

Original Article

Familial clustering of overweight and obesity among schoolchildren in northern China

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Abstract: Background: We aimed to study the prevalence of overweight and obesity and to assess its familial clustering among schoolchildren in northern China. Methods: A cross-sectional study was conducted on 95,292 schoolchildren in northern China to investigate the prevalence of overweight and obesity. A group of overweight and obese children (n = 450) was selected using a cluster sampling method. Answers from a questionnaire on their and their families' nutrition and behaviors were recorded and analyzed statistically. Results: The prevalence of overweight and obesity in schoolchildren was 27.4% and 13.2%, respectively. The prevalence of overweight and obesity were significantly higher in boys than in girls. The prevalence of familial clustering of overweight and obesity was 75.3% and 20.3%, respectively. The prevalence of overweight in first-generation (parents) and second-generation (grandparents) relatives was 54.6% and 53.1%, respectively. There was a linear trend toward correlation between age and the rates of overweight and obesity. The familial clustering of obesity with family income reached statistical significance. Conclusion: The prevalence of overweight and obesity was extremely high, especially among boys and their fathers. Evidence of familial clustering of overweight and obesity among schoolchildren and their parental family members in northern China is emerging.

Keywords: Children, overweight, obesity, familial clustering, nutrition

Introduction

The prevalence of being overweight and the prevalence of being obese among children and adolescents have been gradually increasing worldwide. Studies estimate that 22 million children under the age of five are severely overweight worldwide [1]. Although the highest rates of childhood obesity are observed in developed countries, obesity has also been increasing in developing countries [2]. In East Asia and Southeast Asia, especially China, rapid urbanization and socio-economic development combined with changes in eating habits and physical activities have led to an increase in obesity in adults as well as in children [3].

The eating habits of the Chinese have changed substantially due to dramatic economic achievements in the past decades, which has caused a rapid and sustained reduction in the proportion of underweight children. At the same time, the level of obesity in the urban popula-

tion, particularly in large coastal cities, has reached that of developed countries. In 2000, the respective proportions of obese and overweight boys aged 7 to 18 years were 11.3% and 6.5% in Beijing and 13.2% and 4.9% in Shanghai, whereas the prevalence of obesity and overweight in girls of the same age range was 8.2% and 3.7% in Beijing, and 7.3% and 2.6% in Shanghai [4, 5].

Familial clustering of a disease is defined as the occurrence of the disease within certain families in excess of the common expectations of occurrence in the population. This has been demonstrated for many diseases, including kidney disease, Meniere's disease, cardiovascular diseases and several types of cancer [6-10]. Several reports have investigated the familial clustering of obesity in different countries [11-13]. However, the familial clustering tendency of obesity in China remains unclear. In this study, we investigated the prevalence of overweight and obesity in schoolchildren as well as potential environmental and genetic contribu-

Overweight and obesity among children

Table 1. The incidence of overweight and obese children in primary schools stratified by gender (n = 95292)

Weight group	Total n = 95292	Boy n = 50439	Girl n = 44853	P*
Overweight (%)	26110 (27.4)	16402 (32.5)	9708 (21.6)	< 0.001
Obese (%)	12611 (13.2)	7944 (15.7)	4667 (13.2)	< 0.001

*Comparison between boy and girl using chi-square test.

Table 2. The incidence of overweight and obese children in primary schools stratified by age (n = 95292)

Age Groups	Total	Overweight (%)	Obese (%)
7	17708	4944 (27.9)	2359 (13.3)
8	17672	4687 (26.5)	2376 (13.4)
9	18962	5127 (27.0)	2548 (13.4)
10	15792	4535 (28.7)	2227 (14.1)
11	15700	4467 (28.5)	2150 (13.7)
12	6605	1633 (24.7)	652 (9.9)
13 to 14	2853	717 (25.1)	299 (10.5)
P*	-	0.224	< 0.001

*Cochran-Armitage trend test for age.

tors to obesity in northern China. Our conclusions indicate that obesity is the result of complex interactions between multiple genetic and environmental factors. Importantly, familial clustering is demonstrable among overweight and obese schoolchildren.

Materials and methods

Ethics statement

This work was approved by the ethics committee of the First Hospital of Hebei Medical University and all aspects of the study comply with the Declaration of Helsinki (20090101). The study's aims, procedures and measurements were explained as part of informed consent. The Ethics Committee of the First Hospital of Hebei Medical University approved the informed consent procedures for this study. Subjects were recruited from 150 elementary schools in five Shijiazhuang districts. Both boys and girls were recruited and sent informed consent forms. The researchers explained the purpose and research process to them before they took the forms to their parents and asked permission. Finally written informed consents were obtained from the parents for their children's participation.

Sample

All participants with serious heart, liver and kidney diseases were excluded. Finally, 95292

schoolchildren (50439 boys and 44853 girls) from grades 1 to 6 at 150 elementary schools in five Shijiazhuang districts (Qiao-Xi, Qiao-Dong, Yu-Hua, Xin-Hua and Chuang-An) were sampled at the beginning of school in the autumn of 2009. A total of 450 overweight and obese children among them were randomly selected to participate in the familial clustering of overweight and obesity study using a cluster sampling method.

Procedures and measurements

All schoolchildren were investigated based on obesity and overweight. Weights of parental relatives were measured; other familial data, including birth weights of children and family incomes, were collected by survey. The height and weight of children were measured in the morning following a standardized procedure, and anthropometric data were collected by trained medical personnel [14]. Heights were measured without shoes using a portable stadiometer, and weights were measured (without outerwear) on a calibrated beam scale. All measuring instruments were calibrated every day before measurement. The body mass index (BMI) was calculated as weight (kg) divided by height (m) squared, as classified by the Working Group on Obesity in China (WGOC) [15]. The WGOC revised the standard following International Obesity Task Force standards and the characteristics of the Chinese people. BMI thus defined was used to classify participants. A primary school from each district was randomly selected and used as a monitoring point. If the sample size of one primary school was too small, another primary school was randomly selected to be a monitoring point. Seven primary schools were selected to be monitoring points for investigating dietary behavior, lifestyle, familial clustering of overweight and obesity and the factors that can influence familial clustering in overweight and obese children. The overweight and obese children and their family members who had agreed to be participants and answered preliminary question-

Overweight and obesity among children

Table 3. The incidence of overweight and obese family members of overweight children in primary schools stratified by generation (n = 1090)

Weight group	Total n = 1090	First generation (Parents) n = 879	Second generation (Grandparents) n = 211	P*
Overweight (%)	592 (54.3)	480 (54.6)	112 (53.1)	0.689
Obese (%)	153 (14.0)	124 (14.1)	29 (13.7)	0.892

*Comparison between first generation and second generation using chi-square test.

naires were investigated by trained medical personnel. The questionnaires adopted a unified layout and were filled out by the children and their parents within a specified time. After the medical personnel had reviewed everything, the original information was analyzed using SPSS 13.0 software.

Statistical analysis

We defined childhood obesity and overweight based on the WGO and their BMI formula. A participant was classified as obese (overweight) when their BMI went above 95% (85%) of the standard for the same age and gender. Additionally, we defined adult obesity and overweight following the 'Prevention and control guidelines in Chinese adult overweight and obesity', as recommended by the Ministry of Health in China. Moreover, in our study we defined familial clustering as the presence of overweight/obesity in more than half of any cohabiting family members.

Analyses were stratified by gender, age and other factors as defined in the text and tables. The rates of overweight and obesity among children of different gender, and between first- and second-generation relatives (parents and grandparents), were analyzed by chi-square test. To test if the father played an important role in familial clustering, we used a chi-square test between the rates of being overweight and being obese of fathers and those of mothers. The rates of familial clustering of obesity among children of different gender were also analyzed using a chi-square test. We used a Linear-by-Linear Association test to analyze the linear trend between age and the rates of overweight and obesity. The familial clustering of obesity among obese children of different birth weights and different family incomes was analyzed using a nonparametric test. The rates of normal weight, overweight and obesity stratified by gender, generation and parents' gender were analyzed using a nonparametric test. The SPSS statistical package (SPSS Inc., version 13.0)

was utilized for the analysis. All *p* values below 0.05 were considered significant.

Results

Overweight and obese children

Among 95,292 children, 26,110 were overweight and 12,611 were obese. The rates of being overweight and being obese were 27.4% and 13.2%, respectively. The overweight and obesity rates of boys were higher than those of girls, and significant differences were observed between the rates of overweight and obesity in boys and in girls (overweight: $X^2 = 1411.33$, $p < 0.05$; obesity: $X^2 = 590.60$, $p < 0.05$). There was a significant difference among the rates of normal weight, overweight and obesity stratified by gender using a nonparametric test ($Z = -49.472$, $p < 0.05$; **Table 1**). The highest rates of overweight and obesity were found in the 10 to 11 age group. The rates of overweight and obesity in this group were 28.7% and 14.1%, respectively (**Table 2**). We found a linear trend between age and the rates of overweight and obesity ($X^2 = 24.164$, $p < 0.05$).

Overweight and obesity among family members of overweight children

A total of 1090 parental family members, including 879 from the first generation (father and mother) and 211 from the second generation (grandparents, and maternal grandparents), were involved in this cross-sectional study. Rates of overweight and obesity were 54.3% (592 of 1090) and 14.0% (153 of 1090), respectively, in the combined first-and second-generation relatives. No significant difference was observed in rates of overweight or obesity between first-generation and second-generation relatives (overweight: $X^2 = 0.160$, $p > 0.05$; obesity: $X^2 = 8.350$, $p > 0.05$). We also found no significant differences among the rates of normal weight, overweight and obesity stratified by generation using a nonparametric test ($Z = -0.471$, $p > 0.05$; **Table 3**).

The first-generation relatives included 441 fathers and 438 mothers. Fathers displayed significantly higher rates of overweight and obesity than mothers (overweight: $X^2 = 95.650$,

Overweight and obesity among children

Table 4. The incidence of overweight and obese parents of overweight children in primary schools (n = 879)

Weight group	Total n = 879	Father n = 441	Mother n = 438	P*
Overweight (%)	480 (54.6)	313 (71.0)	167 (38.1)	< 0.001
Obese (%)	124 (14.1)	88 (20.0)	36 (8.2)	< 0.001

*Comparison between father and mother using chi-square test.

Table 5. Familial clustering of obesity among obese children of different birth weights

Birth Weight	Number of children	Clustering of obesity (%)
Low (< 2500 g)	4	1 (25)
Normal (2500-4000 g)	164	29 (17.7)
High (> 4000 g)	52	13 (25)

Table 6. Familial clustering of obesity among obese children of different family incomes

Family average per capita income (RMB)	Number of children	Clustering of obesity (%)*
< 2000	19	1 (5.3)
2000-4999	19	1 (5.3)
5000-9999	40	11 (27.5)
10000-19999	80	18 (22.5)
20000-49999	61	11 (18.0)
> 50000	17	2 (11.8)

* $H = 7.661, p < 0.05$.

$p < 0.05$; obesity: $X^2 = 24.977, p < 0.05$). We also observed significant differences among the rates of normal weight, overweight and obesity stratified by parental gender using a non-parametric test ($Z = -13.269, p < 0.05$) (Table 4).

The prevalence of familial clustering among obese and overweight children

Based on a random-cluster sampling method, 339 of 450 families (75.3%) with overweight children displayed a familial clustering trend and 48 of 236 families (20.3%) with obese children displayed a familial clustering trend. The rates of familial clustering of overweight among boys and girls aged 7 to 13 years old were 77.5% and 70.5%, respectively. The rates of familial clustering of obesity among boys and girls aged 7 to 13 years old were 22.7% and 16.3%, respectively, a difference that was not statistically significant ($X^2 = 1.377, p = 0.241$).

The effects of birth weight and income on familial clustering

The prevalence of familial clustering of obesity among children of different birth weights: The survey showed that the prevalence of familial clustering of obesity did not differ significantly among children of different birth weights ($H = 1.415, p > 0.05$). However, the birth weights of many of the obese children were much higher than those of normal-weight children. Of 220 obese children, 4 were of low birth weight, 164 of normal birth weight and 52 of high birth weight. The proportion of those with high birth weight was 23.6% (Table 5). This percentage is much higher than the high birth weight rate of normal children, which is 5.3%, according to a study by international association of obstetrics [16].

The prevalence of familial clustering of obesity among children of different family incomes: We surveyed 247 families of obese children. The percentages of families who's per capita annual household income (RMB) was < 2000, 2000 to 4999, 5000 to 9999, 10000 to 19999, 20000 to 49999 and > 50000 were 8%, 8%, 17%, 34%, 26% and 7%, respectively. The familial clustering of obesity among obese children of different family incomes differed significantly ($H = 7.661, p < 0.05$; Table 6).

Discussion

Obese parents are more likely to have obese children. Parents provide both the genes and nutritional environment for their children, and familial patterns of adiposity are the result of gene-environment interactions. Several groups have reported that children of overweight parents are prone to being overweight [12, 17-20]. Guillaume found a familial clustering trend of obesity in three generations, emphasizing the influence of strong genetic traits on obesity in a Belgian population. On the other hand, Bouchard concluded that the genetic predisposition to weight gain is expressed when the individual is exposed to a specific environment. The present study showed that the prevalence of being overweight and being obese of school-children was extremely high in northern China. The rates of overweight (27.4%) and obesity (13.2%) in northern China are higher than previ-

ous reports 5 from other large cities in China in 2005, which indicates that a dramatic and steadily increasing trend of overweight and obesity in northern China will likely occur. Currently, these rates have equaled or even surpassed the rates of overweight and obesity in developed countries. No significant difference was observed in rates of overweight or obesity between first- and second-generation parental relatives in our study. Most importantly, we found that families with overweight and obese children displayed a familial clustering trend in northern China. Results of the present study confirmed that high adiposity runs in families.

Unfortunately, parents do not appear to be educated about the obesity of their children. Our survey results indicate that only 7.2% of parents were aware that obese children can develop hypertension. Only 3.2% of parents reported an awareness that diabetes can result from childhood obesity, and 1.7% of parents realized that obese children can develop heart and brain vascular diseases. A total of 72.9% the parents we surveyed have never controlled the body weight of their child, and 6.6% of parents thought that the fat of their children was muscle. These data suggest that the majority of parents lack general knowledge of childhood obesity, which may reduce their concern about this issue and its effects on their children. The parents of obese children have evidently not been able to correct the habits of their children that contribute to their condition. Therefore, fully understanding the close relationship between childhood obesity and many other diseases in adulthood is critically important. Parents are recommended to take appropriate measures to prevent obesity at early stages to reduce or avoid the further development of cardiovascular diseases [21]. At the same time, the development of obesity is highly related to eating habits and lifestyle. The lifestyle of parents significantly influences that of their children. Our demonstration of clustering of obesity within families provides support for emphasizing familial environmental factors as part of prevention or treatment of childhood obesity [22], and suggests that obesity awareness among family members will be essential in controlling and ameliorating this condition in children.

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Disclosure of conflict of interest

None.

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Overweight and obesity among children

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