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Determinants of childhood overweight and obesity in China

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In order to investigate the determinants of childhood overweight and obesity in China, the prevalence of overweight (including obesity) was compared according to different dietary and physical activity patterns and parental body weight status. A total of 6826 children aged 7–17 years from the 2002 China National Nutrition and Health Survey were included in the study. Information for dietary intake was collected using three consecutive 24-h recalls by trained interviewers. The amounts of cooking oil and condiments consumed were weighed. An interview-administered 1-year physical activity questionnaire was used to collect physical activity information. The results showed that the heavier the parental body weight, the higher the overweight prevalence in children. The prevalence ratio increased if parent(s) were overweight and/or obese, up to 12·2 if both parents were obese. Overweight children consumed significantly more dietary energy, protein and fat, but less carbohydrate than their normal weight counterparts. On average, overweight children spent 0·5 h less on moderate/vigorous activities and 2·3 h more on low intensity activities per week. The following prevalence ratios were statistically significant: walking to and from school (0·6); moderate/vigorous activities $\geq$45 min/d (0·8); low intensity physical activities $>$2 h/d (1·3); the consumption of $\geq$25 g/d cooking oil (1·4); $\geq$200 g/d meat and meat products consumption (1·5); $\geq$100 g/d dairy products (1·8). After adjustment for parental body weight status and socioeconomic status, only cooking oil consumption and walking to and from school remained significantly related to child overweight. In conclusion, parental weight status is an important determinant. Fat intake, low intensity activities and active transport to/from school may be suitable entry points for overweight prevention among Chinese school children.

Chinese children: Overweight: Parent: Diet: Physical activity

Not being a problem at all in the 1980s, the prevalence of overweight and obesity among children in China was approximately 5 % and 2 % respectively in 2002 (Li *et al.* 2005). Compared with that in developed countries, childhood obesity is still relatively rare in China; however, the risk for metabolic syndrome among overweight adolescents is similar to those living in the USA (Li *et al.* 2005). Moreover, childhood obesity and its adverse health consequences may persist to adulthood. A positive relationship was found between childhood obesity and increased morbidity and mortality in adulthood (Wabitsch, 2000).

Obesity is a multi-factorial disease and its development is the result of multiple interactions between genes and environment (Allison *et al.* 1999; Lobstein *et al.* 2004). Twins adoption and family studies have found that heritability of BMI was in the range of 25–85 %, but it is the environment that allows the expression of obesity (Allison *et al.* 1999; Lobstein *et al.* 2004).

The purpose of the present study is to investigate the important determinants of childhood overweight and obesity in China, including dietary intakes, leisure time physical activity patterns, parental weight status and socioeconomic status, using the data of the 2002 China National Nutrition and Health Survey. This is the first national representative survey addressing the relationship among diet, physical activity and obesity of children and their parents together in China. The findings will be helpful for developing national strategies for the prevention of childhood overweight and obesity in China.

Methods

The 2002 China National Nutrition and Health Survey is a nationally representative cross-sectional survey (Wang, 2005) that covered thirty-one provinces, autonomous regions and the municipalities directly affiliated to the central government (Hong Kong, Macao and Taiwan are not included). A multi-step cluster sampling method (equal sample size at each step) was used for subject selection. All 2860 counties/districts/cities were divided into six categories (big cities, medium and small cities, rural 1, 2, 3 and 4) based on its type and the level of economic development (from high to low). From each of the six categories, twenty-two counties/districts/cities were selected using a systematic sampling method and a total of 132 counties/districts/cities were chosen at Step 1. Three townships/sub-districts were randomly chosen from each selected country/district/city and a total of 396 at Step 2. Two villages/neighbourhood committees (792 in total) were randomly chosen from the selected townships/sub-districts at Step 3. Ninety households were randomly selected from each village/neighbourhood, giving a total of 71 971 households. From each village/neighbourhood thirty

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out of ninety households were randomly selected for dietary and physical activity assessments. Sampling involved a total of 272 023 subjects aged 2–101 years, representing the national population, one-third of them randomly selected for the dietary and physical activity investigation and of these subjects, 8861 were aged 7–17 years.

Data collection

Subjects went to the study sites (such as the neighbourhood committee centre, the office of the village leader, etc.) for the anthropometric measurements. Investigators made home visits to collect the food and activity information.

Fasting body weight was measured in the morning to the nearest 0·10 kg with a balance-beam scale (Liaoning) while the subjects were wearing lightweight clothing. Height was measured to the nearest 0·1 cm using a standard steel strip stadiometer (Liaoning) in bare-footed subjects (Wang, 2005). The standard procedure was followed by all trained investigators.

Trained interviewers went to the subjects' homes to collect the information on food intake using the 24-h dietary recall method for three consecutive days (two weekdays and one weekend day) and to weigh the home cooking oil and condiment consumption of all the family members in these 3 d (Wang, 2005). The percentage of the oil and condiments from home that the child consumed was calculated by the ratio of child's energy requirement:energy intakes of all family members. The energy and nutrient intakes were calculated using the data of dietary intake in conjunction with the China Food Composition Table (Yang *et al.* 2002). Energy density of each subject was calculated as average energy intake (kJ) divided by average food weight (g) per d (Drewnowski *et al.* 2004), all beverages except water were included in the food weight calculation.

Information on leisure time physical activity was collected using a 1-year physical activity questionnaire administered by trained interviewers. The questionnaire consisted of four domains: transport; exercise; sedentary activities; housework. Active transport was defined as going to/from school mainly by bike or by walking, while inactive transport was defined as going by bus, motor-cycle, car or sitting on the back of a parent's bike. Sedentary activities included television viewing, computer use, video games, reading and study. Housework included cooking, washing by hand, cleaning the house and taking care of elders/babies. Moderate to vigorous activities included sports/exercise, active transport and housework, and low intensity activities included sedentary activities, inactive transport and studying.

The protocol of the survey was approved by the Ethical Committee of the National Institute for Nutrition and Food Safety, Chinese Center for Disease Control and Prevention. Signed consent forms were obtained from both their parents or guardians and the children themselves.

Definition of overweight

Overweight was defined using age- and sex-specific BMI cut-off points developed by the Working Group for Obesity in China (2004), as BMI for age- and sex-specific categories between the 85th and 95th percentile, whereas obesity was defined as BMI at the 95th percentile or higher (Group of China Obesity Task Force, 2004). In the present study, overweight ($\geq$ 85th percentile) among children included both overweight and obesity.

Adult (parent) overweight and obesity were defined as BMI 24–28 kg/m^2 and BMI $\geq$28 kg/m^2 respectively as recommended by the Working Group for Obesity in China (Cooperative Meta-analysis Group of China Obesity Task Force, 2002).

Statistical methods

Only one child from the 1775 families living together that have more than one child was randomly selected for the analysis, then 6828 from the 8861 children were included in the present study.

Dietary intakes and physical activity patterns were presented by overweight and normal weight children. Differences between the overweight and normal weight groups were compared using Wilcoxon's signed rank sum test for continuous values, while χ^2 tests were applied to proportions for those with and without certain patterns. Cox regression analysis (Barros & Hirakata, 2003; Schiaffino *et al.* 2003) was used to estimate the prevalence ratios of overweight between different dietary or physical activity patterns, where survival time is artificially set equal to 1. The cut-off points of the food intakes used in Cox regression analysis were defined according to the Food Pagoda for Chinese People (Chinese Nutrition Society, 2005). The moderate to vigorous physical activity duration cut-off was taken at 45 min/d, which had been thought to be minimally required to prevent the transition to overweight or obesity (Saris *et al.* 2003).

The data of body weight and height information of the parents were available in a random subgroup of 4596 children. Prevalence of childhood overweight was calculated by parental weight status groups and the prevalence ratio was calculated using Cox regressions.

Because parental weight and socioeconomic status may influence child weight independently, as well as through eating/activity, we included the results both with and without adjustment of parental weight and socioeconomic status.

All statistical analyses were done with SAS (version 9.1; SAS Institute Inc., Cary, NC, USA) and the significant level was set at 0·05.

Results

Weight, height and BMI of the 6828 subjects are shown in Table 1. Overweight and obesity percentage of the present sample was 4·5 and 2·2, respectively.

Dietary intake

The dietary energy and nutrient intakes of overweight and normal weight children are described and compared in Table 2. Overweight children consumed significantly more dietary energy, protein and fat and less carbohydrate than their counterparts with normal weight. Protein and fat contributed significantly more, while carbohydrate contributed significantly less to the daily energy intake among overweight children.

The contribution of several food items to total food weights is shown in Table 3. Overweight children consumed less

Table 1. Characteristics of the children*
(Mean values and standard deviations)

	Overweight		Normal weight	
	Mean	SD	Mean	SD
n	458		6368	
Girls (%)	36·5		42·9	
Age (years)	11·4	2·8	11·2	2·7
Height (cm)	148·3	15·8	141·5	15·8
Weight (kg)	52·0	15·2	33·7	11·2
BMI (kg/m^2)	23·1	2·9	16·3	2·2

* For details of subjects, see p. 211.

cereal grains and vegetables and more fruits, meats, cooking oil, egg, fish, milk and legumes.

Physical activity

Table 4 presents the average duration of leisure time activities among all children in the sample and among children participating in the respective activities. Overweight children spent less time on housework and active transport and also performed less total moderate/vigorous activities, but they spent longer time on low-intensity activities, including leisure time reading, computer use, video games, study and inactive transport. On average, overweight children spent 2·3 h per week more on low-intensity activities and 0·5 h less in moderate/vigorous activities than their counterparts with normal weight.

Parental weight status

The prevalence of childhood overweight by parental weight status is shown in Table 5. The heavier the parental body weight, the higher the overweight prevalence in children. Among the children whose parents were both obese, 39·1 % were overweight. The prevalence ratio increased if parent(s) were overweight and/or obese, up to 12·2 if both parents were obese. After including the dietary and physical activity patterns of children in the model, the prevalence ratio still increased steadily with parental weight status (Table 5).

Table 2. Energy and nutrients intakes of overweight and normal weight children§
(Mean values and standard deviations)

	Overweight		Normal weight	
	Mean	SD	Mean	SD
Energy (MJ/d)†	8·5	2·7	8·1*	2·7
Protein (g/d)†	63·7	23·7	56·2*	21·4
Protein (%)‡	12·7		11·8*	
Fat (g/d)†	79·3	41·9	65·6*	42·1
Fat (%)‡	34·7		29·6*	
Carbohydrate (g/d)†	264·9	102·3	279·3*	97·8
Carbohydrate (%)‡	52·6		58·7*	
Fibre (g/MJ)†	1·2	0·7	1·3*	0·7
Food weight (g)	1008·1	340·6	912·7*	308·2
Energy density (kJ/g)†	8·7	2·1	9·1*	2·1

Mean values were significantly different: *$P<0·05$.
† Wilcoxon's signed rank sum test.
‡ χ^2 test.
§ For details of subjects, see p. 211.

Prevalence analysis

Overweight prevalence and prevalence ratios of children with different lifestyles are shown in Table 6. Overweight prevalence among children who spent more than 45 min/d on moderate/vigorous activities or walked to school was less than their counterparts who spent less than 45 min/d on moderate/vigorous activities or went to school by bus. A significantly higher prevalence of overweight was observed among those who spent more than 2 h on low-intensity activities, consumed $\geq$25 g cooking oil, $\geq$200 g meat and meat products and/or $\geq$100 g dairy products daily. The prevalence ratios were 1·3, 1·4, 1·5 and 1·8, respectively.

Adjustment for parental weight status, family income and mother's educational levels resulted in loss of significance of the prevalence ratio of moderate/vigorous activities $\geq$45 min/d, low-intensity physical activities $\geq$2 h, $\geq$200 g meat and meat products and $\geq$100 g dairy products but the prevalence ratios of walking to/from school and $\geq$25 g cooking oil were still significant (0·6 and 1·3, respectively). The prevalence ratios and 95 % CI of middle and high family income levels were 1·4 (1·1, 1·8) and 1·7 (1·1, 2·5), of middle and high mother's educational levels were 1·3 (1·0, 1·7) and 1·7 (1·1, 2·6), respectively.

Discussion

Based on present cross-sectional observation, overweight children consumed significantly more dietary energy, protein and fat but less carbohydrate than their counterparts with normal weight. On average, overweight children spent 0·5 h less on moderate/vigorous activities, but 2·3 h more on low-intensity activities per week. Several dietary and physical activity factors are related to overweight among Chinese children. Parental body weight is also an important determinant. The addition of parental body weight status, family income level and mother's education to the model made some of the associations disappear. However, it can be argued that this may lead to over-adjustment, since income and educational status may be part of the same causal pathway.

Unlike in the USA, where obesity prevalence increased while the reported dietary fat intakes decreased in recent decades (Centers for Disease Control and Prevention, 2004), in China, obesity increased parallel with dietary fat increment. The average daily dietary fat intake among Chinese people increased from 48 g to 58 g during 1982–1992, and continued to increase to 76 g per d during 1992–2002. Among Chinese adolescents, contribution of dietary fat to total energy increased one to two points in only 2 years (from 1991 to 1993) (Wang *et al.* 1998). Energy and fat intakes have been found to be positively associated with BMI among male adults and energy intake among women in China (Paeratakul *et al.* 1998). The present results show that overweight Chinese children reported high energy and fat intakes. Overconsumption of cooking oil may be one of the contribution factors for overweight. The recommended consumption of fats and oil is 25 g/d (Chinese Nutrition Society, 2005); however, 70·1 % of overweight children failed to follow this

Table 3. Food patterns of overweight and normal weight children§

	Food weight				Energy			
	(g)		(%)†		(kJ)		(%)‡	
	Overweight	Normal weight	Overweight	Normal weight	Overweight	Normal weight	Overweight	Normal weight
Rice/Wheat	372·7	391·5*	39·4	44·9*	4406·6	4791·1*	52·4	60·3*
Vegetable	216·5	220·5	21·3	23·9*	222·0	231·2	2·7	3·0*
Meat/products	87·4	64·7*	8·4	6·8*	979·4	772·0*	11·2	9·0*
Fruit	64·3	53·9*	5·5	5·1*	107·8	94·5*	1·3	1·2*
Oil	40·8	35·9*	4·2	4·0*	1530·3	1343·9*	17·8	16·0*
Milk/Dairy	55·8	24·3*	4·7	2·2*	138·8	65·2*	1·7	0·8*
Egg	31·7	20·4*	3·2	2·3*	174·7	112·0*	2·1	1·5*
Fish	38·9	24·0*	3·6	2·5*	114·1	72·3*	1·4	0·9*
Bean/products	15·5	13·0*	1·6	1·5*	232·4	216·5*	2·7	2·6*
Others	84·5	64·4*	8·1	6·9*	572·7	380·4*	6·5	4·6*

* $P<0·05$; Wilcoxon's signed rank sum test.
† Percentage of total food intake (food weight of each kind (g) / total food intake (g)).
‡ Percentage of total energy intake (energy intake from each kind of food (kcal) / total energy intake (kcal)).
§ For details of subjects, see p. 211.

recommendation. Overconsumption of oil was also observed in overweight Chinese women (Hu *et al.* 2002). Current results about energy density is in direct opposition to data found elsewhere, specifically the USA (Ledikwe *et al.* 2006), because the Chinese diet is still plant based. It really looks paradox when the overweight eat more high-energy density foods such as meat, cooking oil, fish, eggs, etc, while their diet is low energy density. From Table 3, it can be seen that those foods account for a very low percentage of the total foods, in contrast rice, wheat and their products contributed 40 % total foods and >50 % energy. Therefore, the energy density of these diets depends relatively more on cereals.

Low physical activity and/or increasing sedentary activities are widely thought to be related to weight gain (Must & Tybor, 2005). The current study shows that overweight children spent less time on moderate/vigorous physical activities, especially housework and active transport, but not exercise. In adults, walking has been demonstrated to be beneficial to health and weight control (Hu *et al.* 2002; Gordon-Larsen *et al.* 2005), while motorized vehicle use seems to be associated with overweight and other disorders. Among US young adults, the proportion of individuals using active transportation was higher among non-overweight compared to overweight ones (to work 9·2 *v.* 6·8 %; to school 29·7 *v.* 22·6 %) (Gordon-Larsen *et al.* 2005). Among Chinese adults, going to and from work by walking or bicycle seems to reduce the risk of overweight by 50 % compared with going by bus (Hu *et al.* 2002). Men who acquired a motor vehicle experienced a 1·8 kg greater weight gain and had 2:1 odds of becoming obese (Bell *et al.* 2002).

The present study is in line with previous studies (Jacobson & Rowe, 1998; Bogaert *et al.* 2003; Treuth *et al.* 2003;

Table 4. Physical activity patterns of overweight and normal weight children§
(Mean values and standard deviations)

	Duration† (h/week)						Duration‡ (h/week)			
	Overweight		Normal weight		Participation rate		Overweight		Normal weight	
	Mean	SD	Mean	SD	Overweight (%)	Normal weight (%)	Mean	SD	Mean	SD
Moderate/vigorous physical activity										
Exercise	1·1	2·1	0·8	1·9	41·7	41·2	2·7	2·6	2·0*	2·6
Housework	1·1	3·1	1·7	4·0	29·5	39·8*	3·6	4·7	4·3*	5·3
Active transport	1·9	1·6	2·2	1·9	84·5	91·6*	2·3	1·5	2·4	1·9
Activity time	4·1	4·1	4·7	4·9	93·7	96·4*	4·4	4·1	4·9	4·9
Low intensity activities (inactive)										
Television	9·3	6·5	9·4	6·4	91·7	90·2	10·1	6·1	10·5*	5·8
Leisure reading	5·1	6·6	4·6*	6·4	67·7	57·4*	7·5	6·8	8·0*	6·7
Computer	0·9	2·8	0·5*	2·4	13·3	6·7*	6·9	4·1	7·4	5·9
Video games	0·5	2·1	0·3*	1·7	9·2	5·4*	5·9	4·4	5·3	4·9
Studying	7·9	4·3	6·9*	4·1	98·7	97·4	8·0	4·3	7·1*	4·0
Inactive transport	0·4	1·4	0·2*	0·9	14·4	5·9*	3·0	2·5	3·0	2·3
Total inactive time	24·2	11·7	21·9*	11·2						

Mean values were significantly different (Wilcoxon's signed rank sum test for mean comparison and χ^2 test for participant rate): *$P<0·05$.
† Average duration among all children in sample.
‡ Average duration among participating children.
§ For details of subjects, see p. 211.

Table 5. Prevalence of childhood overweight by parental weight status‡

	Childhood overweight				
		Prevalence ratio			
Parental weight status	Prevalence (%)	Unadjusted	95% CI	Adjusted†	95% CI
At least one underweight	3·0	0·9	0·5, 1·8	1·0	0·5, 1·9
Both normal weight	3·2		–		–
One normal weight, one overweight	6·9	2·2*	1·6, 3·0	1·9*	1·4, 2·7
Both overweight	11·4	3·6*	2·5, 5·0	3·1*	2·2, 4·3
One overweight, one obese	22·0	6·9*	4·7, 10·0	5·6*	3·8, 8·3
Both obese	39·1	12·2*	7·2, 20·7	9·5*	5·5, 16·3

Prevalence ratio of having overweight or obese children compared with the group that had both parents at normal weight (Cox regression analysis): *$P<0·05$.

† Other factors included in the model: energy and food intakes; leisure time physical activity and inactivity patterns; mother's educational level; family income levels.

‡ For details of subjects, see p. 211.

Benton, 2004; Veugelers & Fitzgerald, 2005), concluding that parental overweight is the most potent risk factor for childhood obesity. Treuth and colleagues found that a stepwise increase in gains in fat mass and percentage body fat over time occurred with increasing parental body weight status (Treuth *et al.* 2003). The association reflects both genetic and environmental influence for the development of overweight. In addition to the high genetic similarity among members of a family (Jacobson & Rowe, 1998), parents play an important role in the development of children's physical activity patterns (Bogaert *et al.* 2003) and eating behaviours and attitudes (Benton, 2004). Parents may be responsible for the overconsumption of cooking oil by children. Parents' socioeconomic status also has an important effect on childhood obesity (Veugelers & Fitzgerald, 2005).

Table 6. Association between determinants and overweight status†

			Prevalence ratio	
Risk factors	*n*	Overweight prevalence	OR	95% CI
Sex				
Boys	3925	7·4		
Girls	2901	5·8**	0·8*	0·7, 1·0
Moderate/vigorous activity(min/d)				
<45	4809	7·2		
≥ 45	2017	5·6**	0·8*	0·6, 1·0
Transport to/from school				
By bus	440	15·0		
By bike	1156	9·0	0·7	0·5, 1·1
Walking	5230	5·5**	0·6*	0·5, 0·8
Inactivity (h/d)				
≤ 2	1626	4·9		
>2	5200	7·3**	1·3 *	1·0, 1·7
Meat and meat products (g/d)				
<200	5531	5·6		
≥ 200	1295	11·3**	1·5*	1·2, 1·8
Cooking oil (g/d)				
<25	2782	4·9		
≥ 25	4044	7·9**	1·4*	1·2, 1·8
Dairy products (g/d)				
<100	6161	5·9		
≥ 100	665	14·3**	1·8*	1·4, 2·3

* $P<0·05$ (Cox regression analysis), other factors included in the model but not significant at 0·05 level are energy intake, cereal, vegetable/fruit and legume consumption.

** $P<0·01$ (χ^2 test).

† For details of subjects, see p. 211.

Being nationally representative and comprising both diet and physical activity information and parental information are strengths of the present study. The limitation is that the results are based on cross-sectional observation. Therefore, it is not possible to demonstrate a cause-and-effect relationship. The observed associations may be either causal in direction or a consequence of childhood obesity.

Based on the associations we found, the following points might be considered in further studies and, if confirmed, in prevention programmes: (1) the tradition of going to/from school by walking or by bike should be encouraged; (2) limiting fat intake and particularly the overconsumption of cooking oil in China is a challenge, given the habit of frying foods; (3) reduce low-intensity activities and encourage the children to be more active; (4) parental participation and family involvement may enhance the effect of such programmes on childhood obesity in China.

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