DIFFERENT DIETARY PATTERNS ARE ASSOCIATED WITH THE DISPARITY IN OVERWEIGHT OF BOYS BETWEEN RURAL AND URBAN CHINA

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Abstract. This study aimed to compare the dietary pattern and BMI of Chinese children between rural and urban areas and to investigate the association between these two variables. Children aged 7-18 years (urban: 870; rural: 1,692) from the 2004, 2006, 2009, and 2011 China Health and Nutrition Surveys were recruited. The criteria of the Working Group on Obesity in China were used to define overweight and obesity and determine differences in body mass index (BMI) between urban and rural children. A consumption recall module for all foods over three days were used to describe dietary patterns. Subgroup differences in dietary pattern were identified using analysis of covariance. The relationship between children's BMI and calorie structure was identified using nonparametric estimation and multiple variables linear regression models. Results show significant differences both in the overweight rate and dietary pattern between boys from urban and rural areas. Heterogeneity of calorie composition was positively associated with standardized BMI for boys. A higher proportion of calories from protein contributed to boys' BMI. However, no significant association was detected for girls.

Keywords: BMI, children, dietary pattern, overweight

INTRODUCTION

Raising concerns on overweight and obesity in children appeared in China in the past decades (Dietz, 1994; Popkin, 2008; Tian and Yu, 2015). The 2015 Report on Chinese Nutrition and Chronic Disease found that the national overweight and obesity rates in children aged 6-17 years are 9.6% and 6.4%, respectively. Overweight and obesity in childhood are urgent health problems that require treatment, because obesity not only triggers various health problems requiring medical and psychological treatment, but is also closely associated with obesity in adulthood (Guo and Chumlea, 1999). Moreover, the persistence of childhood overweight and obesity increases the risk of diseases in adulthood, such as diabetes, hypertension, coronary artery disease, and certain cancers (Barton, 2012).

Overweight and obesity in children might be related to their living environ-

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ment, genetic inheritance, and physical activity (Nguyen and El-Serag, 2010). Among these factors, the dietary pattern is a crucial controllable factor that represents the combined effect of various types of food and efficaciously illustrates the impact of diet on health outcomes (Zhang *et al*, 2015). With the urbanization and modernization of China, urban and rural areas exhibit completely different food demand patterns due to different food availability (Liu *et al*, 2014), various food cultures and habits, higher opportunity cost in preparing food at home in urban area (Monsivais *et al,* 2014), demand disparity caused by occupations (Huang, 1999), market vulnerability and own farming (Huang, 1999).

Furthermore, different dietary pattern between rural and urban areas may lead to differences in overweight and obesity rates in children. Previous studies found rather controversial results in the relationship between dietary pattern and body mass index (BMI), (Esmaillzadeh and Azadbakht, 2008; McNaughton *et al,* 2008) and dietary pattern have generally used samples from only urban or rural areas or recruited two groups that are completely identical (Popkin *et al,* 2006; Gordon-Larsen *et al,* 2014). However, children from urban and rural areas exhibit different characteristics, which should be accounted for in relevant studies.

This study aimed to reveal and compare the BMI and dietary pattern of children from urban and rural areas, and further explored the potential relationship between children's BMI and their dietary pattern according to sex.

MATERIALS AND METHODS

Study subjects

This study utilized data from the China Health and Nutrition Survey (CHNS) database, focussing on children aged between 7-18 years because children's height and weight standards were typically set for this age group. To reduce the influence of measurement errors on the results, we did not use samples with calorie intake>8,000 kcal/d or <500 kcal/d (n = 5). We also omitted samples with incomplete information on food consumption or BMI (n = 686). We excluded samples with incomplete personal information for children and incomplete family-related information (n = 1,375). The final sample contained 2,562 observations (a total of 2001 children, of which 1,528 have been observed once, 784 have been observed twice, 222 have been observed thrice, and 28 appeared in all four rounds), which included 870 urban observations and 1,692 rural observations.

Anthropometric data

Height was measured without shoes to the nearest 0.2 cm by using a portable Seca stadiometer (Seca North America, Chino, CA). Weight was measured without shoes and in light clothing to the nearest 0.1 kg on a calibrated beam scale. BMI was calculated as the weight (kg) divided by the height squared (m^2).

In contrast to adults, the analysis of BMI in children should consider sex and age differences (Chen, 2008). This study applied the WGOC (Working Group on Obesity in China) criteria, which were established on the basis of specific sex and age characteristics, to calculate the overweight and obesity rates of urban and rural children (Table 1) (Ji, 2005). In addition, to incorporate the BMIs of children of different sexes and ages into a unified analytical framework, the sex- and age-specific BMI cut-offs developed by the World Health Organization (WHO) were used to standardise the children's BMIs in

the samples (Powell and Nguyen, 2013).

Assessment of dietary pattern

To reflect differences in the dietary pattern of urban and rural children, 13 indicators were employed based on food and nutrition. Six food-based indicators were the consumption of vegetables, meat, aquatic products (such as fish and shrimp), eggs, milk, and fruits. The other seven nutrition-based indicators were the intake of energy, carbohydrates, fats, and proteins and features of the calorie composition, namely calorie density, calories from protein, and calories from fat. CHNS includes a consumption recall module for all foods over three days, nutrition intake measures are the average amount calculated by nutritionists based on a three-day record of food consumption in each household. Subsequently, the children's average daily consumption of each category of food was calculated according to these food codes and adopted as food indices. Using the food indices and the food nutrition data of 'China Food Composition', the average daily nutrient intake and calorie composition features were calculated for each respondent. More information about this dataset can be found elsewhere (Zhang *et al*, 2014).

Covariates

To exclude the influence of confounding factors, this study collected family-related information, including the household income (RMB/year), household size, the children's characteristics (age, sex, physical activity, whether the child is a student, and sleep time), and characteristics of household head (age, sex, physical activity, and education level). A further explanation about these variables was in Table 2.

Statistical analysis

Descriptive analyses were performed to evaluate the characteristics of the whole population and the two subsamples according to sex. Continuous variables are expressed as the mean and 95% confidential interval and categorical variables as percentages. Moreover, all variables were compared between boys and girls by using Student's *t* tests for continuous variables and chi-square tests for binary variables.

We first calculated the overweight and obesity rates of boys and girls from urban and rural areas and conducted an independent samples *t*-test for urban and rural children. Standardized BMI are compared across different groups. Furthermore, the covariance analysis was used to detect whether differences exist in the dietary pattern of rural and urban children after controlling for the children's characteristics (sex, age, and physical activity intensity) and household income. Finally, multivariable linear regression and nonparametric fitting were used to estimate the relationships between the children's standardized BMI and the proportions of calories from protein and fat.

All data processing and analysis were conducted using Stata/SE version 12 (StataCorp, College Station, TX). All statistical tests were bilateral; the confidence level was set as $p<0.05$.

Ethical considerations

The CHNS data adopted in our research are public data from an observational study that is not a clinical trial study. The survey was approved by the review board of University of North Carolina at Chapel Hill (UNC-CH) and the Chinese Institute of Nutrition and Food Safety (INFS) at the China Center for Disease Control and Prevention (CCDC). All participants provided written informed consent and all methods were performed

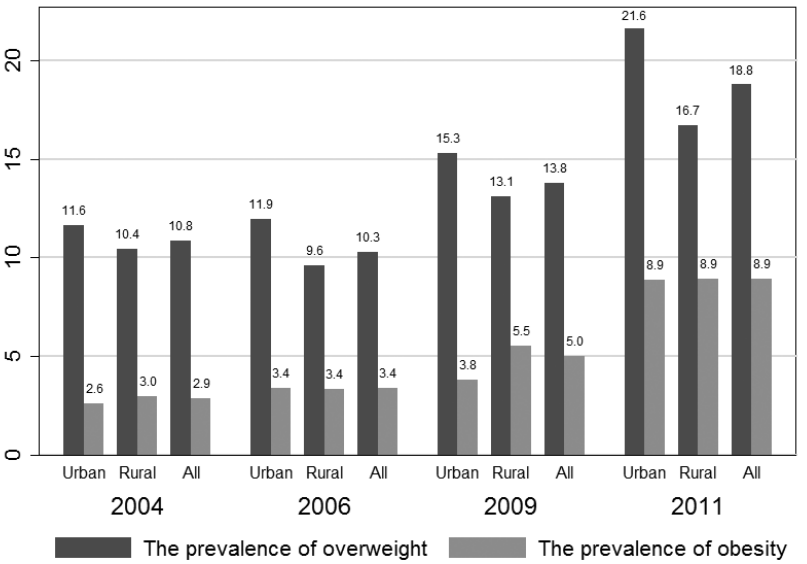

Fig 1–The dark gray column indicated the prevalence of overweight and the light gray column indicated the prevalence rate of obesity.

in accordance with the relevant guidelines and regulations. The ethics committees of the Medical Faculty of the University of Goettingen and the University of North Carolina at Chapel Hill approved our use of this data in 2013.

RESULTS

Prevalence of overweight and obesity

Rising prevalence of overweight and obesity were observed both in urban and rural children in China in recent years (Fig 1). According to WGOC's measurement criteria, Table 1 shows that although no significant difference was observed in obesity between urban and rural children, the prevalence of overweight was significantly higher in urban children (15.9%; 95% CI: 13.4-18.3) than in rural children (12.4%; 95% CI: 10.8-14.0). The difference in the prevalence of overweight between urban and rural children is mainly attributable to the difference between urban and rural boys, as observed in an analysis stratified by sex. The overweight rate in urban boys (19.6%; 95% CI: 15.8-23.4) was significantly higher than that in rural boys (13.4%; 95% CI: 11.2-15.6), whereas no statistically significant difference was observed between urban and rural girls. Moreover, the prevalence of overweight and obesity was higher in boys than in girls.

Table 2 reports the standardized BMI using gender and age specific BMI reference values developed by the WHO. Overall, the mean standardized BMI of urban children (1.003; 95% CI: 0.992-1.015) was significantly higher than that of rural children (0.985; 95% CI: 0.977-0.993). The standardized BMI of urban boys (1.023; 95% CI: 1.006-1.041) was significantly higher than that of rural boys (0.997; 95% CI: 0.986-1.008). In contrast to boys, no significant difference was observed in the standardized BMI between urban and rural girls.

Dietary pattern in urban and rural areas

Table 3 provides the current dietary pattern of urban and rural children. The food-based indicators revealed that urban children's average daily consumption of meat, aquatic products, eggs, milk, and fruit were significantly greater than rural children, while the daily consumption of vegetable was significantly less than their rural counterparts. The nutrients-based indicators revealed that urban children's daily intake of proteins, and fats were significantly greater than rural children,

Table1
Prevalence of overweight and obesity in urban and rural children aged 7-18 years.

Gender	Urban mean (95%CI)			Rural mean(95%CI)			Urban- rural comparison (p-value)[a]	
	n	Overweight	Obesity	n	Overweight	Obesity	Overweight	Obesity
Boys	424	19.6 (15.8-23.4)	6.1 (3.8-8.4)	947	13.4 (11.2-15.6)	5.7 (4.2-7.2)	0.006	0.757
Girls	446	12.3 (9.3-15.4)	4.3 (2.4-6.1)	745	11.1 (8.9-13.4)	4.4 (2.9-5.9)	0.539	0.890
All	870	15.9 (13.4-18.3)	5.2 (3.7-6.7)	1,692	12.4 (10.8-14.0)	5.1 (4.1-6.2)	0.020	0.974

[a]The independent samples t-test revealed significant differences between urban and rural children.

Table 2
Standardized BMI of urban and rural children aged 7-18 years[a].

Gender	Urban mean(95% CI)		Rural mean(95% CI)		Urban-rural comparison
	Standardized BMI	p-value	Standardized BMI	p-value	p-value
Boys	1.023 (1.006-1.041)	0.008	0.997 (0.986-1.008)	0.609	0.011
Girls	0.985 (0.969-1.000)	0.054	0.969 (0.958-0.981)	<0.001	0.131
All	1.003 (0.992-1.015)	0.556	0.985 (0.977-0.993)	<0.001	0.010

[a]The independent samples t-test was used to analyse urban and rural children, and p-values are listed in the last column. The one-sample mean-comparison test was used for comparisons between the standardized BMI and 1, and p-values are listed in columns 3 and 5.

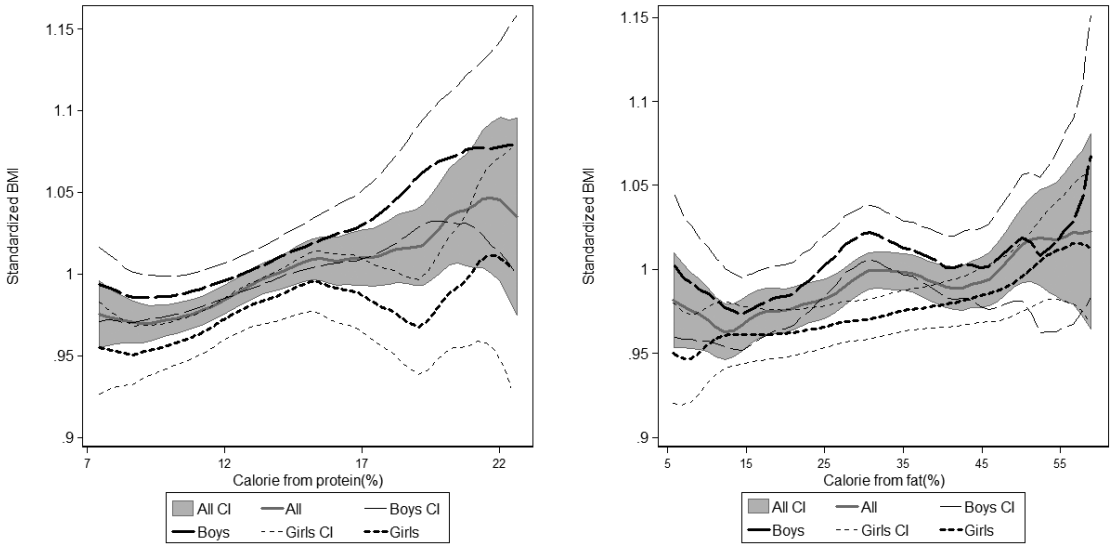

Fig 2–The solid line, long dashed line, and short dashed line indicate the whole sample, sample of boys, and sample of girls, respectively. The bold curve denotes fitted values, and the nonbold curve represents the 95% confidence interval. To exclude the influence of extreme values, samples were bilaterally truncated, and the upper bound is 1%; the lower bound is 99%.

while the daily intake of carbohydrates was significantly less than their rural counterparts.

Urban children have lower calorie density and higher proportions of calorie from protein and fat. These findings show that differences exist in the amount of food, nutrients, and calorie composition between urban and rural children, which are preliminarily indications of differences in the dietary pattern of urban and rural children. Further covariance analysis and comparison of dietary pattern for children by gender provided additional evidence that rural and urban children have different dietary pattern (Table 2, 3).

Association of dietary pattern with BMI

After adjustment for confounders, multiple regression analysis showed that the calorie composition did clearly influence BMI for all children due to the strong preference for boys, as showed in Table 4, the difference in the calorie composition of boys dramatically affected their BMI. Specifically, when the proportion of calories from protein increased by 10%, the standardized BMI of boys correspondingly increased by 0.04, which indicated a significant increase of 0.724 since the sample mean BMI is 18.1. However, the calorie composition of girls did not significantly affect their BMI. Fig 2 further confirmed that children's BMI was slightly positively correlated with the proportion of calories obtained from protein and fat.

DISCUSSION

This study is the first to determine the difference in overweight and obesity and dietary pattern between urban and rural children in China and explore the relationships among these factors. Between 2004 and 2011, the overweight and obesity rates of Chinese children from both urban and rural areas tended to increase, which is consistent with the switching toward a

Table 3
Daily dietary intake of children in urban and rural areas in China.

Dietary structure	Full sample (*n*=2,562) Mean ± SD	Urban (*n*=870) Mean ± SD	Rural (*n*=1,692) Mean ± SD	Comparison *p*-value[a]
Food consumption				
Vegetable (g)	236.1 ± 156.5	220.2 ± 135.7	244.2 ± 165.6	<0.001
Meat (g)	81.6 ± 79.6	107.9 ± 87.1	68 ± 71.9	<0.001
Aquatic products (g)	23.7 ± 43.3	31.5 ± 49.6	19.6 ± 39.0	<0.001
Egg (g)	25.9 ± 31.2	31.5 ± 35.0	23.0 ± 28.6	<0.001
Milk (g)	27.0 ± 73.2	56.1 ± 100.6	12.1 ± 47.5	<0.001
Fruit (g)	63.6 ± 118.5	81.4 ± 120.0	54.5 ± 16.8	<0.001
Nutrients intake				
Calorie (kcal)	1,781.4 ± 635.3	1,810.2 ± 681.8	1,766.5 ± 609.8	0.613
Carbohydrate (g)	249.6 ± 97.6	233.1 ± 95.4	258.1 ± 97.7	<0.001
Protein (g)	57.3 ± 24.6	63.2 ± 29.2	54.3 ± 21.2	<0.001
Fat (g)	61.4 ± 35.5	69.2 ± 37.9	57.3 ± 33.6	<0.001
Calorie composition				
Density (kcal/g)[b]	2.1 ± 0.7	2.0 ± 0.8	2.2 ± 0.7	<0.001
From protein (%)	13.0 ± 3.1	14.1 ± 3.5	12.4 ± 2.7	<0.001
From fat (%)	30.4 ± 11.4	33.9 ± 11.1	28.6 ± 11.2	<0.001

[a]The *p*-value was calculated using ANCOVA adjusted for children's age, sex, physical activity and household income. The F test was used to assess statistically significant differences in food structure and nutrition status between the urban and rural children.
[b]Calorie density (kcal/g) =Total calorie intake (kcal)/Total food consumption (g).

high-fat diet and the increasing inactivity (Du *et al*, 2002). The significant increase in obesity rates between 2009 and 2011, particularly for urban areas, might be attributed to the food retail revolution at recent years in China and the increasing consumption of processed food (Zhou *et al*, 2015).

Although no significant differences were observed in the obesity rate between urban and rural children, the overweight rate was significantly higher in urban children than in rural children, and these differences mainly come from the difference between urban and rural boys. However, girls exhibited no significant difference. Comparison of the children's standardized BMI revealed the same result. In addition, regardless of the residential area (urban or rural), overweight and obesity are more serious in boys than in girls. Similar results were also found in a study using 1992 CHNS data (Ge, 1999). This phenomenon may be attributed to two causes. First, girls are more concerned about their appearance than boys, which may be a crucial reason for the lower overweight rate in girls (Wang *et al*, 2000). Second, considering the population structure of China, rural girls are more likely to have younger brothers and younger sisters than boys. Consequently, fewer family resources are available to girls due to increases in the number of children (Wang *et al*, 2000).

Notably, despite increased overweight and obesity rates in Chinese children, the BMI of urban children is relatively normal.

Table 4
Association between standardized BMI and calorie status (n=2,562)[a].

	Full sample (n=2,562)			Boys (n=1,371)			Girls (n=1,191)		
	β	SE	p-value	β	SE	p-value	β	SE	p-value
Calorie composition									
From protein	0.0030	0.0013	0.019	0.0040	0.0018	0.025	0.0022	0.0018	0.222
From fat	0.0004	0.0004	0.335	0.0004	0.0005	0.376	0.0003	0.0005	0.604
Control variables									
Household income	0.0078	0.0036	0.029	0.0098	0.0050	0.051	0.0037	0.0051	0.469
Household size	-0.0054	0.0024	0.025	-0.0033	0.0033	0.330	-0.0058	0.0034	0.085
Children ratio	-0.1205	0.0310	<0.001	-0.0750	0.0447	0.094	-0.1517	0.0422	<0.001
Children status									
Activity	-0.0126	0.0058	0.029	-0.0163	0.0083	0.051	-0.0092	0.0085	0.279
Education	0.0253	0.0135	0.061	0.0373	0.0185	0.044	0.0093	0.0181	0.609
Sleep	0.0010	0.0033	0.774	0.0067	0.0045	0.135	-0.0053	0.0046	0.245
Householder status									
Age	-0.0007	0.0004	0.041	-0.0006	0.0005	0.246	-0.0008	0.0005	0.093
Male	0.0103	0.0077	0.182	0.0142	0.0099	0.153	0.0032	0.0118	0.785
Activity	-0.0047	0.0037	0.198	-0.0012	0.0046	0.801	-0.0085	0.0057	0.136
Education	0.0085	0.0037	0.021	0.0121	0.0051	0.017	0.0057	0.0052	0.272
Region[b]	0.0109	0.0087	0.213	-0.0016	0.0122	0.895	0.0186	0.012	0.122
Constant	0.9547	0.0584	<0.001	0.8406	0.0819	<0.001	1.0835	0.0813	<0.001

[a]Multivariable linear regression analysis was performed to adjust the effect of children's status (physical activity, education, and sleep), household income, household size, children ratio, householder's status (age, sex, physical activity, and education) and region. Cluster-robust (at the household level) standard errors are reported to correct intra-group correlation in error terms.
[b]Urban=0, rural=1.

This is because urban boys as a whole are at a risk of being overweight, and urban girls are at a risk of being underweight. Overall, the standardized BMI of rural children was significantly less than 1, indicating that rural children overall are still at a risk of being underweight. This result confirms that Chinese people are currently at the stage of coexist of under-nutrition and over-nutrition (Wang *et al,* 2008). Therefore, the health conditions of urban and rural children should be considered different.

Analysis of dietary pattern revealed significant differences in food consumption, nutrition intake, and calorie composition between urban and rural children, regardless of sex. The calorie intake from protein and fat was greater in urban children than in rural children. Moreover, the calorie density of rural children was markedly higher than that of urban children, which is inconsistent with previous study (Lachat *et al,* 2009). A nutritious diet pattern is usually accompanied by a lower calorie density, which indirectly reflects that urban children consume a more nutritious diet than rural children do (Drewnowski and Fulgoni, 2014). However, the different dietary pattern between urban and rural areas can be attributed to many reasons such as higher food expen-

diture in urban households, which often leads to a low calorie density and a more nutritious dietary pattern (Drewnowski *et al*, 2007).

Finally, we confirmed that children's standardized BMI is closely related to the calorie composition (Thompson *et al*, 2006; Wate *et al*, 2013). The heterogeneity of the calorie composition of urban and rural boys effectively explains the differences in their BMI. Specifically, the high proportion of calories from protein remarkably improves the standardized BMI of boys. However, the difference in the calorie composition of girls does not significantly influence their standardized BMI.

The strength of this study is that urban and rural children were considered as two heterogeneous groups to systematically reveal the differences in overweight and obesity between them. Moreover, food consumption, the nutrition structure, and BMI were compared in detail, and the relationship between dietary pattern and BMI was explored. These factors have never been explored in previous studies.

This study still suffers to several limitations. First, many other foods (*eg*, snacks and drinks) and nutrients (*eg*, vitamin D, Fe, Cu) are also crucial factors that affect overweight and obesity in children (Mercille *et al*, 2010; Rosenblum *et al*, 2012). Their role remains for future research. Second, this research only revealed the statistical association between dietary pattern and BMI, while the function remained for further clinical research.

In conclusion, the differences in food consumption by urban and rural children result in a different nutrition structure. The heterogeneity of the nutrition structure of urban and rural boys contributes to the differences in their BMI. By contrast, the nutrition structure of urban and rural girls does not significantly affect their BMI.

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CONFLICT OF INTERESTS

We declared that no competing interests exist.

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