

Original Article

Increased pre-school overweight and obesity prevalence between 2004 and 2013 is associated with appetite, eating frequency and supportive facilities: the Jiaxing Birth Cohort in China

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Background and Objectives: Childhood obesity is increasing. However, little is known about the changes in dietary factors and supportive facilities associated with childhood obesity. We aimed to document the changes in various dietary factors and supportive facilities and their associations with obesity among pre-school children. **Methods and Study Design:** Among 42,531 children 4-5 years old, recruited between 2004 and 2013 in the Jiaxing Birth Cohort, we examined the changes in the prevalence of various dietary factors and supportive facilities and overweight/obesity over 10 years. We used logistic regression to investigate the cross-sectional association between these factors and childhood overweight/obesity risk, adjusting for potential confounders. **Results:** The prevalence of childhood overweight/obesity increased steadily from 11.8% (boy: 14.8%; girl: 9%) during 2004-2005 to 18% (boy: 21.4%; girl: 15%) during 2012-2013. The prevalence of meal/snack frequency 3 times/day decreased substantially from 23% during 2004-2005 to 8% during 2012-2013, with more children having 5 times/day: from 32% to 45.6%. Children with a fair/bad appetite, compared with those with a good appetite, had a 45% (OR: 0.55; 95% CI: 0.49, 0.62) lower risk of overweight/obesity. Children with a meal frequency ≥ 6 times/day (compared with 3 times/day) had a 0.12 (95% CI: 0.03, 0.2) higher BMI-z-score. **Conclusions:** The prevalence of childhood overweight/obesity has increased substantially within a decade in southeast China. A better appetite and greater eating frequency were associated with the increased prevalence.

Key Words: obesity, overweight, prevalence, lifestyle, childhood

INTRODUCTION

The prevalence of childhood obesity has been increasing globally, especially in developing countries such as China.^{1,2} According to a Chinese National survey in 2010, the prevalence of childhood overweight/obesity was 19.2% among children at 7-18 years old.² Accumulating evidence suggests that childhood obesity may lead to several childhood and adolescent comorbidities, including hypertension, early puberty, menstrual irregularities and asthma.³ Therefore, it is necessary to identify potential risk factors to curb the epidemic of the childhood obesity.

Among Chinese populations, several studies suggested that dietary factors, lifestyles or supportive facilities such as screen time, less physical activity, shorter sleep duration, snacking, unhealthy dietary habit were associated with higher risk of childhood obesity.⁴⁻⁸ One of our previous studies in the Jiaxing Birth Cohort also suggested that shorter (≤ 10 h) or longer sleep time (≥ 13 h) was associated with higher risk of childhood overweight/obesity.⁹ Of note, most of these studies have small/moderate sample

size. In addition, only one narrow time-period was used for these studies, while little is known about the trends/change in the prevalence in these risk factors with time. Clarifying the change in the prevalence of some potential dietary or other risk factors and their associations with childhood obesity will help better understand the role of these potential risk factors in obesity development at childhood.

Therefore, in the present study, we aimed to characterise the change in prevalence of selected dietary factors/supportive facility and childhood overweight/obesity

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from 2004 to 2013, and to investigate their cross-sectional associations in a large population-based cohort study in Southeast China.

METHODS

Study populations

This study was based on the Jiaxing Birth Cohort (JBC) study, an on-going large population-based birth cohort study. The details of the study design have been described previously.¹⁰ Briefly, the JBC study recruited 338,413 mother-child pairs, who registered at local clinics before or during pregnancy at one of the seven divisions/counties in the Jiaxing area in southeast China. The children were followed up at ages 3, 6, 9 and 12 months during infancy stage, every 6 months between ages 12 and 36 months during toddler stage, and thereafter every year before they started school. Detailed maternal characteristics including age, BMI, education, occupation, menarcheal age, parity, delivery mode, gestational ages were recorded during follow-ups. Children with follow-up information at 4-5 years old (48-50 months) on anthropometric parameters (body weight, height) ($n=42,531$) were included in the present cross-sectional analysis, as has been used previously.^{9,11,12} The study protocol was approved by the ethics committee of the College of Biosystem Engineering & Food Science at Zhejiang University in China.

Measurement of anthropometric parameters, lifestyles and dietary factors

Anthropometric parameters including body weight and height of the children were measured to the nearest 0.1 kg and 0.1 cm respectively at their clinic visits at 4-5 years old. Z-scores of BMI-for-age were calculated according to the 2006 WHO Child Growth Standards.¹³ In the present study, we defined overweight/obesity as the BMI-z-score ≥ 1 .

Dietary factors and supportive facilities of the children were collected via questionnaire at in-person interview by trained nurses/doctors during the clinic visit. These factors included nursery status (yes, no), outdoor physical activity (>2 hours/day, 1-2 hours/day, <1 hour/day), appetite (good, fair/bad), meal (including snack) frequency and sleep duration. Other maternal or children characteristics were retrieved in the database from the JBC study, including maternal menarcheal age at delivery, maternal education ($>$ high school, high school, $<$ high school), maternal occupation (farmwork /housework, routine job, others), maternal Caesarean section status (yes vs. no), maternal parity (first pregnancy, >1 pregnancy), maternal gestational age, maternal BMI, offspring sex and birth weight.

Statistical analysis

All statistical analyses were performed using STATA version 14 (StataCorp). Logistic regression was used to estimate the association of dietary factors/supportive facilities (nursery status, outdoor physical activity, appetite and meal/snack frequency) with risk of overweight/obesity among the children adjusting for maternal gestational weeks, delivery mode, maternal age at delivery, maternal BMI, maternal menarcheal age, maternal

educational level, maternal occupation, children age (in months), birth weight, sex, sleeping duration and mutual adjustment for the tested risk factors. Linear regression was used to estimate the relationship of BMI-z-score of the children with these exposures, adjusting for the same potential confounders listed in the above logistic model. Subgroup analysis based on sex was performed to examine the influence of sex on the associations due to the substantial difference in the prevalence of overweight/obesity between boys and girls. A two-tailed $p < 0.05$ was considered significant.

RESULTS

Mothers of the overweight/obese children were more likely to have a higher BMI, an earlier menarcheal age, a routine job, a higher education level, and a Caesarean-section delivery mode. Overweight/obese children were more likely to be boys, have a higher birth weight, a better appetite and a higher meal/snack frequency (Table 1).

The prevalence of childhood overweight/obesity increased steadily from 11.8% (boy: 14.8%; girl: 9%) between 2004-2005 to 18% (boy: 21.4%; girl: 15%) between 2012-2013 (Figure 1). Prevalence of children staying at nursery increased steadily over ten years: 41%, 64.5%, 71.2%, 82.4% and 82.1% for the duration of 2004-2005, 2006-2007, 2008-2009, 2010-2011 and 2012-2013, respectively (Figure 2). There were fewer children with outdoor activity >2 hours/day between 2012-2013 (prevalence: 99%) compared with that between 2004-2005 (prevalence: 96.1%). The prevalence of children with good appetite was 86% between 2004-2005, with a slight decrease over the 10 years (Figure 2). Prevalence of children with meal/snack frequency of 3 times/day decreased substantially from 23% between 2004-2005 to 8% between 2012-2013, with more children having meal/snack frequency of 5 times/day: from 32% to 45.6%. These trends were similar among boys and girls (Figure 3, Figure 4).

Children with fair/bad appetite, compared with those with good appetite, were associated with a 45% (OR: 0.55; 95% CI: 0.49, 0.62) lower risk of overweight/obesity, and 0.24 (95% CI: -0.27, -0.21) lower BMI-z-score. Children with meal/snack frequency ≥ 6 times/day (compared with 3 times/day) were associated with 0.12 (95% CI: 0.03, 0.2) higher BMI-z-score (Table 2), and this association was significant only in boys, not girls.

DISCUSSION

In the present study, we found that the overweight/obesity prevalence increased impressively over the ten years between 2004 and 2013. In addition, the prevalence of children staying at a nursery increased, while outdoor activity decreased over the ten years, and the meal/snack frequency increased remarkably over the ten years. Both higher meal/snack frequency and better appetite was associated with a higher risk of childhood overweight/obesity or higher BMI-z-score.

In 2010, the prevalence of childhood overweight/obesity was 19.2% totally (23.4% for boys and 14.5% for girls) in a Chinese national survey,² which was quite consistent with the prevalence in the present study that, between 2012-2013, 18% (boy: 21.4%; girl: 15%) of

Table 1. Population characteristics of the pre-school children at 4-5 years old in the Jiaxing Birth Cohort

	n	Normal weight, n (%)	Overweight/obesity, n (%)
Maternal age (years)			
<35	41423	35392 (97.4)	6031 (97.5)
≥35	1107	952 (2.62)	155 (2.51)
Maternal BMI (kg/m ²)			
<18.5	7940	7266 (21.2)	674 (11.5)
18.5-24.9	29987	25396 (74.1)	4591 (78.4)
25-29.9	2007	1477 (4.31)	530 (9.05)
≥30	205	141 (0.41)	64 (1.09)
Maternal menarcheal age (years)			
<14	6062	5032 (13.9)	1030 (16.7)
14-15	25094	21409 (59.1)	3685 (59.8)
>15	11233	9788 (27.0)	1445 (23.5)
Maternal education			
<High school	30940	26619 (73.3)	4321 (69.9)
High school	7507	6321 (17.4)	1186 (19.2)
>High school	4039	3363 (9.26)	676 (10.9)
Maternal occupation			
Farm work/housework	28136	24232 (66.8)	3904 (63.2)
Routine job	10684	9011 (24.8)	1673 (27.1)
Others	3662	3057 (0.08)	605 (0.10)
Maternal parity			
First pregnancy	35679	30374 (83.6)	5305 (85.8)
>1 pregnancy	6852	5971 (16.4)	881 (14.2)
Caesarean - section			
No	11218	9843 (27.1)	1375 (22.3)
Yes	31222	26428 (72.9)	4794 (77.7)
Gestational age (wk)			
Preterm delivery (<37)	1115	943 (2.59)	172 (2.78)
Term delivery (≥37)	41416	35402 (97.4)	6014 (97.2)
Birth weight (g)			
Low (<2500)	751	692 (1.9)	59 (0.95)
Normal (2500-3999)	39057	33632 (92.5)	5425 (87.7)
High (≥4000)	2723	2021 (5.56)	702 (11.4)
Offspring sex			
Boy	21999	18169 (50)	3830 (61.9)
Girl	20532	18176 (50)	2356 (38.1)
Sleep duration			
<11 hours	7300	6261 (27)	1039 (26.3)
11-13 hours	18874	16106 (69.3)	2768 (70.1)
>13 hours	1001	860 (3.70)	141 (3.57)
Nursery status			
Stay at home	12027	10370 (30.6)	1657 (28.5)
Stay at nursery	27667	23500 (69.4)	4167 (71.6)
Outdoor activity			
>2 hours/day	26480	22643 (96.1)	3837 (96.4)
1-2 hours/day	850	734 (3.11)	116 (2.91)
<1 hours/day	219	191 (0.81)	28 (0.7)
Appetite			
Good	22901	19351 (83.6)	3550 (90.3)
Fair/bad	4173	3792 (16.4)	381 (9.69)
Eating l frequency			
3 times/day	4148	3579 (15.6)	569 (14.6)
4 times/day	12962	11198 (48.8)	1764 (45.2)
5 times/day	9239	7761 (33.8)	1478 (37.8)
≥6 times/day	518	423 (1.84)	95 (2.43)

the children were overweight/obese. The increase in the prevalence of overweight/obesity over years in the present study was also consistent with the trend reported in the national survey data.² These results suggested that the generalizability of our present cohort was quite good, and the results from this large cohort confirmed the increasing severity of childhood adiposity in China.

Although a variety of studies have investigated the prevalence of dietary or lifestyle factors among Chinese

children,^{5,6,14-16} no study has investigated the trends in the change of the prevalence of our selected risk factors, including nursery status, outdoor activity, appetite, and meal/snack frequency. Increase in the prevalence of staying at nursery may reflect the increase in the family income between the 2004 and 2013, and it became more affordable for most families to send their children to nursery over the ten years in China. Correspondingly, the outdoor time decreased as staying at nursery was normal-

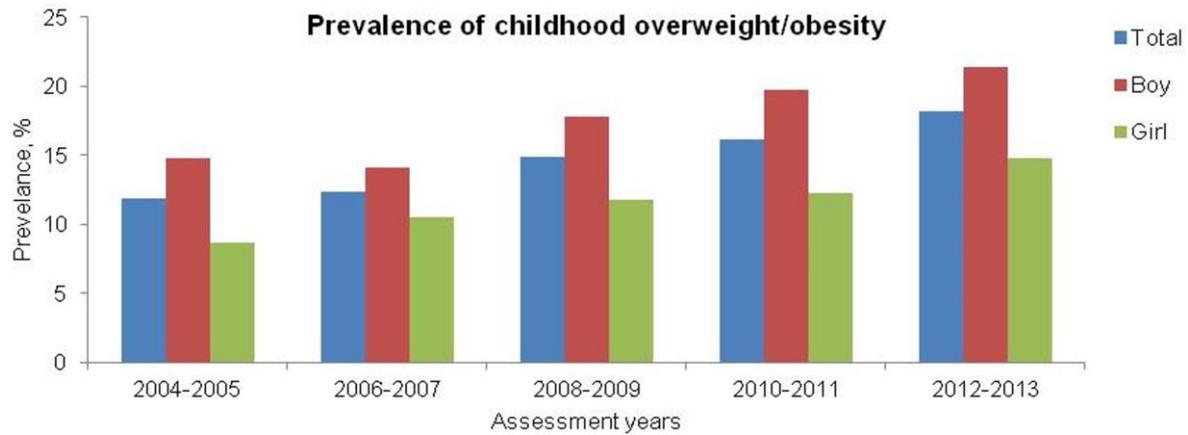


Figure 1. Change in the prevalence of childhood overweight/obesity over 10 years among pre-school children in the Jiaxing Birth Cohort.

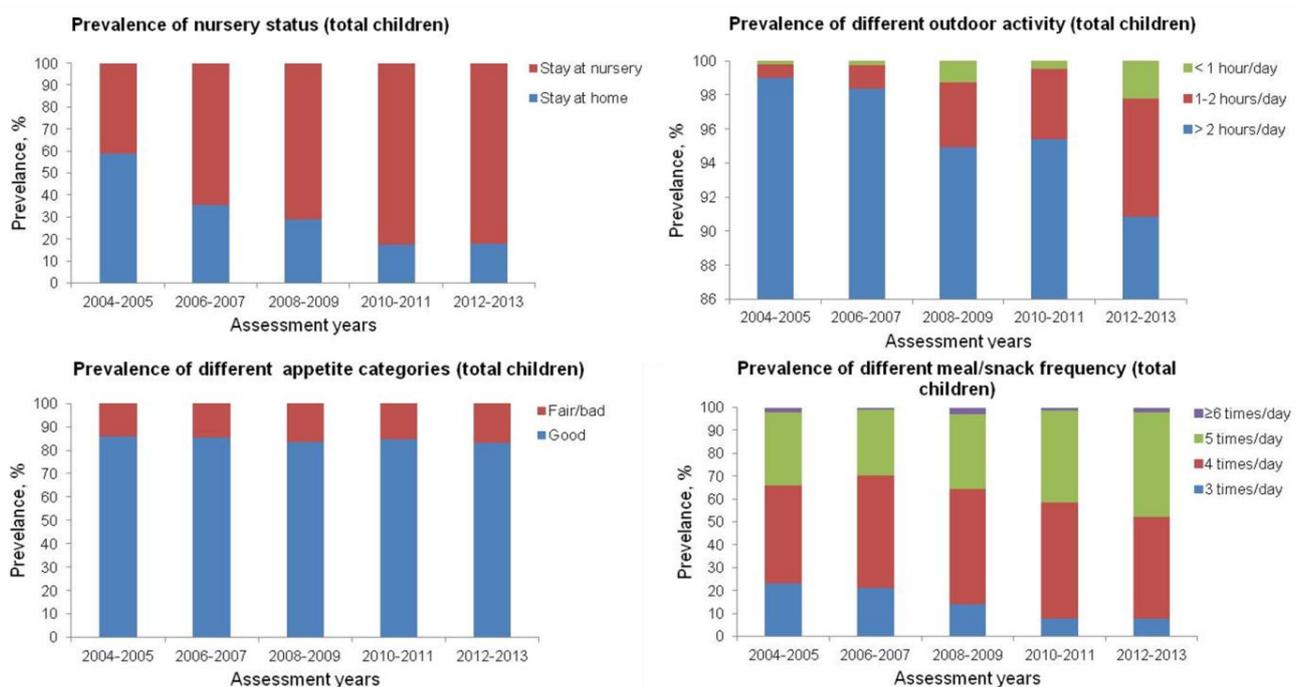


Figure 2. Nursery usage, outdoor activity, appetite and eating prevalence 10 years among pre-school children in the Jiaxing Birth Cohort

ly defined and considered as indoor time during our data collection. We observed a slight decrease in the prevalence of good appetite. This decrease in good appetite may reflect the increase in the picky eating behaviour, as parents of picky eating children were more likely to report that their children consumed a limited variety of foods and had a bad appetite.¹⁷ Not surprisingly, we found increased prevalence of children with more meal/snack frequency (5 or ≥ 6 times/day). This was consistent with the China Health and Nutrition Survey that between 1991 and 2009, snacking prevalence, frequency of daily snacking occasions and percentage of total daily energy intake from snacks increased significantly across all ages in China.¹⁸

In the cross-sectional analyses of these dietary factors/supportive facilities with childhood overweight/obesity risk and BMI-z-score, we did not find a significant association for nursery status or outdoor activity. This is conceivable, as nursery status and outdoor

activity could not well capture the real life physical activity or sedentary time, but rather they are the index of socioeconomic status. We found that good appetite compared with fair/bad appetite was associated with a higher overweight/obesity risk and higher BMI-z-score. Similarly, there was a positive association between meal/snack frequency ≥ 6 times/day and BMI-z-score. These results might be likely due to the fact that overweight/obese children tended to eat more and their parents were more likely to report good appetite for these children. On the other hand, it might be that the children with a better appetite had a higher total energy intake, with a greater risk of obesity.¹⁸ Nevertheless, a better appetite could be favourable given the continuing malnutrition and iron-deficiency anaemia to be found among Chinese teenagers.^{19,20} We show this competing risk and benefit of a better appetite in Figure 5. Therefore, a school-based nutrition education aimed at the promotion of a varied and nutritious dietary pattern could allow a good appetite to

be healthful, reducing its potential to cause adiposity. The present study adds to the rationale for school-based nutrition education and related food systems, especially given that school-based nutrition interventions for obesity in China have so far been relatively unsuccessful.²¹ A nation-wide campaign to promote healthy dietary patterns in accordance with the dietary guidelines directed at adults should benefit the whole family, including children and curb the present trajectory towards more and more childhood obesity.²²

Our previous study based on the same cohort found that shorter sleep hours were associated with higher risk of childhood obesity,⁹ which indicated that sleep deprivation (or increased wakefulness) may be an underlying consid-

eration. In turn, those habits which may correct this diurnal rhythm like physical activity and screen-time management might merit attention in dealing with eating behaviour and its body compositional consequences.²³ Nevertheless, since we adjusted for sleep duration, the findings for eating behaviour are likely to be independent of sleep deprivation.

There are several strengths in the present study. First, to the best of our knowledge, we report the increasing prevalence of dietary/supportive facility factors including appetite and meal/snack frequency over a decade and early in life in a large cohort of Chinese pre-schoolers. Second, the trend in prevalence of childhood overfatness in the present cohort is consistent with the Chinese na-

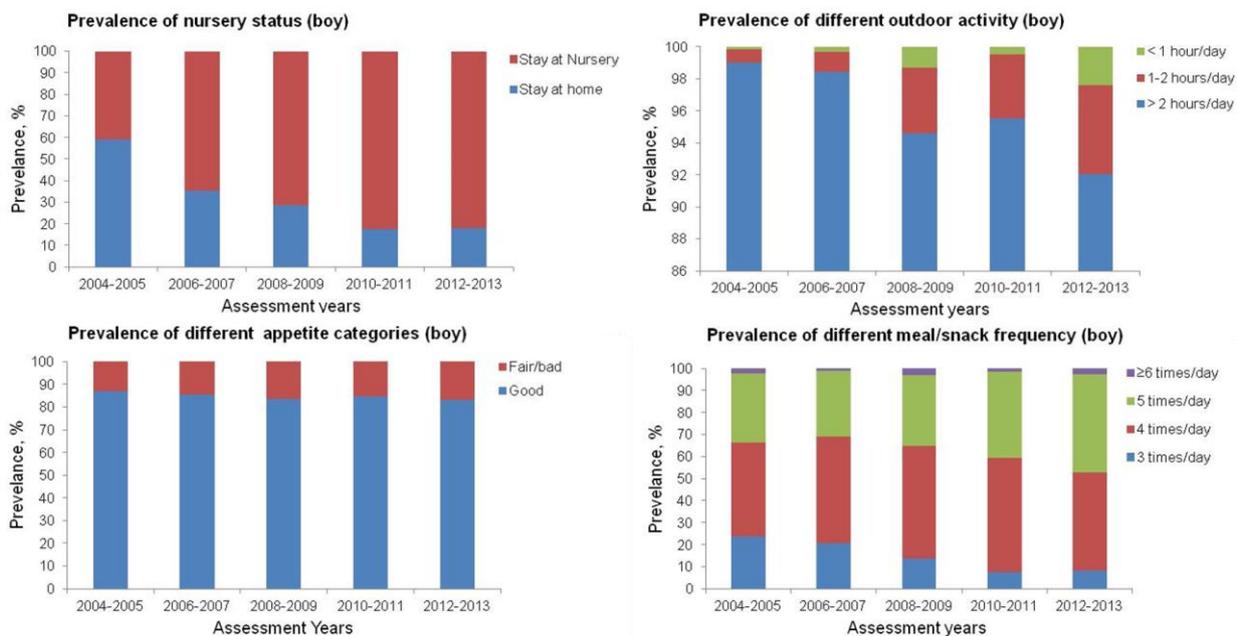


Figure 3. Nursery usage, outdoor activity, appetite and eating prevalence 10 years among pre-school boys in the Jiaying Birth Cohort.

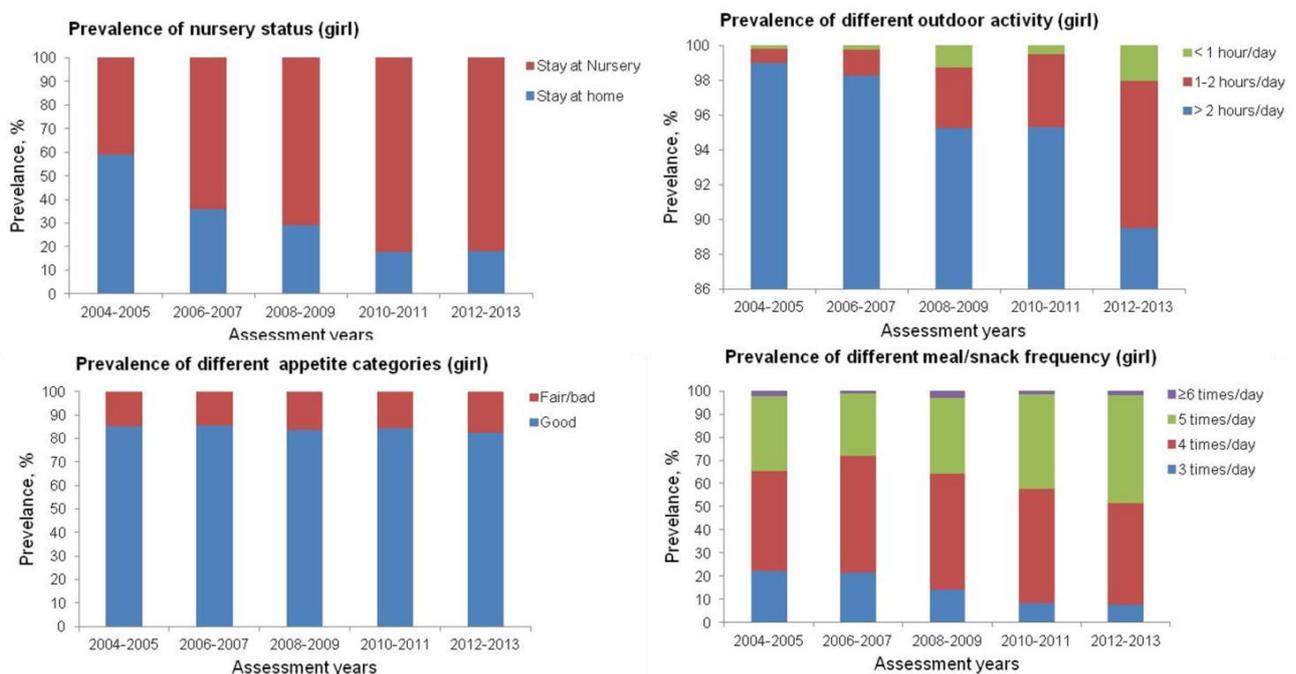


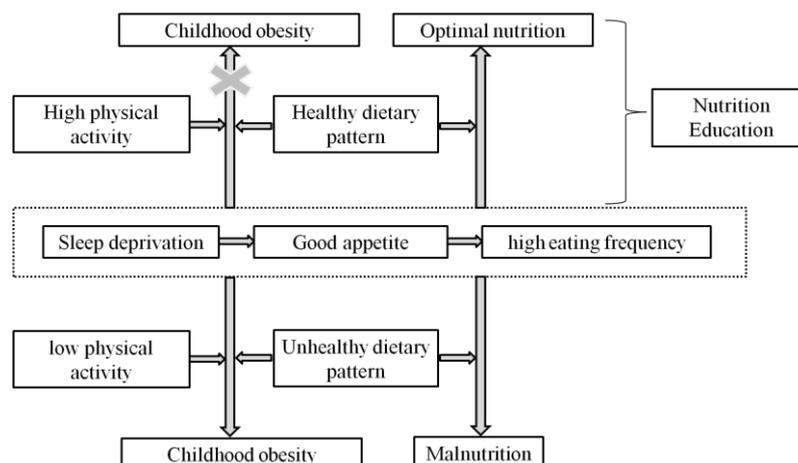
Figure 4. Nursery usage, outdoor activity, appetite and eating prevalence 10 years among pre-school girls in the Jiaying Birth Cohort.

Table 2. Association of dietary or other potential risk factors with risk of overweight/obesity and BMI-z-score among pre-school children at 4-5 years old in the Jiaxing Birth Cohort

Risk factors	Categories	Risk of overweight/obesity			BMI-z-score		
		OR [†]	95% CI	p-value	Beta [‡]	95% CI	p-value
All children (n=25,105)							
Nursery status	Stay at home	1	ref		1	ref	
	Stay at nursery	1.05	0.97, 1.13	0.22	-0.01	-0.03, 0.01	0.398
Outdoor activity	>2 hours/day	1	ref		1	ref	
	1-2 hours/day	1.05	0.84, 1.31	0.668	0.02	-0.05, 0.09	0.54
	<1 hours/day	0.98	0.64, 1.53	0.945	0.01	-0.12, 0.13	0.938
Appetite	Good	1	ref		1	ref	
	Fair/bad	0.55	0.49, 0.62	<0.001	-0.24	-0.27, -0.21	<0.001
Meal/snack frequency	3 times/day	1	ref		1	ref	
	4 times/day	0.89	0.80, 0.99	0.033	-0.02	-0.05, 0.01	0.263
	5 times/day	1	0.89, 1.12	0.987	0.03	-0.01, 0.06	0.116
	≥6 times/day	1.19	0.93, 1.54	0.173	0.12	0.03, 0.2	0.007
Boys (n=12,959)							
Nursery status	Stay at home	1	Ref		1	ref	
	Stay at nursery	1.06	0.96, 1.17	0.244	-0.01	-0.04, 0.02	0.544
Outdoor activity	>2 hours/day	1	Ref		1	ref	
	1-2 hours/day	1.05	0.78, 1.4	0.766	0.01	-0.09, 0.11	0.803
	<1 hours/day	1.15	0.67, 1.96	0.612	0.05	-0.13, 0.23	0.579
Appetite	Good	1	ref		1	ref	
	Fair/bad	0.54	0.46, 0.63	<0.001	-0.26	-0.31, -0.21	<0.001
Meal/snack frequency	3 times/day	1	ref		1	ref	
	4 times/day	0.9	0.78, 1.04	0.15	0.01	-0.04, 0.05	0.834
	5 times/day	0.98	0.85, 1.14	0.832	0.04	-0.01, 0.09	0.101
	≥6 times/day	1.31	0.95, 1.81	0.097	0.17	0.05, 0.29	0.006
Girls (n=12,111)							
Nursery status	Stay at home	1	ref		1	ref	
	Stay at nursery	1.03	0.92, 1.16	0.606	-0.01	-0.04, 0.02	0.609
Outdoor activity	>2 hours/day	1	ref		1	ref	
	1-2 hours/day	1.06	0.75, 1.48	0.749	0.03	-0.06, 0.12	0.519
	<1 hours/day	0.71	0.32, 1.58	0.408	-0.05	-0.23, 0.12	0.541
Appetite	Good	1	ref		1	ref	
	Fair/bad	0.57	0.47, 0.69	<0.001	-0.22	-0.26, -0.18	<0.001
Meal/snack frequency	3 times/day	1	ref		1	ref	
	4 times/day	0.87	0.74, 1.04	0.119	-0.04	-0.09, 0	0.058
	5 times/day	1.03	0.86, 1.23	0.753	0.01	-0.03, 0.06	0.587
	≥6 times/day	1.04	0.68, 1.60	0.845	0.06	-0.06, 0.18	0.318

[†]Logistic regression was used to calculate the odds ratio (OR) and 95% CI of childhood overweight/obesity risk for different categories of children behaviors, adjusting for maternal gestational weeks, C-section, maternal age at delivery, maternal BMI, maternal menarcheal age, maternal educational level, maternal occupation, children age (in months), birth weight, sex (for the results among all children), and mutual adjustment of all the other covariates within the table.

[‡]Linear regression was used to calculate the Beta coefficient (95% CI) of BMI-z-score for different categories of children behaviors, adjusting for maternal gestational weeks, C-section, maternal age at delivery, maternal BMI, maternal menarcheal age, maternal education, maternal occupation, children age (in months), birth weight, sex (for the results among all children), and mutual adjustment of all the other covariates within the table.

**Figure 5.** Diagram for the competing risk and benefit of a good appetite, high eating frequency for childhood obesity and nutritional status.

tional survey,² and therefore our results may be generalisable to other populations in China. Third, our study has a large sample size and a decade of observation from 2004 to 2013.

The principal limitation of the present study is that the associations between risk factors and childhood body compositional disorder obesity are limited to BMI-z-scores and are cross-sectional. Observational studies of this kind cannot infer causality and residual confounders may exist. In addition, complexity in pathogenesis may not be appreciated in a large cohort study where data collection is constrained for logistic or economic reasons.

In conclusion, childhood overweight/obesity increases substantially between 2004 and 2013 in Jiaxing, South-east China. Among the risk factors evaluated in the present study, a better appetite and increased eating frequency are associated with a higher risk of childhood overweight/obesity.

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AUTHOR DISCLOSURES

No competing interests are reported.

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