Appetite 91 (2015) 248–255

Contents lists available at ScienceDirect

Appetite

journal homepage: www.elsevier.com/locate/appet

Research report

Prevalence of picky eating behaviour in Chinese school-age children and associations with anthropometric parameters and intelligence quotient. A cross-sectional study ☆

Yong Xue [a], Eva Lee [b], Ke Ning [a], Yingdong Zheng [c], Defu Ma [a], Hongchong Gao [d], Baoru Yang [e,a], Ying Bai [f], Peiyu Wang [a], Yumei Zhang [a,*]

[a] Department of Nutrition & Food Hygiene, School of Public Health, Peking University Health Science Center, 38 Xueyuan Road, Haidian District, Beijing 100191, China
[b] School of Medicine, University of California Los Angeles, Los Angeles, CA 90095, USA
[c] Department of Epidemiology & Biostatistics, School of Public Health, Peking University Health Science Center, Beijing 100191, China
[d] School of Clinical Medicine, Capital University of Medical Sciences, Beijing 100069, China
[e] Food Chemistry & Food Development, Department of Biochemistry, University of Turku, Turku 20014, Finland
[f] Dairy Research Institute, Inner Mongolia Mengniu Dairy (Group) Co. Ltd, Hohhot 011500, China

ARTICLE INFO

Article history:
Received 3 November 2014
Received in revised form 15 April 2015
Accepted 22 April 2015
Available online 28 April 2015

Keywords:
Picky eating
Chinese
Dietary intake
Growth and development
Intelligence

ABSTRACT

Previous studies have demonstrated the importance of eating behaviour regarding dietary variety and nutrient intake of children. However, the association between picky eating and growth of children is still a topic of debate. This study sought to estimate the prevalence of picky eating and to identify possible associations with the growth of school-age children in China. In this survey, 793 healthy children aged 7–12 years were recruited from nine cities and rural areas in China using a multi-stage cluster sampling method. Data collected included socio-demographic information and parents' perceptions of picky eating using a structured questionnaire, nutrient intake using 24-hour dietary recall, weight and height using body measurements, and intelligence using the Wechsler Intelligence Scale for Children. Blood samples were collected and analysed for minerals. The prevalence of picky eating reported by parents was 59.3% in children. Compared with non-picky eaters, picky eaters had a lower dietary intake of energy, protein, carbohydrates, most vitamins and minerals, and lower levels of magnesium, iron, and copper in the blood ($p < 0.05$), and also had a 0.184 z-score lower in height for age (95% CI: −0.332, 0.036; $p = 0.015$), a 0.385 z-score lower in weight for age (95% CI: −0.533, −0.237; $p < 0.001$), a 0.383 z-score lower in BMI for age (95% CI: −0.563, −0.203; $p < 0.001$), and scored 2.726 points higher on the intelligence test (95% CI: 0.809, 4.643; $p = 0.006$) when adjusted for children's birth weight and food allergy, mothers' education, and family income. Picky eating behaviour towards meat, eggs and vegetables showed negative associations with growth. Picky eating behaviour is prevalent in school-age children in China and may have a negative effect on growth.

Abbreviations: α-TE, α-tocopherol equivalent; BAZ, body weight index for age Z-scores; BMI, body weight index; CI, confidence interval; EDTA, ethylene diamine tetraacetic acid; HAZ, height for age Z-scores; Hb, haemoglobin; IQ, intelligence quotient; MCV, mean corpuscular volume; NE, niacin equivalent; SD, standard deviation; SE, standard error; SEM, standard error of the mean; PIQ, performance intelligence quotient; RBC, red blood count; RE, retinol equivalent; VIQ, verbal intelligence quotient; WAZ, weight for age Z-scores; WISC-RC, The Chinese version of Wechsler Intelligence Scale for Children.

☆ *Acknowledgments:* The authors wish to thank all participants in our study. The investigation was supported by Mengniu Dairy Co. Ltd (Inner Mongolia, China). The study was carried out in cooperation with the School of Public Health at Suzhou University, Guangzhou University of Chinese Medicine, Zhengzhou University, and several other universities in China. The authors declare that they have no competing interests. YM. Z, PY. W, YD. Z, and Y. B conceived and led the study. K. N, HC. G, and DF. M coordinated data collection. Y. X, E. L, and BR. Y conducted the analyses and were the primary writers of the manuscript. All authors contributed to the interpretation of the data and the writing of the manuscript. All authors read and approved the final version of the manuscript.

* Corresponding author.
E-mail address: zhangyumei@bjmu.edu.cn (Y. Zhang).

http://dx.doi.org/10.1016/j.appet.2015.04.065

Introduction

Picky eating is characterised by an unwillingness to try new foods, a dislike of certain types of foods, and strong opinions about food preparation (Galloway, Fiorito, Lee, & Birch, 2005; Jacobi, Schmitz, & Agras, 2008; Shim, Kim, & Mathai, 2011), which result in eating small quantities and a limited variety of food, potentially impacting a child's growth (Goncalves, Moreira, Trindade, & Fiates, 2013; Li, Shi, Wan, Hotta, & Ushijima, 2001; Steyn, Nel, Nantel, Kennedy, & Labadarios, 2006). Further, it can result in long-term eating disorders in adolescence and early adulthood (Needham, Dwyer, Randall-Simpson, & Heeney, 2007; Woolston, 1983). Prevalence studies (Goh & Jacob, 2012; Jacobi et al., 2008; Mascola, Bryson, & Agras, 2010; Micali et al., 2011) of childhood picky eating have reported conflicting results, possibly due to inconsistencies in definitions and methods of assessment, as well as different age ranges of children studied. Very young children will express their food preferences through body language or non-linguistic verbalisations, while older children will become more autonomous towards food choices and preferences during their time at school, so that the parent perceives the rejection of food as being stronger as the child ages (Dovey, Staples, Gibson, & Halford, 2008). Some picky eating behaviour in very young children, from parents' subjective perceptions, may be due to neophobia, which is different from pickiness in older children. School-aged children are rapidly growing and have relatively high nutrient requirements; therefore, their eating habits are critical for optimal development. However, picky eating behaviour is relatively common during childhood while at school, with the prevalence ranging from 13% to 47% in developed countries (Goh & Jacob, 2012; Jacobi et al., 2008; Mascola et al., 2010). There is little information on picky eating of school-aged children in China.

Picky eating in early childhood has been shown to continue into mid-adolescence, which is associated with eating disorders, lasting fussy eating, and limited dietary variety in adolescence and adulthood (Kotler, Cohen, Davies, Pine, & Walsh, 2001; McDermott et al., 2010; Nicklaus, Boggio, Chabanet, & Issanchou, 2005). However, the influence of picky eating on the growth of children is still a topic of debate. One longitudinal study (Dubois, Farmer, Girard, Peterson, & Tatone-Tokuda, 2007) following 1498 children aged 2.5, 3.5, and 4.5 years in Québec found that picky eaters were twice as likely to be underweight at 4.5 years old than children who were never picky eaters. Contradictory findings (Mascola et al., 2010) from another longitudinal study with 120 children in the San Francisco Bay area followed from 2 to 11 years of age suggested no significant effects of picky eating behaviour on growth. These contradictory results might be due to differences in definitions and assessments of picky eating, and failing to adjust for various confounding factors including age, gender, birth weight of the child, and socio-demographics. At the same time, there is no study examining the correlations between picky eating and Chinese children's growth. Therefore, it would be of value to identify the correlation between picky eating and growth of school-age children in China.

Intellectual status is of critical importance for schoolchildren, and is often a major concern of parents. Previous studies (Benton, 2010; McAfee et al., 2012) indicated that nutrition during early childhood had long-lasting impacts on the intelligence of children. As the brain develops more quickly than the rest of the body, nutrient deficiency, especially protein, iodine, iron, zinc, folic acid, and vitamin B 12, at a critical stage of development may result in lasting changes in brain structure and, thus, intelligence (Benton, 2010). Picky eating characterised as the consumption of an inadequate variety and amount of food(s) may result in a long-lasting lower nutrient intake. However, nothing is known about the correlation between picky eating and intelligence of school-age children.

Picky eaters usually have a limited dietary variety and consume few fruits, vegetables, and meat rich in micronutrients (Shim et al., 2011). In addition, their intake of fats, fibre, protein and sweets is lower than that of non-picky eaters (Galloway et al., 2005). It is still unclear whether the impact of picky eating on height and weight depends on the types of food rejected by the picky eaters. A lower intake of vitamin E and C, and fibre was found in picky nine-year-old girls (Galloway et al., 2005); however, there is little information regarding the nutrient intake of Chinese school-aged picky eaters, not just picky girls. Long-lasting lower nutrient intake may result in nutrient deficiency, but there is also a lack of knowledge regarding the differences in micronutrients in the blood between picky eaters and non-picky eaters.

Therefore, this study was performed to estimate the prevalence of picky eating behaviour in school-aged children in China; to investigate possible associations between picky eating behaviour and children's anthropometric parameters and intelligence quotient, and to identify potential mechanisms from the viewpoint of nutrient intake and micronutrients in whole blood.

Subjects and methods

Study sample

Data for this study were collected between November 2011 and April 2012 from healthy school-age children in China. The study was approved by the Ethical Committee in Health Science Center at Peking University (NO.IRB00001052-11042). All participants gave their written and informed consent signed by their legal guardians. Using a multi-stage stratified cluster sampling method, 814 children aged 7–12 years were recruited. In the first stage, seven major cities and two villages were selected representing various geographic locations and different levels of economic development: Beijing, Guangzhou, Chengdu, Shenyang, Suzhou, Lanzhou, and Zhengzhou, one village in the plains and one village in the mountainous area in the suburb of Xingtai, Hebei province. In the second stage, considering the size and representativeness of the samples, one large primary school located in a semi-urban area within each city/village was selected. In the last stage, one class of the second-grade, and one class of the fourth-grade in each primary school was selected randomly, and all children within the classes selected were surveyed. The first and second stages were carried out with purposive sampling, and the third stage was carried out with random sampling. Inclusion criteria were an age of 7–12 years, no reported birth defects, such as congenital heart disease, hydrocephalus or deformity at birth, no reported infantile paralysis or thalassemia, and no on-going acute health problems such as a common cold or diarrhoea. Of the 814 children, 21 were excluded from the analysis of data because of missing physical measurements (10), blood samples (5), or a failure to complete the questionnaire (6).

Socio-demographics, anthropometry, intelligence and blood measurement

After determining eligibility, a research assistant contacted families and arranged a meeting with parents for a face-to-face interview. The socio-demographic information was collected from the parents with a structured questionnaire survey (mothers: 95.8% of parents), and was administered by trained interviewers. Demographic data included child's date of birth, gender, ethnicity, and birth weight, and parents' educational level – 1) illiteracy; 2) primary school; 3) middle school; 4) senior high school; 5) college; 6) graduate or above – as well as family income (per capita monthly income) – 1) below 2000 Yuan; 2) 2000–4000 Yuan; 3) above 4000 Yuan; 4) unclear. Data on child's food allergy history and parents' body weight and height were also collected from the interview.

In every primary school, two well-trained researchers measured children's height and weight, respectively. The participants were asked to remove all heavy clothes and shoes, and to leave on only minimal clothing in a comfortable preparation area. Weight was taken to the nearest 0.1 kg on a calibrated electronic scale (EKS 7028; BEAVER INTERNATIONAL HOLDING Ltd., Hong Kong, China), and standing height was taken to the nearest 0.1 cm using a calibrated height measuring tape (SECA 206; SECA Ltd., Hamburg, Germany) suspended from the wall. For the measurement of height, the participants were required to stand erect with the shoulders level, hands by their sides, thighs and heels held comfortably together, and the upper backs, buttocks, and heels comfortably in contact with the wall. All physical measurements were carried out three times, and the mean values were calculated.

The Chinese version of Wechsler Intelligence Scale for Children (WISC-RC) was used to evaluate intelligence. The Chinese version has shown good reliability and validity (Li, Jin, Vandenberg, Zhu, & Tang, 1990), and has been used widely to measure the general intelligence of schoolchildren in China (Liu & Wang, 2002; Shang & Tang, 2010; Xing et al., 2014; Yang, Liu, & Townes, 1994). Eight investigators trained by child psychologists from Beijing Normal University administered the tests. The results of five verbal subtests reflecting verbal skills and crystallised intelligence, and five performance subtests measuring visual–spatial skills and fluid intelligence, were combined to form VIQ and PIQ (verbal and performance IQ), respectively. In the end, the results of all 10 subtests were combined to produce a Full Scale IQ (FIQ).

Blood samples were collected from all the participants in the morning before breakfast for the measurement of minerals and haemoglobin. The samples were drawn *via* venepuncture. A blood sample of 1 mL was collected into one metal-free Heparin-treated tube for blood routine examination. Haematological parameters, including red blood count (RBC), mean corpuscular volume (MCV), and haemoglobin (Hb) were performed using a haematology analyser (HF-3800; HANFANG Ltd., Jinan, China). Another 2 mL was collected into a metal-free, EDTA-treated tube for the measurement of minerals. The concentration of calcium, copper, iron, magnesium, and zinc in the blood were measured with a BOHUI 5100S atomic absorption spectrophotometer (BOHUI INNOVATION Ltd., Beijing, China) using hollow cathode lamps (422.7, 285.2, 248.3, 213.9, and 324.7 nm for Ca, Mg, Fe, Zn, and Cu, respectively), and all blood analyses were performed in the same laboratory (LAWKE HEALTH LAB CENTER., Beijing, China).

Variables for picky eating reported by parents

In the current study, we defined a picky eater as a child who consumes an inadequate variety and amount of food(s) through rejection of foods that were familiar (and unfamiliar) to them. The definition was provided to parents before the picky eating assessment, and parent's perceptions were used to judge if their child was a "picky eater". The parent (usually the mother) was asked, "Do you consider your child as having picky eating behaviour?" with three response categories: 1) never picky, 2) somewhat picky, and 3) always picky. Unless she chose "never picky", her child was qualified as a picky eater. A previous review (Dovey et al., 2008) about picky eating indicated that differences in measuring the "picky" construct would only lead to further confusion and problematic theoretical interpretations; therefore, our single question was chosen based on observations from previous studies to keep the construct consistent (Carruth, Ziegler, Gordon, & Barr, 2004; Goh & Jacob, 2012; Jacobi, Agras, Bryson, & Hammer, 2003; Jacobi et al., 2008; Mascola et al., 2010). At the same time, another previous study (Jacobi et al., 2003) had shown that behavioural measures of picky eating were highly correlated with maternal perceptions of picky eating. Unless the parent chose "never picky", she was asked to describe the age of onset and duration of picky eating behaviour (open-ended numeric questions). Rejection of food is one of the key aspects of picky eating behaviour (Dovey et al., 2008): therefore, the parent of the picky eater indicated which specific subgroups of food (response categories: milk and milk products, soy and soy products, cereal and cereal products, vegetables, fruits, meat, eggs, and others) were disliked by the child.

Dietary measurement

The school-age children's nutrient intake was determined based on the dietary data collected on weekdays. Before the dietary survey, some food models and a series of pictures of standard bowls and spoons were shown and explained to help the parent identify and quantify the food intake of the child. Trained and experienced interviewers coached the parent to carefully recall the type of meal, place of consumption, types, and amounts of all food items during the previous 24 hours (the same day for the children in the same research area). The parent was encouraged to provide additional information to determine the overall makeup and amounts of particular food items in dishes consumed in the household. Information about milk and milk products intake was collected including the type, brand name, manufacturer, and volume of actual consumption. Considering that some school-aged children might have meals at school or elsewhere (mostly at home), interviewers had to complete the collection of dietary data from the children. Energy, protein, fat, carbohydrates, dietary fibre, and micronutrients were estimated by the China Food Composition Database (2004) (Yang, Wang, & Pan, 2005), which covers 757 food items. If the children were taking dietary supplements, parents were asked to supply the basic supplement information, including the brand name, manufacturer, and daily dosage, in order to estimate nutrient intake through the dietary supplements.

Statistical analysis

The database was established by using Epi Data version 3.0, and a double data entry was carried out. We used mean values ± standard deviations or percentages to describe the baseline characteristics of participants. Between categorical data, comparisons were made using Pearson's χ^2 test. Student's t-test was used for the analysis of normally distributed data. According to the US CDC Growth Standards, we calculated height for age z-scores (HAZ), weight for age z-scores (WAZ), and body weight index for age z-scores (BAZ) of the participants using Epi Info 7. Because the multilevel model accounts for the clustering of the data and can correct biases in parameter estimates and produce correct CIs and significance tests, we used the statistical software MLwiN 2.31 to construct multilevel (two levels) mixed-effects linear regression models with different investigation areas (level 1: seven cities and two rural villages) nested within individuals (level 2) to identify associations between picky eating and children's height, weight, BMI (body weight index), HAZ, WAZ, BAZ, and IQ, and associations between different food subgroups disliked by picky eaters and HAZ, WAZ, and BAZ of children. All of the regression analyses were adjusted to eliminate the impact of the following potential confounders: child's age and birth weight (continuous variables), child's gender (male, female) and food allergy history (yes, no, unclear), mother's education (middle school or below, high school, college or above), family's per capita monthly income (<2000 Yuan, 2000–4000 Yuan, >4000 Yuan, unclear), and other covariates listed below each table. The regression coefficients were expressed by β, SEM and the 95% CI in comparison between picky eating and nonpicky eating groups. The Kolmogorov–Smirnov test was used to determine whether nutrient intake, haemoglobin, and minerals in the blood were normally distributed. Because the data did not follow a normal distribution, medians (interquartile range) were used to describe the continuous variables, and nonparametric Mann–Whitney U two-sample tests (continuous variables) were used to compare differences between the two groups. Before analysis of multilevel mixed-effects linear regression (level 1: investigation areas; level 2:

individuals), the natural logarithm was applied to normalise the data, and the analyses were adjusted for various variables in two models (adjusted factors in model 1: child's age and gender; adjusted factors in model 2: child's age, gender, and birth weight, mother's education, and family income). All of the analyses, except multilevel analyses, were carried out using version SPSS 20.0 (SPSS Inc. Chicago, Illinois, USA), all tests were two-tailed, and statistical significance was set at $p < 0.05$.

Results

Among the 814 healthy school-aged children meeting the inclusion criteria, 793 completed the questionnaire and had their blood samples collected. Of the final study population, 323 (40.7%) children were non-picky eaters and 470 (59.3%) were picky eaters based on parent's perceptions.

Socio-demographic information of the participants and their mothers is summarised in Table 1. There were no significant differences in mothers' heights, BMIs, or family's per capita monthly income between the picky eating and non-picky eating groups. The mothers in the picky eating group were younger ($p < 0.001$), weighed less ($p = 0.026$), and had lower educational levels ($p = 0.017$) than those in the non-picky eating group. Compared with non-picky eaters, picky eaters were younger ($p = 0.003$). There were no statistically significant differences in birth weight, ethnicity, and gender of the children between the two groups. Though a significant difference in food allergy history was found between the two groups, there was no significant difference between the participants in their perceptions of food allergy history ($\chi^2 = 3.095$, $p = 0.079$). The total rate of dietary supplements intake in picky eating group was significantly higher than that in non-picky eating group ($p = 0.014$).

Crude and adjusted linear regression analyses indicated that children in the picky eating group had significantly lower anthropometric measures, including height, weight, and BMI compared with the non-picky eating group ($p < 0.01$). Picky eating behaviour was associated with a reduction of 1.294 cm in height (95% CI: –2.267, –0.321; $p = 0.009$), 2.857 kg in weight (95% CI: –3.993, –1.721; $p < 0.001$), and 1.198 kg/m^2 in BMI (95% CI: –1.653, –0.743; $p < 0.001$). As for z-scores, lower height for age, weight for age, and BMI for age were found in the picky eating group from crude and adjusted linear regression analyses ($p < 0.05$) (Table 2). Regarding z-score, picky eaters had a reduction of 0.184 in height for age (95% CI: –0.332, 0.036; $p = 0.015$), 0.385 in weight for age (95% CI: –0.533, –0.237; $p < 0.001$), and 0.383 in BMI for age (95% CI: –0.563, –0.203; $p < 0.001$) compared with the non-picky eaters. The mean score of intelligence in the picky eating group was higher by 2.726 than the corresponding value in the non-picky eating group (95% CI: 0.809, 4.643; $p = 0.006$).

There was a considerable variation in duration of picky eating behaviour among the subjects. Picky eating lasted 0–3 years in 84 (17.9%) participants, 3–6 years in 194 (41.3%) participants, and over six years in 141 (30.0%) participants. Figure 1 shows the z-scores of non-picky eaters and picky eaters with different durations of picky eating behaviour. Compared with the non-picky eating group, those with over six years of picky eating had lower z-scores for height for age, weight for age, and BMI for age ($p = 0.009$, $p < 0.001$, $p = 0.005$, respectively), while those with 3–6 years had lower z-scores for height for age, weight for age, and BMI for age ($p = 0.024$, $p < 0.001$, $p < 0.001$). Additionally, children with 0–3 years of picky eating behaviour had a lower weight for age and BMI for age ($p = 0.033$, $p = 0.015$, respectively). The duration of picky eating behaviour seemed to be negatively associated with z-scores of height for age, weight for age, and BMI for age.

To detect the correlations between picky eating of different kinds of food and children's z-scores, adjusted linear regression analyses were used, and all subgroups of picky eating were compared with the non-picky eating group. The results are shown in Table 3. The foods disliked by the picky eaters were vegetables (51.1% of the picky eaters), soy (27.9%), meat (25.7%), eggs (21.7%), cereal (19.4%), milk (13.0%), sweet foods (11.1%), and fruits (9.8%). Compared to the non-picky eaters, the picky eaters disliking vegetables had reduced z-scores by 0.216 in height for age (95% CI: –0.375, –0.057; $p = 0.008$) and 0.229 in weight for age (95% CI: –0.385, –0.073; $p = 0.004$). The z-scores of children avoiding meat were lower by 0.259 in height for age (95% CI: –0.459, –0.059; $p = 0.011$), 0.513 in weight for age (95% CI: –0.709, –0.317; $p < 0.001$), and 0.562 in BMI for age (95% CI: –0.803, –0.321; $p < 0.001$). Picky eaters disliking eggs had lower z-scores in height for age (by 0.238, 95% CI: –0.458, –0.018; $p = 0.034$), in weight for age (by 0.379, 95% CI: –0.595, –0.163; $p = 0.001$), and in BMI for age (by 0.338, 95% CI: –0.603, –0.073; $p = 0.013$). No significant association was found between z-scores and avoidance of other foods such as milk, soy, cereal, fruits, and sweet foods ($p > 0.05$).

The results of dietary nutrient intake from the 24-hour diet recall are provided in Table 4. Crude and adjusted linear regression analyses indicated that children in the picky eating group had a lower intake of energy, protein, carbohydrates, and dietary fibre ($p < 0.05$) when compared with the non-picky eating group. In the case of vitamins, including vitamin A, thiamine, riboflavin, vitamin C, and vitamin E, picky eaters had significantly lower intakes compared with non-picky eaters ($p < 0.05$), but niacin intake was not significantly lower in the picky eater group. Compared with the non-picky eating group, the picky eating group had significantly lower intakes of calcium, magnesium, iron, zinc, and copper ($p < 0.01$) as seen from the crude and adjusted linear regression analyses.

Table 1
Socio-demographic characteristics of mother–child dyads of the study population.

	Non-picky eating (n = 323)	Picky eating (n = 470)	p value
Mother's characteristics			
	mean ± SD[b]	mean ± SD[b]	
Age, year[a]	36.8 ± 4.9	35.4 ± 4.4	<0.001
Height, cm	161.2 ± 4.8	160.8 ± 5.4	0.302
Weight, kg[a]	59.1 ± 8.7	57.7 ± 8.7	0.026
BMI, kg/m^2	22.7 ± 3.1	22.3 ± 3.3	0.075
	n (%)	n (%)	
Education[a]			0.017
Middle school or below	186 (57.6)	266 (56.6)	
High school	94 (29.1)	170 (36.2)	
College or above	36 (11.1)	29 (6.2)	
Unclear	7 (2.2)	5 (1.1)	
Per capita monthly income, Yuan			0.311
<2000	159 (49.2)	209 (44.5)	
2000–4000	73 (22.6)	124 (26.4)	
>4000	39 (12.1)	70 (14.9)	
Unclear	52 (16.1)	67 (14.3)	
Child's characteristics			
	mean ± SD[b]	mean ± SD[b]	
Age, year[a]	9.6 ± 1.7	9.2 ± 1.7	0.003
Birth weight, kg	3.4 ± 0.5	3.4 ± 0.6	0.551
	n (%)	n (%)	
Ethnicity			0.672
Han	315 (97.5)	456 (97.0)	
Others	7 (2.5)	14 (3.0)	
Gender			0.434
Male	162 (50.2)	249 (53.0)	
Female	161 (49.8)	221 (47.0)	
Food allergy[a]			0.002
Yes	21 (6.5)	43 (9.2)	
No	263 (81.4)	331 (70.4)	
Unclear	39 (12.1)	96 (20.4)	
Dietary supplement[a]			0.014
Yes	267(82.7)	354(75.3)	
No	56(17.3)	116(24.7)	

[a] Indicates significant differences between non-picky and picky eating groups, $p < 0.05$.
[b] SD = standard deviation.

Table 2
Comparison of anthropometric parameters and IQ between picky and non-picky eating groups of school-aged children.

	Non-picky eating[a] (n = 323)	Picky eating[a] (n = 470)	*p* value	Adjusted[b] β[c]	SEM	95% confidence interval	Adjusted *p* value
Height, cm	138.0 ± 11.2	135.0 ± 11.2	<0.001	−1.294	0.497	−2.267, −0.321	0.009
HAZ	0.29 ± 1.16	0.13 ± 1.03	0.045	−0.184	0.076	−0.332, −0.036	0.015
Weight, kg	34.8 ± 11.4	31.0 ± 9.6	<0.001	−2.857	0.580	−3.993, −1.721	<0.001
WAZ	0.25 ± 1.17	−0.07 ± 1.09	<0.001	−0.385	0.075	−0.533, −0.237	<0.001
BMI, kg/m^2	17.9 ± 3.9	16.7 ± 3.0	<0.001	−1.198	0.227	−1.653, −0.743	<0.001
BAZ	0.09 ± 1.54	−0.22 ± 1.25	0.002	−0.383	0.092	−0.563, −0.203	<0.001
Intelligence, IQ	97.6 ± 17.2	101.4 ± 13.6	0.001	2.726	0.978	0.809, 4.643	0.006

[a] Values were given as Mean ± SE.
[b] All of the models were constructed using multilevel (two levels) mixed-effects linear regression with the iterative generalised least-squares estimation method. Results of the measurements from the regression models with adjustment for child's age, birth weight, gender (female, male), and food allergy history (yes, no, and unclear), mother's education (middle school or below, high school, college or above, and unclear), and family's per capita monthly income (<2000 Yuan, 2000–4000 Yuan, >4000 Yuan, and unclear). Results of z-scores from the regression models with adjustment for child's birth weight and food allergy history, mother's education, and family's per capita monthly income.
[c] β represents the difference in mean anthropometric parameters and IQ between non-picky and picky eating groups after adjusting for the covariates listed above.

The contents of haemoglobin and minerals in the blood are listed in Table 5. Compared to the non-picky eating group, children with picky eating habits did not have significantly lower haemoglobin ($p > 0.05$) from the adjusted linear regression analysis. There were no significant differences in minerals, including calcium and zinc, between the two groups ($p > 0.05$). However, picky eaters had lower magnesium, iron, and copper levels in the blood compared to non-picky eaters ($p < 0.05$).

Discussion

Previous studies (Goh & Jacob, 2012; Jacobi et al., 2008; Mascola et al., 2010) found that the prevalence of picky eating behaviour in children perceived by parents was common in different developed countries, which was linked to nutritional problems in children (Galloway et al., 2005; Jacobi et al., 2008; Shim et al., 2011). The prevalence of picking eating behaviour among Chinese

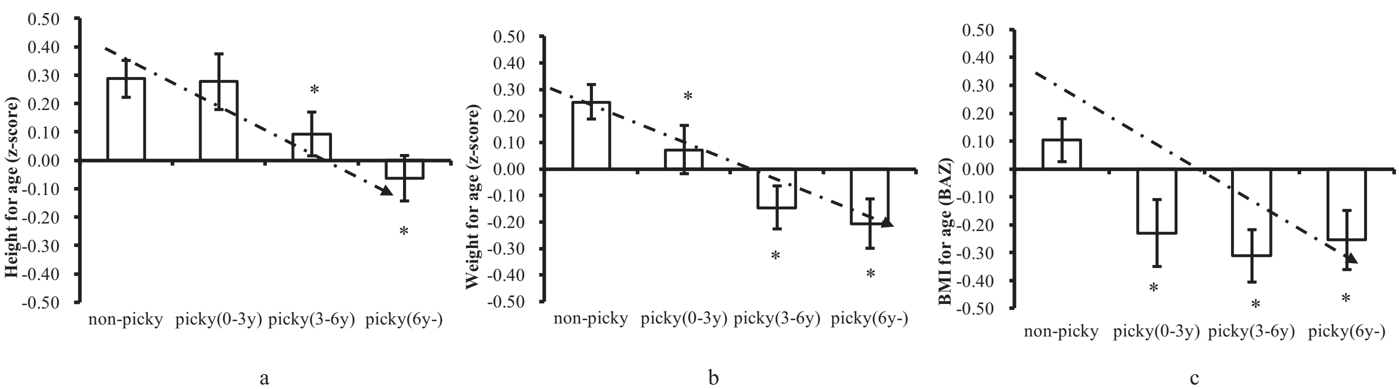

Fig. 1. Z-scores of schoolchildren with picky eating behaviour lasting different periods of time (means and standard errors). (a) Height for age (z-score); (b) Weight for age (z-score); (c) BMI for age (z-score). *Indicates significant differences between non-picky and picky eating groups ($p < 0.05$). All of the models were constructed using multilevel (two levels) mixed-effects linear regression with the iterative generalised least-squares estimation method, which were adjusted for child's birth weight and food allergy history, mother's education, and family's per capita monthly income.

Table 3
Influence of picky eating of different kinds of food by the picky eating group on z-scores of anthropometric parameters of school-aged children investigated in the study.

	N	HAZ			WAZ			BAZ		
		Adjusted[a] β[b] (95% CI)	SEM	Adjusted *p*	Adjusted[a] β[b] (95% CI)	SEM	Adjusted *p*	Adjusted[a] β[b] (95% CI)	SEM	Adjusted *p*
Milk	61	−0.083 (−0.359, 0.193)	0.141	0.554	−0.042 (−0.313, 0.229)	0.139	0.759	0.031 (−0.303, 0.365)	0.170	0.856
Soy	131	0.098 (−0.099, 0.295)	0.101	0.331	0.055 (−0.139, 0.249)	0.099	0.578	0.043 (−0.195, 0.281)	0.122	0.725
Cereal	91	0.036 (−0.190, 0.262)	0.115	0.757	−0.113 (−0.335, 0.109)	0.113	0.321	−0.194 (−0.467, 0.079)	0.139	0.165
Vegetables	240	−0.216 (−0.375, −0.057)	0.081	0.008	−0.229 (−0.385, −0.073)	0.080	0.004	−0.129 (−0.321, 0.063)	0.098	0.189
Fruits	46	0.154 (−0.155, 0.463)	0.158	0.328	0.120 (−0.184, 0.424)	0.155	0.439	0.043 (−0.331, 0.417)	0.191	0.821
Meat	121	−0.259 (−0.459, −0.059)	0.102	0.011	−0.513 (−0.709, −0.317)	0.100	<0.001	−0.562 (−0.803, −0.321)	0.123	<0.001
Sweet food	52	0.106 (−0.188, 0.400)	0.150	0.482	0.142 (−0.147, 0.431)	0.147	0.336	−0.018 (−0.373, 0.337)	0.181	0.920
Eggs	102	−0.238 (−0.458, −0.018)	0.112	0.034	−0.379 (−0.595, −0.163)	0.110	<0.001	−0.338 (−0.603, −0.073)	0.135	0.013

[a] All of the models were constructed using multilevel (two levels) mixed-effects linear regression with the iterative generalised least-squares estimation method. Results of the z-scores from the regression models with adjustment for child's birth weight and food allergy history (yes, no, and unclear), mother's education (middle school or below, high school, college or above, and unclear), family's per capita monthly income (<2000 Yuan, 2000–4000 Yuan, >4000 Yuan, and unclear) and other kinds of food related to children's growth listed above.
[b] β represents the difference in mean z-scores between non-picky and picky eating groups after adjusting for the covariates listed above.
CI, confidence interval.

Table 4
Daily dietary intake of energy, macronutrients, dietary fibre, minerals and vitamins of school-age children investigated in the study.

	Non-picky eating (n = 323)		Picky eating (n = 470)		Unadjusted *p* value[a]	Adjusted *p* value[b]	Adjusted *p* value[c]
	Median	(25th, 75th)	Median	(25th, 75th)			
Energy (kcal)	1470.14	(1192.15, 2028.70)	1297.15	(974.61, 1803.82)	<0.001	0.006	0.004
Protein (g)	54.93	(38.48, 72.52)	46.23	(30.83, 63.37)	<0.001	0.001	0.001
Fat (g)	56.90	(41.38, 77.36)	49.58	(33.79, 68.01)	<0.001	0.077	0.065
Carbohydrate (g)	198.38	(139.86, 298.23)	169.03	(119.29, 251.84)	<0.001	0.015	0.011
Dietary fibre (g)	6.37	(4.23, 11.58)	5.03	(3.23, 8.72)	<0.001	0.002	<0.001
Vitamin A (μg RE[d])	294.48	(165.25, 430.03)	228.91	(114.90, 377.73)	0.001	0.034	0.027
Thiamine (mg)	0.60	(0.42, 0.93)	0.49	(0.34, 0.76)	<0.001	0.004	0.003
Riboflavin (mg)	0.76	(0.51, 1.05)	0.65	(0.44, 0.90)	<0.001	0.005	0.003
Niacin (mg NE[e])	11.28	(6.82, 16.43)	9.16	(5.55, 13.51)	<0.001	0.054	0.049
Vitamin C (mg)	52.63	(27.69, 100.10)	35.73	(17.08, 67.50)	<0.001	0.004	0.004
Vitamin E (mg α-TE[f])	19.26	(12.84, 26.31)	16.40	(11.61, 23.61)	0.001	0.033	0.024
Calcium (mg)	330.47	(193.01, 544.88)	288.70	(156.60, 470.93)	<0.001	0.010	0.006
Magnesium (mg)	208.86	(151.03, 284.16)	173.20	(120.66, 233.95)	<0.001	0.001	<0.001
Iron (mg)	14.72	(11.00, 22.02)	12.58	(9.01, 18.06)	<0.001	0.002	<0.001
Zinc (mg)	7.54	(5.51, 10.61)	6.61	(4.62, 8.94)	<0.001	<0.001	<0.001
Copper (mg)	1.19	(0.85, 1.91)	1.01	(0.67, 1.39)	<0.001	<0.001	<0.001

All of the models were constructed using multilevel (two levels) mixed-effects linear regression with the iterative generalised least-squares estimation method.
[a] Comparisons of nutrient intake between non-picky and picky eating groups using Mann–Whitney U tests.
[b] Model 1 adjusted for child's age and gender.
[c] Model 2 adjusted for child's age, gender (female, male), birth weight, and food allergy history (yes, no, and unclear), mother's education (middle school or below, high school, college or above, and unclear), and family's per capita monthly income (<2000 Yuan, 2000–4000 Yuan, >4000 Yuan, and unclear).
[d] Retinol equivalent.
[e] Niacin equivalent.
[f] α-Tocopherol equivalent.

school-aged children has not been reported previously. Furthermore, it is still a topic of debate whether picky eating behaviour significantly influences growth in children (Carruth & Skinner, 2000; Dubois, Farmer, Girard, & Peterson, 2007; Marchi & Cohen, 1990; Wright & Birks, 2000; Wright, Parkinson, Shipton, & Drewett, 2007). To study the prevalence of picky eating among Chinese children of school-age and to verify the relationship between picky eating behaviour and children's anthropometric parameters and intelligence quotient, 793 healthy school-aged children between the ages of seven and twelve were recruited by a multi-stage stratified cluster sampling method. Socio-demographic information, anthropometry, intelligence, nutrient intake from a 24-hour diet recall, and blood samples were collected and analysed.

Picky eating is considered to be a complex behaviour (Goh & Jacob, 2012; Jacobi et al., 2008; Mascola et al., 2010; Micali et al., 2011), which is hard to quantify accurately in childhood. Picky eaters are usually defined as children who consume an inadequate variety of foods through rejection of some foods because of preparation methods, flavour or texture. This definition also includes consumption of an inadequate amount of food (Dovey et al., 2008; Rydell, Dahl, & Sundelin, 1995), which is in line with the definition of picky eating behaviour applied in the current study. Picky eating has been disparately measured in different papers using the Child Feeding Questionnaire (Dovey et al., 2008; Mascola et al., 2010) or a single question about parents' perceptions of picky eating behaviour. In the current study, parents' perceptions were used as the judgement of a "picky eater", which was kept consistent with previous studies (Carruth et al., 2004; Goh & Jacob, 2012; Jacobi et al., 2003, 2008; Mascola et al., 2010) to reduce the confusion of the concept.

In the current study, the prevalence of picky eaters was over 59% in the study population, which is higher than the prevalence reported in a study conducted with children aged 1–10 years in Singapore (Goh & Jacob, 2012). The study reported that the child was always (25.1%) or sometimes (24.1%) a picky eater, and the prevalence of picky eating occurring "all the time" was 47.4%. Other studies have found rates ranging from 13 to 50% in developed countries (Carruth et al., 2004; Jacobi et al., 2008; Mascola et al., 2010), and 17% in rural areas of China (Li et al., 2001). The higher prevalence of picky eaters in this study might be due to several factors. Compared with infants, toddlers, and pre-schoolers, preferences towards foods are more certain and clearly expressed with linguistic verbalisations in school-aged children, which results in parents more strongly perceiving picky eating. At the same time, the population of picky eaters included "somewhat" picky eaters and "always" picky eaters, and someone with a few aspects of picky

Table 5
Comparison of mean concentrations of haemoglobin and minerals in the blood of school-age children investigated in the study.

	Non-picky eating (n = 323)		Picky eating (n = 470)		Unadjusted *p* value[a]	Adjusted *p* value[b]	Adjusted *p* value[c]
	Median	(25th, 75th)	Median	(25th, 75th)			
Haemoglobin (g/L)	131	(125, 135)	129	(124, 134)	0.021	0.060	0.071
Calcium (mmol/L)	1.68	(1.61, 1.82)	1.70	(1.63, 1.81)	0.281	0.956	1.000
Magnesium (mmol/L)	1.48	(1.40, 1.60)	1.45	(1.36, 1.54)	<0.001	<0.001	<0.001
Iron (mmol/L)	8.11	(7.52, 8.68)	7.89	(7.39, 8.41)	<0.001	0.007	0.014
Zinc (μmol/L)	81.3	(77.8, 87.8)	79.5	(76.9, 84.2)	<0.001	0.721	1.000
Copper (μmol/L)	14.2	(13.0, 15.6)	14.0	(12.8, 15.4)	0.384	0.044	0.028

All of the models were constructed using multilevel (two levels) mixed-effects linear regression with the iterative generalised least-squares estimation method.
[a] Comparison of haemoglobin and minerals between non-picky and picky eating groups using Mann–Whitney U tests.
[b] Model 1 adjusted for child's age and gender.
[c] Model 2 adjusted for child's age, gender (female, male), birth weight, and food allergy history (yes, no, and unclear), mother's education (middle school or below, high school, college or above, and unclear), and family's per capita monthly income (<2000 Yuan, 2000–4000 Yuan, >4000 Yuan, and unclear).

eating behaviour might be reported as a picky eater with high attention focused on children's dietary habits in urban areas.

In the current study, we found that mothers of picky eaters were younger, weighed less and were less educated compared to mothers of non-picky eaters. With the rapid economic development of China, the cultural contracture and lifestyle is experiencing great change (Dearth-Wesley, Wang, & Popkin, 2008), and more young women pursue fashion through dieting or picky eating to control weight. Familial eating habits play a key role in children's diets; family members impart examples of eating habits and influence access to foods at home (Gillman et al., 2000). Therefore, the children of younger mothers who weigh less might slip into poor eating habits, including picky eating, more easily. At the same time, older and more educated mothers might pay more attention to children's eating behaviours and provide them with a better selection of fruits and vegetables (Dubois, Farmer, Girard & Peterson, 2007). More research is required to obtain a thorough understanding of the effects of environmental factors on picky eating.

There are a number of studies that have examined the possible effects of picky eating on children's growth, but results reported so far are inconsistent. By assessing eating behaviour at 2.5, 3.5, and 4.5 years of age, and measuring weight and height at 4.5 years of age in a longitudinal study of 1498 children, Dubois, Farmer, Girard, Peterson, and Tatone-Tokuda (2007) found that children who were picky eaters were twice as likely to be underweight at 4.5 years old than children without any history of picky eating behaviour. In another prospective study (Mascola et al., 2010), 120 children were followed from two to 11 years of age, and height and weight were assessed from when they were 2–7 years old, and at 9.5 and 11-years of age. No significant effects of picky eating behaviour on growth were observed. Wright et al. (2007) conducted a cross-sectional analysis of 455 children who were 30 months old. Picky eating was only weakly associated with poor growth as measured by weight and z-scores of weight (the United Kingdom 1990 growth reference). Children with picky eating behaviours were slightly lighter and shorter than non-picky eaters were, but the differences were not statistically significant. Inconsistent results might be due to the samples with different age ranges. Few previous studies with large populations were focused on school-aged children; essentially, the effects of picky eating on children's growth may appear more and more obvious as the child ages, given that picky eaters of longer duration have much stronger preferences (Mascola et al., 2010) and a greater deficit in the variety of food consumed than picky eaters of a shorter duration and non-picky eaters. Our results from crude and adjusted linear regression analyses suggested that picky eating behaviour was associated with the growth of school-aged children, even when using z-scores, and the effects would become more pronounced with longer durations of picky eating. Overall, more longitudinal studies with large populations are needed to verify the negative effects of picky eating behaviour on children's growth.

Few studies have investigated problematic eating behaviours and intelligence of school-aged children. The findings of the present study indicated that there was a significant association between picky eating behaviour and intelligence. More specifically, contrary to our hypothesis, the picky eaters' IQ scores were significantly higher than non-picky eaters' IQs. Dietary supplements enriched with vitamins, minerals, and other substances are increasingly consumed worldwide to help some children meet their nutritional needs (Chen, Binns, Maycock, Liu, & Zhang, 2014; Marra & Boyar, 2009). Parents' perceptions of picky eaters' lower nutrient intake may prompt them to purchase dietary supplements for children. Thus, it is possible that higher IQ scores in picky eaters is attributed to the possibility of taking food supplements including zinc, iron, multi-vitamins/minerals, fish oil, etc. Actually, the total rate of dietary supplements intake in the picky eating group was significantly higher when compared with the non-picky eating group in the present study, and the single rate of iron supplements was also higher than that in the non-picky eating group (4.7% vs 1.5%). Considering that picky eating behaviour shows up protective effect for overweight (Galloway et al., 2005), and obesity can lower children's IQ by harming key brain regions and functions that support the IQ (Galvan, Uauy, Lopez-Rodriguez, & Kain, 2014; Yu, Han, Cao, & Guo, 2010), another potential mechanism of higher IQ in picky eating group may be partly due to less possibility of overweight or obesity. However, this relationship requires further investigation to disentangle the possible hereditary, nutrimental, and environmental causal pathways of these mechanisms.

Picky eating behaviour characterised by a lower intake and a limited variety of foods, especially vegetables and fruits, draws the attention of parents. However, it is still unknown which subgroups of food play critical roles in the growth of picky eaters. The findings of the present study indicated that a disliking of vegetables, meat, and eggs had significant negative associations with growth. Given that lower levels of energy, protein, dietary fibre, thiamine, vitamin C, magnesium, zinc, and copper were found in picky eaters disliking vegetables (Table S1), lower protein, dietary fibre, thiamine, riboflavin, niacin, vitamin C, iron, zinc, and copper were found in picky eaters disliking meat (Table S2), and lower levels of vitamin A, vitamin C, calcium, zinc, and copper were found in picky eaters disking eggs (Table S3), parents should pay more attention when picky eaters reject vegetables, meat, and eggs than when they reject other food subgroups.

There have been several studies (Fortunato & Scheimann, 2008; Galloway et al., 2005; Galloway, Lee, & Birch, 2003; Powell, Farrow, & Meyer, 2011; Shim et al., 2011) that reported a lower intake of nutrients in picky eaters. Galloway et al. (2005) found that picky eaters consumed less food rich in vitamin E, vitamin C, folate, and fibre, especially when they consumed fewer fruits and vegetables than non-picky eaters did. In the current study, a lower intake of energy, protein, carbohydrates and dietary fibre were found in the picky eating group. Meat and eggs, and vegetables are important sources of energy, protein, and fibre, respectively. However, 25.7%, 21.7%, and 51.1% of picky eaters disliked the above-mentioned foods, respectively. It is possible that a lower intake of energy, protein and dietary fibre were due to limited vegetable, meat, and egg intake. We also found a lower intake of micronutrients, including vitamin A, thiamine, riboflavin, vitamin C, vitamin E, calcium, magnesium, iron, zinc, and copper, in the picky eating group when compared with the non-picky eating group. Severe and chronic inadequacies in the intake of these micronutrients may lead to an decrease in blood levels, and may even result in damage to cells, alteration in immune functions, digestive problems, and even developmental delays in growing children (Dovey et al., 2008, 2008; Hashizume et al., 2005). Importantly, in comparison with the situation of the non-picky eaters, lower levels of magnesium, iron and copper in the blood were found in the picky eating group, which may, over the long-term, have a major impact on the anthropometric parameters of children.

This study has several limitations. Firstly, it was difficult to quantify accurately picky eating behaviour in school-aged children based on the perceptions of parents. Differences exist in judgement and perception of picky eating, which may have affected the results to some extent. Although a strict definition was given, and quality control efforts were made in our study, some children still may have been misclassified because of self-report and subjective measures, thus emphasising the importance of a more applicable psychometric tool for future research. Secondly, although significant associations between picky eating behaviour and children's growth and nutrient intake have been found in other studies, our cross-sectional study design did not provide direct evidence ofcausality. A longitudinal study with a larger sample size and consideration of potential confounders needs be carried out in the future. Thirdly, although a number of socio-demographic characteristics were controlled, other potential covariates, such as parenting style, food environment at home, and fashion-seeking psychology, were not taken into account. These additional factors might have also affected the outcome of the study (Cooke et al., 2004; Dovey et al., 2008; Nicklas et al., 2001). Fourth, the 24-hour dietary recall questionnaire is widely used to assess children's nutrient intake (Carruth et al., 2004; Galloway et al., 2003, 2005), but it is difficult to accurately estimate individual's daily diets because of variability, and nutrients of some food items with commercial package have to be replaced by mean value of corresponding type because of missing detailed information, especially for milk. Arrangements for quality control, including trained researchers, face-to-face interviews, food pictures, and models, were used in the present study to minimise this.

Conclusions

This study suggests that picky eating is a public health problem of high prevalence in school-aged children in China. Compared with non-picky eaters, picky eaters have a lower intake of energy, protein, dietary fibre, riboflavin, and some minerals, and lower levels of microelements in the blood, which may explain the negative associations between picky eating and the growth of children, especially in those disliking meat, eggs, and vegetables. Nutritional guidance for parents is necessary in order to obtain a healthier eating pattern in school-aged children and to address the potential needs of nutritional supplements in children. Various factors contributing to picky eating behaviour, such as diet, family, and socioeconomic background, should be thoroughly studied in the future.

References

Benton, D. (2010). The influence of dietary status on the cognitive performance of children. *Molecular Nutrition and Food Research*, *54*(4), 457–470.
Carruth, B. R., & Skinner, J. D. (2000). Revisiting the picky eater phenomenon. Neophobic behaviors of young children. *Journal of the American College of Nutrition*, *19*(6), 771–780.
Carruth, B. R., Ziegler, P. J., Gordon, A., & Barr, S. I. (2004). Prevalence of picky eaters among infants and toddlers and their caregivers' decisions about offering a new food. *Journal of the American Dietetic Association*, *104*(1 Suppl. 1), s57–s64.
Chen, S., Binns, C. W., Maycock, B., Liu, Y., & Zhang, Y. (2014). Prevalence of dietary supplement use in healthy pre-school Chinese children in Australia and China. *Nutrients*, *6*(2), 815–828.
Cooke, L. J., Wardle, J., Gibson, E. L., Sapochnik, M., Sheiham, A., & Lawson, M. (2004). Demographic, familial and trait predictors of fruit and vegetable consumption by pre-school children. *Public Health Nutrition*, *7*(2), 295–302.
Dearth-Wesley, T., Wang, H., & Popkin, B. M. (2008). Under- and overnutrition dynamics in Chinese children and adults (1991–2004). *European Journal of Clinical Nutrition*, *62*(11), 1302–1307.
Dovey, T. M., Staples, P. A., Gibson, E. L., & Halford, J. C. (2008). Food neophobia and 'picky/fussy' eating in children. A review. *Appetite*, *50*(2–3), 181–193.
Dubois, L., Farmer, A., Girard, M., Peterson, K., & Tatone-Tokuda, F. (2007). Problem eating behaviors related to social factors and body weight in preschool children. A longitudinal study. *The International Journal of Behavioral Nutrition and Physical Activity*, *4*, 9.
Dubois, L., Farmer, A. P., Girard, M., & Peterson, K. (2007). Preschool children's eating behaviours are related to dietary adequacy and body weight. *European Journal of Clinical Nutrition*, *61*(7), 846–855.
Fortunato, J. E., & Scheimann, A. O. (2008). Protein-energy malnutrition and feeding refusal secondary to food allergies. *Clinical Pediatrics*, *47*(5), 496–499.
Galloway, A. T., Fiorito, L., Lee, Y., & Birch, L. L. (2005). Parental pressure, dietary patterns, and weight status among girls who are "picky eaters". *Journal of the American Dietetic Association*, *105*(4), 541–548.
Galloway, A. T., Lee, Y., & Birch, L. L. (2003). Predictors and consequences of food neophobia and pickiness in young girls. *Journal of the American Dietetic Association*, *103*(6), 692–698.
Galvan, M., Uauy, R., Lopez-Rodriguez, G., & Kain, J. (2014). Association between childhood obesity, cognitive development, physical fitness and social-emotional wellbeing in a transitional economy. *Annals of Human Biology*, *41*(2), 99–104.
Gillman, M. W., Rifas-Shiman, S. L., Frazier, A. L., Rockett, H. R., Camargo, C. J., Field, A. E., et al. (2000). Family dinner and diet quality among older children and adolescents. *Archives of Family Medicine*, *9*(3), 235–240.
Goh, D. Y., & Jacob, A. (2012). Perception of picky eating among children in Singapore and its impact on caregivers. A questionnaire survey. *Asia Pacific Family Medicine*, *11*(1), 5.
Goncalves, J. A., Moreira, E. A., Trindade, E. B., & Fiates, G. M. (2013). Eating disorders in childhood and adolescence. *Revista Paulista de Pediatria*, *31*(1), 96–103.
Hashizume, M., Chiba, M., Shinohara, A., Iwabuchi, S., Sasaki, S., Shimoda, T., et al. (2005). Anaemia, iron deficiency and vitamin A status among school-aged children in rural Kazakhstan. *Public Health Nutrition*, *8*(6), 564–571.
Jacobi, C., Agras, W. S., Bryson, S., & Hammer, L. D. (2003). Behavioral validation, precursors, and concomitants of picky eating in childhood. *Journal of the American Academy of Child and Adolescent Psychiatry*, *42*(1), 76–84.
Jacobi, C., Schmitz, G., & Agras, W. S. (2008). Is picky eating an eating disorder? *The International Journal of Eating Disorders*, *41*(7), 626–634.
Kotler, L. A., Cohen, P., Davies, M., Pine, D. S., & Walsh, B. T. (2001). Longitudinal relationships between childhood, adolescent, and adult eating disorders. *Journal of the American Academy of Child and Adolescent Psychiatry*, *40*(12), 1434–1440.
Li, D., Jin, Y., Vandenberg, S. G., Zhu, Y. M., & Tang, C. H. (1990). Report on Shanghai norms for the Chinese translation of the Wechsler Intelligence Scale for Children-Revised. *Psychological Reports*, *67*(2), 531–541.
Li, Y., Shi, A., Wan, Y., Hotta, M., & Ushijima, H. (2001). Child behavior problems. Prevalence and correlates in rural minority areas of China. *Pediatrics International*, *43*(6), 651–661.
Liu, Y., & Wang, Y. (2002). [Cognitive functions of children with attention deficit/hyperactivity disorder]. *Zhonghua Yi Xue Za Zhi*, *82*(6), 389–392.
Marchi, M., & Cohen, P. (1990). Early childhood eating behaviors and adolescent eating disorders. *Journal of the American Academy of Child and Adolescent Psychiatry*, *29*(1), 112–117.
Marra, M. V., & Boyar, A. P. (2009). Position of the American Dietetic Association. Nutrient supplementation. *Journal of the American Dietetic Association*, *109*(12), 2073–2085.
Mascola, A. J., Bryson, S. W., & Agras, W. S. (2010). Picky eating during childhood. A longitudinal study to age 11 years. *Eating Behaviors*, *11*(4), 253–257.
McAfee, A. J., Mulhern, M. S., McSorley, E. M., Wallace, J. M., Bonham, M. P., Faure, J., et al. (2012). Intakes and adequacy of potentially important nutrients for cognitive development among 5-year-old children in the Seychelles Child Development and Nutrition Study. *Public Health Nutrition*, *15*(9), 1670–1677.
McDermott, B. M., Mamun, A. A., Najman, J. M., Williams, G. M., O'Callaghan, M. J., & Bor, W. (2010). Longitudinal correlates of the persistence of irregular eating from age 5 to 14 years. *Acta Paediatrica*, *99*(1), 68–71.
Micali, N., Simonoff, E., Elberling, H., Rask, C. U., Olsen, E. M., & Skovgaard, A. M. (2011). Eating patterns in a population-based sample of children aged 5 to 7 years. Association with psychopathology and parentally perceived impairment. *Journal of Developmental and Behavioral Pediatrics*, *32*(8), 572–580.
Needham, L., Dwyer, J. J., Randall-Simpson, J., & Heeney, E. S. (2007). Supporting healthy eating among preschoolers. Challenges for child care staff. *Canadian Journal of Dietetic Practice and Research: A Publication of Dietitians of Canada*, *68*(2), 107–110.
Nicklas, T. A., Baranowski, T., Baranowski, J. C., Cullen, K., Rittenberry, L., & Olvera, N. (2001). Family and child-care provider influences on preschool children's fruit, juice, and vegetable consumption. *Nutrition Reviews*, *59*(7), 224–235.
Nicklaus, S., Boggio, V., Chabanet, C., & Issanchou, S. (2005). A prospective study of food variety seeking in childhood, adolescence and early adult life. *Appetite*, *44*(3), 289–297.
Powell, F. C., Farrow, C. V., & Meyer, C. (2011). Food avoidance in children. The influence of maternal feeding practices and behaviours. *Appetite*, *57*(3), 683–692.
Rydell, A. M., Dahl, M., & Sundelin, C. (1995). Characteristics of school children who are choosy eaters. *The Journal of Genetic Psychology; Child Behavior, Animal Behavior, and Comparative Psychology*, *156*(2), 217–229.
Shang, Y., & Tang, L. H. (2010). [Intelligence level and characteristics of cognitive structure in school-age children infected with soil-transmitted helminthes]. *Zhongguo Ji Sheng Chong Xue Yu Ji Sheng Chong Bing Za Zhi*, *28*(6), 423–426.
Shim, J. E., Kim, J., & Mathai, R. A. (2011). Associations of infant feeding practices and picky eating behaviors of preschool children. *Journal of the American Dietetic Association*, *111*(9), 1363–1368.
Steyn, N. P., Nel, J. H., Nantel, G., Kennedy, G., & Labadarios, D. (2006). Food variety and dietary diversity scores in children. Are they good indicators of dietary adequacy? *Public Health Nutrition*, *9*(5), 644–650.
Woolston, J. L. (1983). Eating disorders in infancy and early childhood. *Journal of the American Academy of Child Psychiatry*, *22*(2), 114–121.
Wright, C., & Birks, E. (2000). Risk factors for failure to thrive. A population-based survey. *Child: Care, Health and Development*, *26*(1), 5–16.
Wright, C. M., Parkinson, K. N., Shipton, D., & Drewett, R. F. (2007). How do toddler eating problems relate to their eating behavior, food preferences, and growth? *Pediatrics*, *120*(4), e1069–e1075.
Xing, L. F., Qian, Y. L., Chen, L. T., Zhang, F. H., Xu, X. F., Qu, F., et al. (2014). Is there a difference in cognitive development between preschool singletons and twins born after intracytoplasmic sperm injection or in vitro fertilization? *Journal of Zhejiang University. Science. B*, *15*(1), 51–57.
Yang, L. L., Liu, M. L., & Townes, B. D. (1994). Neuropsychological and behavioral status of Chinese children with acyanotic congenital heart disease. *The International Journal of Neuroscience*, *74*(1–4), 109–115.
Yang, Y. X., Wang, G. Y., & Pan, X. C. (2005). *China food composition 2004* (Book 2, 1st ed.). Beijing: Peking University Medical Press.
Yu, Z. B., Han, S. P., Cao, X. G., & Guo, X. R. (2010). Intelligence in relation to obesity. A systematic review and meta-analysis. *Obesity Reviews*, *11*(9), 656–670.

Appendix: Supplementary material

Supplementary data to this article can be found online at doi:10.1016/j.appet.2015.04.065.