsylvania, Philadelphia, PA 19104

⁴Faculty, School of Nursing, University of Pennsylvania, Philadelphia, PA 19104

Abstract

Background—Studies have documented a positive relationship between regular breakfast consumption and cognitive outcomes in youth. However, most of these studies have emphasized specific measures of cognition rather than cognitive performance as a broad construct (e.g., IQ test scores) and been limited to Western samples of school-age children and adolescents. This study aims to extend the literature on breakfast consumption and cognition by examining these constructs in a sample of Chinese kindergarten-age children.

Methods—This cross-sectional study consisted of a sample of 1,269 children (697 boys and 572 girls) aged 6 from the Chinese city of Jintan. Cognition was assessed with the Chinese version of the Wechsler Preschool and Primary Scale of Intelligence – Revised. Breakfast habits were assessed through parental questionnaire. Analyses of variance and linear regression models were used to analyze the association between breakfast habits and IQ. Socioeconomic and parental psychosocial variables related to intelligence were controlled for.

Results—Findings showed that children who regularly have breakfast on a near-daily basis had significantly higher full scale, verbal, and performance IQ test scores (all $p < 0.001$) compared to children who “sometimes” have breakfast. This relationship persisted for VIQ (verbal IQ) and FIQ (full IQ) even after adjusting for gender, current living location, parental education, parental occupation, and primary child caregiver.

Conclusion—Findings may reflect nutritional as well as social benefits of regular breakfast consumption on cognition, and regular breakfast consumption should be encouraged among young children.

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***Corresponding Author:** Jianghong Liu, PhD, Associate Professor, University of Pennsylvania, Schools of Nursing and Medicine, 418 Curie Blvd., Room 426, Philadelphia, Pennsylvania 19104-6096, Tel: (215) 898-8293, jhliu@nursing.upenn.edu.

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CONFLICT OF INTEREST STATEMENT

The authors have declared that no competing interests exist.

INTRODUCTION

Breakfast is often regarded as the most important meal of the day, and increasing evidence suggests that eating breakfast can yield many health benefits for growing children, ranging from improved overall dietary quality(1) to enhanced classroom performance(2). Observational(3) and intervention(4) studies have also established a strong link between breakfast consumption and children's cognitive abilities. As Gibson & Green outlined in a review, it has long been suggested that manipulations of blood glucose levels result in alterations in cognitive processing efficiency, while more recent evidence calls attention to the neurohormonal perturbations linked to meal intake which leads to cognitive outcomes (5). Much research has demonstrated that breakfast influences specific components of cognitive function, including concentration level (6), school performance (7–9), attention (4, 10–13), and memory (14, 15). Very recently, Taki et al. found that the *type* of breakfast consumed by Japanese children and adolescents can be linked to brain gray and white matter volumes and IQ (16). However, whether breakfast consumption *frequency* has a particular impact on broad cognitive performance, such as verbal and performance IQ, is unknown.

Childhood is a critical period in which dietary and lifestyle patterns are initiated (17), and these habits can have important immediate and long-term implications. Breakfast habits appear to be no exception (1, 18), and irregular breakfast eating has already been associated with a number of unhealthy behaviors, such as smoking, frequent alcohol use, and infrequent exercise (19–22). Chen and colleagues (23) have even reported that both maintaining breakfast eating habits at “seldom” or changing them from “often” to “seldom” was associated with lower quality of life among Japanese schoolchildren. Since early childhood is a time of rapid neurological development, additional research on the effects of breakfast-eating habits on cognitive performance in young children would be beneficial. Early identification of the cognitive effects of breakfast on young children could help guide future interventions during this time of rapid brain and health behavior development. Much of the current literature has been limited to school-age adolescents and young adults, or small, Western samples of elementary school to college students (24, 25).

We aim to extend the body of research on breakfast and cognition by exploring the importance of regular breakfast eating in Chinese kindergarten-age children using a comprehensive indicator of cognitive ability (verbal and performance IQ). Breakfast is highly valued in China, and Chinese adolescents are less likely to skip this meal when compared to those in Western countries (1, 26–30). This high incidence of stable breakfast habits in China makes it an appropriate sample in which to test the potential benefits of habitual breakfast consumption on cognition. Therefore, the purpose of our study is to test our hypothesis that consistent breakfast consumption in a homogenous population of Chinese kindergarten children is associated with increased verbal and performance IQ scores, independent of parental and familial sociodemographic factors.

METHODS

Subjects

In this cross-sectional study, subjects were drawn from The Jintan Child Study, which includes a cohort of 1,656 pre-school children (55.5% boys, 4.5% girls), accounting for 24.3% of all children age 5 and 6 years in Jintan city. They were initially recruited in the spring of 2005 in the city of Jintan, located in the southeastern coastal region of mainland China (26, 31). Detailed sampling and research procedures of this larger cohort study have been described elsewhere (26, 32, 33). Briefly, the China Jintan Child Cohort Study is an ongoing prospective longitudinal study with the main aim of assessing the early health risk factors for the development of child neurobehavioral outcomes. The pre-schools in the

cohort were chosen to be representative of the geographic, social, and economic profile of Jintan (26, 32, 34). The initial recruitment response rate was 97%; among these initial respondents, 98% agreed to participate (26). It was not possible to perform analyses on the non-respondents due to a very limited number (3%).

In the last year of pre-school (in China, this is called “kindergarten”), parents were asked to complete a questionnaire including health and sociodemographic data. Children were tested on their IQ. This study sample consisted of 1,269 children (697 boys and 572 girls) for whom IQ data were available. Approval from Institutional Review Boards was obtained from the University of Pennsylvania and the ethical committee for research at Jintan Hospital in China.

Measures

Breakfast Habits—Parental reports on children’s breakfast consumption habits were obtained through the following question: “In a typical week, how often do your children have breakfast? 1 = Always (6–7 days a week), 2 = Often (4–5 days a week), 3 = Sometimes (2–3 days a week), 4 = Rarely (0–1 days a week).” Categories 3 and 4 were combined due to very few “Rarely” responses. Our preliminary analysis showed that the magnitude, direction, and significance of the effect of breakfast on PIQ, VIQ, and FIQ are very similar for the “always” and “often” groups. Additionally, by testing contrasts from a linear regression that included each of the three breakfast groups separately, we did not find any dose-response relationship in IQ when comparing “always” vs. “often” breakfast groups. These results indicate that the two groups can be reasonably combined. The combination of these variables also allows for a more straightforward interpretation of the results. Therefore, our analysis used dichotomized breakfast habit variable of always and often versus sometimes and rarely.

Cognition (IQ)—At the age of 6 years when the children were in kindergarten, we assessed their IQ using the Chinese version and norms of the Wechsler Preschool and Primary Scale of Intelligence – Revised (35). Details on the IQ assessment procedure can be found in Liu and Lynn (32). The Chinese version of the WPPSI–R has established reliability and validity among Chinese children (36–38). Two bachelor’s-prepared pediatric nurses, who participated in an intensive, three-week training course on administering IQ tests, performed the cognitive assessment. A pilot IQ test was performed on 32 five-year old children in the sample to determine the reliability of testing prior to conducting a large scale IQ test. Two approaches to reliability have been taken: (1) Test-retest reliability (across time) within three weeks and (2) the inter-rater reliability (across two examiners) was tested by the correlation between assessments of the two raters. We reported that IQ test procedures were adequately reliable with a test-retest reliability of 0.87 and inter-rater reliability of 0.91 before we conducted the large-sample testing (32). The IQ test was conducted in a quiet classroom within each kindergarten during various times of the day.

Sociodemographic variables—Sociodemographic information obtained from a questionnaire included information on the child’s gender, age, parental education (highest degree obtained), parental occupation (the occupation held for the longest period in their lives), house size (m²), and home location (city, suburb, or rural). Additionally, information on family structure, such as parental marital status and whether the child had any siblings, was also included in the analysis. Parental education was dichotomized into: less than high school versus some high school or other vocational training, or completed high school or beyond. Parental occupation was categorized into: unemployed or working class versus professional. “Working class” refers here to physical workers (e.g.: janitor). “Professional class” refers to occupations requiring skilled labor (e.g.: professor) (39). Marital status was

recoded as married versus divorced/separated. The latter group also included 18 children (1.4%) that were raised by a single parent. Parents completed the sociodemographic questionnaire at the end of the school year during their at-school meeting. While this questionnaire was self-administered, research assistants were on site to assist parents as needed.

We did not ask for data on family income because it is often not a reliable indicator of socioeconomic status. In particular, China is experiencing rapid socioeconomic changes that have resulted in the instability of income and salary distribution. Furthermore, people in China still consider income to be private information and are reluctant to report it (40). Therefore, we asked for information on house size and family size as indirect indicators of socioeconomic status. Though a majority of our data came from households with two parents and one child, there were a number of households that included grandparents and additional children (though the latter is few due to the one-child policy).

Representativeness of groups

Complete data on both breakfast consumption and IQ are available on 1,269 of the subjects. Those with and without complete data are compared on all key socio-demographic variables used in the final multiple linear regression model. We did not find any significant differences in any key demographic variables except “who raised you.” Subjects whom were raised by their biological parents were more likely to have complete data than subjects raised by “others” (grandparents or other relatives). This result is perhaps not surprising. The parents who were not present to raise their children probably have work commitments which require them to be absent on a regular basis. As a result, they might not have been as available to complete the Breakfast Consumption survey, leading to the missing data. Despite of this, the sub-sample used in this paper can be considered to be adequately representative of the larger Jintan cohort.

Statistical methods

Characteristics of the study sample were summarized by descriptive statistics such as mean, standard deviation (SD), and percentages. The normality assumption for the IQ scales was met by visually examining the histograms. In the univariate analysis, the IQ scales between different breakfast groups were compared by an analysis of variance (ANOVA) model. The associations between breakfast consumption habits and sociodemographic variables were examined using Pearson’s chi-squared tests. Verbal, Performance, and Full Scale IQ was analyzed separately using a multiple linear regression model. We controlled for all of the available sociodemographic variables measured in this study in our multivariate analysis. Significance of the interaction effects between breakfast consumption habits and gender were examined by including an interaction term in the above regression model and evaluated by a Wald test. A p-value <0.05 was considered significant. Data were analyzed using SPSS, Version 17 (Chicago, IL).

RESULTS

Sample and breakfast consumption profiles

Almost 80% of the children reported having breakfast 4–5 times per week (the “often” group), and 14.5% reported having breakfast at least 6 days per week (the “always” group), and only a small portion (5.7%) reported having breakfast < 4 days per week (the “sometimes” group). The Breakfast Consumption habits and sociodemographic characteristics of the 1,269 children and their families are summarized in Table 1. The following variables were associated with differential breakfast consumption habits ($p < 0.05$,

Table 1): living location, parental occupation, and parental education, and they were entered into the multiple linear regression models as covariates for the adjusted analysis.

Comparison of IQ by breakfast habits

The IQ scores for the two breakfast groups (the “sometimes” group and the “often/always” group) are displayed in Table 2. Children who do not regularly eat breakfast had lower full scale, verbal, and performance IQs compared to those who regularly do (all $p < 0.001$). Children who do not often eat breakfast had a 7.9 points lower verbal and 6.1 points lower performance IQ score than children who often or always eat breakfast. The full IQ score was also significantly lower in children who do not often eat breakfast than those who do ($p < 0.001$).

Adjusted associations between IQ and breakfast habits

In the multivariate analysis, children who regularly ate breakfast had a verbal IQ score that was higher, on average, by 5.58 points ($p = 0.003$) and a performance IQ score that was higher, on average, by 2.50 points ($p = 0.17$) compared to children who did not eat breakfast regularly. Covariate effects of child gender, current living location, parental education, parental occupation, and primary child caregiver were controlled for in this multivariate model (see Table 3). For the multivariate model for full IQ, children who ate regular breakfast scored, on average, 4.6 points ($p = 0.008$) higher compared to those who did not eat regular breakfasts, after adjusting for the same set of covariates. No significant interaction effects were found between breakfast eating habits and gender (all $p > 0.60$).

DISCUSSION

The present study found significantly better scores on full, verbal, and performance IQ tests in children who regularly consumed breakfast as compared to those with infrequent breakfast consumption. This effect applied to both boys and girls and remained after controlling for parental education, occupation, and socioeconomic status. These findings are consistent with those reported in previous studies of school-age children, adolescents, and young adults (4, 8, 11, 12) which have shown a dose-response effect between the regularity of breakfast consumption and improved academic performance among adolescents (41). Our study extends these findings in three ways: by investigating children as young as preschool or kindergarten age; by controlling for potential psychosocial confounders, including parental education level; and by using broad measures of cognitive functioning (full, verbal, and performance IQ scores).

Nutritional effect of breakfast

The key finding of this study suggests that breakfast consumption affects cognitive development in children, although the authors cannot offer a mechanistic explanation for the findings due to the nature of this study's designs. One possible pathway concerns the nutritional effects of breakfast consumption. The overnight fast that occurs during sleep represents the longest period of fasting (11), and one important function of breakfast is to replenish low blood glucose levels (42). Although it was not reported in our results, in this cohort we found that rice and noodles made up 69% of the breakfast meal; such carbohydrates can be rapidly broken down into glucose and used to fuel physical and mental function. Indeed, both animal (43) and human (44–46) studies have shown associations between glucose administration and enhanced cognitive ability, specifically aspects such as verbal fluency (47), sustained concentration (45) and memory (42, 48). Biochemical analysis of the brain using a microdialysis sampling technique reveals a 25% decrease in rat hippocampal extracellular glucose during a spatial working memory task, indicating that glucose is being metabolized by this memory center of the brain (48). In terms of the

mechanism of action at this site, glucose is the primary source of the acetyl groups that are used in the formation of acetyl CoA (49), a precursor for the acetylcholine that regulates neurotransmission and benefits components of cognitive function, such as memory (43). More specifically, it has been suggested that glucose may particularly influence declarative memory (43). Glucose's particular influence on declarative memory may explain our finding that the cognitive benefit of breakfast was particularly manifested in higher verbal IQ scores, which require declarative memory skills to recite factual information. Indeed, we found verbal IQ scores in our study to be 8 points higher than performance IQ scores. While previous studies only examined limited components of cognitive ability, we included a comprehensive measure of cognitive ability: IQ. In our study, the standard WPPSI-R IQ test administered to children was composed of 10 subtests that provided a comprehensive assessment of cognitive ability, with verbal and performance IQ subscales. The inclusion of these subscales allowed us to demonstrate a more pronounced increase in verbal IQ, as compared to performance IQ, with habitual breakfast consumption. Nevertheless, we only controlled for sociodemographic variables; other confounders, such as psychological factors, were not controlled for and could possibly attenuate our results on the association between breakfast and IQ.

Since testing occurred at various times throughout the day, however, it is unlikely our results solely reflect the immediate effects of biochemical levels on cognitive performance. Although blood glucose levels can increase significantly an hour after consuming a mostly carbohydrate meal, for example, it also decreases rapidly back to normal levels (50). Rather, the observed differences IQ scores may reflect other nutritional benefits of *regularly* consuming breakfast. For example, previous research has suggested that children and adolescents who eat breakfast have healthier diet and food choices (1, 51, 52) and those who skip breakfast have increased energy intakes from snacks (22). This has been recently demonstrated in preschool-aged children as well (53). Breakfast skippers in this study consumed a lower mean number of servings of vegetables, grains, and dairy products (data not shown). Furthermore, despite similar total daily energy intakes in children who regularly consumed or skipped breakfast, the macronutrient composition of snacks and overall diet were found to vary so that those who skipped breakfast regularly consumed significantly less protein and less energy from protein compared to preschoolers who regularly ate breakfast. The better overall nutrition associated with breakfast eating may in turn result in enhanced intelligence (54, 55).

While increased blood glucose is a well-established mechanism for the interaction between breakfast and memory, increased levels of insulin (56) and cholecystokinin (57) in response to a meal have also been independently linked to enhanced memory by means of neural activation and stimulation of the amygdala and hippocampus. Regardless of whether the mechanism of action lies in the increased levels of glucose, insulin, or cholecystokinin, the fact that the levels of each of these biochemicals rise upon the consumption of a meal highlights the importance of a morning meal after an overnight fast to the benefit of cognitive performance (e.g., attending school) in children. Social interaction effect of breakfast

Another suggested mechanism of action concerns the social aspects of breakfast. Breakfast is a time during which family members interactively prepare and consume food while communicating and socially engaging with one another. At the age of 6 years, a child's cognitive ability at both the verbal and performance levels is rapidly developing (58), and social interaction with parents may promote cognitive/brain development (59).

To our knowledge, our study is the first to demonstrate that verbal IQ is differentially benefited by habitual breakfast consumption. This finding may be especially relevant to the

social interaction aspect of breakfast time. Participation in mealtime discussion may facilitate positive cognitive development by offering children the opportunity to expand their vocabulary, practice synthesizing and comprehending stories, and acquire general knowledge (60). Unlike school-age children and adolescents who are able to prepare and consume their own breakfast independently, younger children, such as those in our study, depend on parents and caregivers to prepare and provide breakfast, and they are more likely to experience and thus benefit from a social breakfast time environment.

Since children who have higher IQs often come from families with higher socioeconomic backgrounds, it may be that higher IQs reflect their socioeconomic status and are not directly related to breakfast consumption. However, we controlled for socioeconomic status and found that the relationship between breakfast consumption and increased IQ persisted, which suggests a direct effect of breakfast on children's cognitive ability, whether due to the nutritional or social interaction influences of this meal. This is further supported by the fact that the relationship between breakfast consumption and IQ was generalizable across both genders and across three different living locations (city, suburb, rural).

Limitations and Future Directions

While our findings are interesting and relevant, they should be interpreted in light of some limitations. Our assessment of breakfast consumption was limited to a qualitative parental report of overall breakfast consumption habits; we did not have a quantitative frequency measure. This introduces the possibility of bias or error in reporting. We are currently collecting self-reported food frequency data, which would enable us to better assess the total dietary adequacy in the future. Also, since breakfast consumption habits and cognitive ability were assessed around the same time, we are unable to assess for a causal relationship between breakfast consumption and later IQ scores. It could be that children with higher IQs are more likely to consume breakfast, as studies indicate that higher executive function of planning behavior was a significant predictor of breakfast consumption habits (61). Other studies show that adolescent's intentions, attitudes, and perceived behavioral control are all significantly correlated with breakfast consumption (62). Furthermore, residual confounding from other nutritional factors and health behavior could be a major limitation of our study. For example, general nutritional status of the children could have been taken into account because children who eat breakfast regularly are also likely to eat other meals regularly, leading to an overall better health status. Therefore it might not be the effects of eating breakfast alone which leads to better IQ. It is also possible that sleep behavior, which has been found to be linked to IQ (63–65), also confounds our results because children who eat regular breakfast are more likely to have a better-structured lifestyle, which means that they could potentially also have a better-structured sleep schedule and are less fatigued. Additionally, our study did not assess children's learning disabilities, autism spectrum disorders, or other health disorders such as birth complications or malnutrition, which could be associated with IQ test performance (66, Malnutrition IQ), and therefore may also be possible confounding factors. Future longitudinal or intervention studies may help to establish a causal relationship. Future studies can also help to understand the possible mediating factors of breakfast consumption and IQ. For example, it was recently found that skipping breakfast is related to high blood lead levels in children (31), which in turn has been associated with IQ deficits (67). While we are also unable to pinpoint whether nutritional or social interaction effects are responsible for our findings, the finding itself (i.e., that regular breakfast boosts cognitive function) remains of importance.

Implications

Public health implications of the current findings can be applied at the educational and practical levels. Pan and colleagues (68) found that after immigration to the United States,

breakfast habits in a sample of 71 students from Eastern countries including China, Japan, and Korea became more unstable. Almost half began to report skipping breakfast, a habit not reported in their home country, presumably due to hectic schedules and a lack of time to prepare the meal. Thus, schools can play an important role and may consider delaying start times and/or providing breakfasts to allow school-aged children to reap the cognitive benefits of eating before an intensive morning curriculum that demands higher level thinking (15). Parents also serve as important influential forces in children's eating habits. Studies suggest that the development of breakfast eating patterns begin at an early age (17) and such habits are likely to carry over into adulthood (69). Parents can therefore promote healthy and regular eating habits in their children by preparing and eating breakfast with their children as well as engaging their children in social interaction during the meal. Because adequate nutrition in early childhood has been linked to increased IQ through childhood (54) which is related to decreased childhood behavioral disorders (70, 71), better career satisfaction (72), and socioeconomic success (73) in adults, breakfast consumption could ultimately benefit long-term physical and mental health outcomes as well as quality of life (74). Finally, our findings suggest that consistent breakfast consumption is associated with cognitive ability in preschool children. These data suggest that, in addition to improving concentration and school performance, eating breakfast regularly, as a nutritional and psychosocial factor, may in part contribute to enhanced cognitive development in early childhood.

In summary, the present study reports that compared to children who consumed breakfast infrequently, children with regular breakfast consumption had significantly better scores on full, verbal, and performance IQ tests. This relationship persisted even after adjusting for confounding factors (e.g. sociodemographic factors), allowing for a clearer representation of the effect of breakfast consumption on a child's cognition. These findings may reflect nutritional as well as social benefits of breakfast consumption on children and hold important public health implications regarding regular breakfast consumption in early young children.

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Table 1

Demographic Characteristics of Study Participants by Breakfast Consumption Habits

Characteristics	Sometimes No. (%)	Often/Always No. (%)	Total No. (%)
Gender			
Male	39 (5.6)	658 (94.4)	697 (54.9)
Female	33 (5.8)	539 (94.2)	572 (45.1)
Current Location			
City	43 (4.7)	880 (95.3)	923 (73.6)
Rural	28 (8.5)	303 (91.5)	331 (26.4)
Father's Education			
Less than high school	65 (7.3)	827 (92.7)	892 (71.0)
High school or more	7 (1.9)	358 (98.1)	365 (29.0)
Mother's Education			
Less than high school	68 (6.8)	935 (93.2)	1003 (79.9)
High school or more	4 (1.6)	249 (98.4)	253 (20.1)
Father's Occupation			
No job or workers	51 (6.9)	692 (93.1)	743 (61.1)
Professional	14 (3.0)	458 (97.0)	472 (38.9)
Mother's Occupation			
No job or workers	59 (6.8)	803 (93.2)	862 (70.4)
Professional	11 (3.0)	352 (97.0)	363 (29.6)
Who Raised You			
Biological Parents	65 (5.6)	1107 (94.5)	1172 (93.3)
Others	6 (7.1)	78 (92.9)	84 (6.7)

Table 2

Cognitive ability (IQ) by Breakfast Consumption Habits and Unadjusted Group Differences

	N	Verbal Mean± SD	Performance Mean ± SD	Full Mean± SD
Breakfast Consumption				
Sometimes	72	96.5±14.9	98.4±15.8	96.9±14.4
Often/Always	1197	104.4±14.8	104.4±14.8	104.6±14.2
Total	1269	104.0±14.9	104.1±14.9	104.2±14.3
Difference				
(Often/Always – Sometimes)		7.9	6.1	7.8
95% Confidence Interval		(4.4,11.4)	(2.5,9.6)	(4.4,11.1)
p-values *		<0.001	0.001	<0.001

* p-values were based on ANOVA F-statistic with Breakfast Consumption as a factor.

Table 3

Results of Multiple Linear Regression Analysis of the Association between Breakfast Consumption and VIQ, PIQ, and FIQ.

	VIQ		PIQ		FIQ	
	Adjusted Difference	p-value	Adjusted Difference	p-value	Adjusted Difference	p-value
Breakfast Consumption						
Often/Always	5.58	0.003	2.50	0.171	4.59	0.008
Sex						
Female	-2.26	0.007	-1.91	0.018	-2.38	0.002
Current location						
Rural	-5.80	<0.001	-7.92	<0.001	-7.64	<0.001
Father's Education						
High school or more	2.08	0.076	3.50	0.002	2.46	0.004
Mother's Education						
High school or more	2.83	0.040	1.46	0.280	2.46	0.055
Father's Occupation						
Professional	2.21	0.045	1.33	0.221	2.01	0.050
Mother's Occupation						
Professional	1.84	0.144	2.69	0.029	2.49	0.032
Who raise you						
Others	-1.31	0.438	-4.48	0.007	-3.08	0.049

Note: The reference groups used were: sometimes (breakfast consumption), male (sex), living in city (current location), less than high school education (education), no jobs or workers (occupation), biological parents (who raise you). No significant interaction effects between breakfast and gender were found based on a Wald test. VIQ= verbal IQ, PIQ= performance IQ, FIQ= full IQ.