

Epidemiology of Overweight and Obesity in Early Childhood in China and Associated Factors

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Objective: To evaluate the epidemiological landscape and identify the risk factors associated with overweight and obesity in early childhood in China.

Methods: We collected measurements of weight and height and calculated the body mass index (BMI) for preschool children. The overweight and obesity status of children aged 2 to 6 years was examined using the 2005 China BMI growth chart. WHO weight-for-length (WFL) charts were used to identify those at risk for early childhood overweight. Data on potential risk factors for childhood overweight/obesity were obtained through questionnaires. Multiple logistic regression analyses were conducted to determine the association between risk factors and overweight/obesity.

Results: Among the 13,896 participants, 7.5% of infants and toddlers were overweight, 18.4% of preschoolers were overweight, and 10.3% of preschoolers were obese. The prevalence of obesity among preschool boys (12.6%) was significantly greater than that among preschool girls (7.7%, $p < 0.001$). Our analysis identified nine risk factors significantly associated with an increased risk of early childhood overweight or obesity. These include guardian status, paternal height, frequency of weekly candy consumption, maternal weight, leg circumference, waist circumference, age at the onset of overweight, age group, and maternal education level. In addition, children born to overweight mothers had a 1.02-fold higher likelihood of being overweight/obese compared to children with mothers of normal weight (95% confidence interval: 1.00–1.03; $p = 0.0106$). Upon adjustment for all potentially confounding variables, the odds ratios for the frequency of weekly candy consumption in children were negatively linked to overweight/obesity (0.98; 95% confidence interval: 0.96–1.00). In addition, gender-dietary habit interactions significantly influenced the risk of overweight/obesity in both positive and negative directions.

Conclusion: Our research on the prevalence and predictors of overweight/obesity in preschool children underscores the importance of recognizing and understanding early childhood obesity within its context. Obesity prevention efforts should target key risk factors, such as parental obesity and unhealthy early childhood lifestyles.

Keywords: epidemiology, obesity, preschool children, infant, toddler

Introduction

Obesity, defined as having a body mass index (BMI) at or above the 95th percentile for age and sex, is one of the most pervasive and preventable health issues affecting children worldwide today.¹ This serious public health challenge affects both high-income developed nations and low- and middle-income developing countries, including China.^{2,3} According to a report from the World Health Organization (WHO), in 2016, more than 340 million children and adolescents aged 5–19 were diagnosed as overweight or obese. Additionally, in 2020, 39 million children under the age of 5 were classified as overweight or obese [WHO Obesity and overweight. 2021, Available from: <https://www.who.int/news-room/fact-sheets>]



[/detail/obesity-and-overweight](#)] Data from the US Centers for Disease Control and Prevention (CDC) for the years 2017 to 2021 indicate that the prevalence of obesity among children and adolescents aged 2–19 years was 19.7%, affecting approximately 14.7 million children and adolescents. When these figures are broken down by age groups, obesity prevalence was 12.7% among 2- to 5-year-olds (preschool children), 20.7% among 6- to 11-year-olds, and 22.2% among 12- to 19-year-olds.

In China, during the years 2009 to 2011, 12% of young children aged 2–6 were found to be obese.⁴ A subsequent report from the Chinese CDC in 2012 revealed that approximately 120 million Chinese children under the age of 18 were either overweight or obese.² In 2015, China had the highest number of overweight and obese children globally.⁵ We recently reported a multicenter cross-sectional study of children and adolescents on the epidemiology of obesity and influential factors in China. Among children and adolescents aged 6–18 years across four provinces of China, the overall prevalence of overweight and obesity was 27.2% and 29.6%, respectively. Among different stages and sexes, the highest prevalence of obesity (15.8%) was observed in adolescent boys. From childhood to adolescence, the obesity rate among boys increased by 0.7% (from 15.1% to 15.8%), whereas that among girls decreased by 0.9% (from 10.8% to 9.9%).⁶ Projections indicate that the number of preschool-aged children with overweight and obesity in China will continue to rise from 12 million in 2012 to 18 million by 2030.⁷ The incidence of overweight and obesity in school-age children in China was 15.5% in 2010, which surged to 24.2% in 2019 and reached a staggering 29.4% in 2022.⁸

The rise in childhood obesity is linked to serious health risks, including type 1 and type 2 diabetes mellitus,^{9,10} cardiometabolic diseases,^{11–13} and mental health issues.^{14,15} Preventing obesity in its early stages has shown greater success in the long term, making early identification of obesity essential to mitigating future health complications.^{16,17} The preschool years (0–6 years) are particularly critical for establishing healthy habits and preventing obesity.¹⁷

Many factors associated with child weight issues have been extensively studied, encompassing child-related factors such as gender, age, birth weight, dietary habits, and activity level. Additionally, home-environmental and familial factors, including parental weight status, education level, and child feeding practices, have also been investigated.^{18,19} Given the alarming increase in the prevalence of early-onset obesity among preschool children and its known connection to obesity in later childhood and adulthood, it is crucial to place significant emphasis on identifying risk factors for overweight and obesity during early life. However, the majority of studies on child obesity have primarily concentrated on school-aged children and their associated risk factors.^{16,20,21} There is a notable scarcity of epidemiologic studies specifically targeting preschool children aged 2–5 years compared with the abundance of studies focusing on school-aged children in the 5- to 18-year age group.²²

Although effective action to prevent the childhood obesity epidemic requires a solid foundation of evidence regarding early-life risk factors, this evidence base is still very incomplete.²³ Current prevention strategies primarily focused on late childhood and adolescence have yielded limited success, as eating behaviors are already well-established by the preschool age.²⁴ Therefore, acknowledging obesity prevalence in preschool children and identifying its risk factors have emerged as a major public health challenges for researchers, educators, and policymakers.

Our study aims to fill this gap by providing comprehensive data on the prevalence and determinants of overweight and obesity in preschool children aged 0–6 years in China. The study had three objectives: (1) ascertain the prevalence of overweight and obesity, comparing prevalence variations by age groups, gender, and physical status, (2) investigate the factors associated with overweight and obesity in early childhood (0 to 6 years) within a substantial cohort of preschool children in China, and (3) explore the associations between changes in the identified factors and alterations in overweight or obesity status.

Methods

Design

The present study is a descriptive and analytical cross-sectional study examining data from 13,896 preschool children aged 0–6 years who had physical examination records and completed self-reported health questionnaires. To design the questionnaire, we referred to sample questionnaires from previous similar studies.^{25–28}

Study Setting

Participants (children and their parents) were recruited from hospitals, daycare centers, and preschools in Beijing, Liaoning, Hubei, and Hainan provinces, China, in 2016. These provinces represent diverse regions of the country, encompassing both urban and rural settings. Beijing, the capital, is a highly developed metropolitan area, while the other provinces have varying levels of development, with Hainan being a tropical island and Liaoning and Hubei having both urban and rural populations. This geographical diversity provides a broad representation of preschool children from different socio-economic and environmental backgrounds in China.

Participants

Children aged 0–6 years, along with their parents were involved in the data collection process. Infants were defined as 0–12 months old, toddlers as 1–2 years old, and preschoolers as 2–6 years old ([Supplemental Table 1](#)).

Inclusion Criteria

Children aged 0–6 years; availability of physical examination records; and completion the self-reported health questionnaire by parents or guardians.

Exclusion Criteria

Children with incomplete physical examination data or missing key information on the health questionnaire and children with known severe health conditions (eg, chronic diseases, disabilities) that may interfere with the evaluation of weight status or other health factors.

Recruitment Methods

Participants were recruited through a multi-stage sampling process. We approached hospitals, day care centers, and preschools in four provinces of China (Beijing, Liaoning, Hubei, and Hainan). Invitations to participate were distributed to parents or guardians, and those expressing interest in the study were asked to sign a consent form. Recruitment was conducted by trained research assistants who explained the study's objectives and provided necessary information to ensure informed consent.

Measures

Trained research assistants measured the child's weight, height, hip size, waist circumference, and blood pressure. Height was measured using a stadiometer (Seca[®] mechanical measuring systems 220, Seca GmbH & Co. KG, Hamburg, Germany), and weight was measured using a calibrated scale (Seca[®] nonautomatic mechanical column scales 700, Seca GmbH & Co. KG, Hamburg, Germany) as part of routine clinical care. Waist Circumference was measured at the midpoint between the lowest rib and the top of the iliac crest using a flexible, non-stretchable measuring tape. Measurements were taken at the end of a normal expiration. Blood pressure was measured using a child-appropriate blood pressure cuff and a sphygmomanometer. Measurements were taken after the child had been seated quietly for at least five minutes. Multiple readings were taken, and the average was recorded. We defined childhood obesity in terms of the body mass index (BMI), which is the most widely accepted surrogate measure of adiposity for evaluating overweight/obesity in children aged 2–6 years.^{29,30}

Data Collection Procedures

Trained research assistants measured the child's weight, height, hip size, waist circumference, and blood pressure. We interviewed the children's parents using health-related questionnaires to collect information on the child's age and gender. Self-reported questionnaires gathered data on sociodemographic conditions, food intake, and lifestyle during interviews with parents. The final questionnaire consisted of three sections ([Supplemental Table 1](#)): 1). Sociodemographic: This section collected demographic information about the research samples, including age, sex, weight, guardian, location, mother's education, and more; 2). Dietary habits: This section covered feeding styles and food choices; 3). Lifestyle: This section encompassed family eating and activity habits, sleep styles, appetite, and parental perceptions on child obesity.

Data Management and Statistical Analyses

We employed three main pre-processing steps, namely, cleaning redundant records, deleting low-quality data fields, and encoding text labels. Initially, the raw dataset consisted of 14,415 records of surveyed children. However, this dataset contained multiple records for some children and redundant records were eliminated. Unique records were grouped based on children's names, ages, sexes, and weights, and one record with median numeric values was retained for each group, and remaining within the same group were excluded as duplicates. In total, 519 redundant records were removed to ensure the final analysis would not be biased, reducing the dataset decreased from 14,415 to 13,896 records. Following this, we eliminated irrelevant or low-quality data fields, resulting in the removal of 10 columns. Finally, we transformed multiple categorical data values into numeric values using label encoding. As a result, after two rounds of cleaning and text label encoding, the final harmonized dataset included 13,896 encounter records and 65 data variables for analysis. We also extracted subsets of the full data set based on age, sex, and BMI.

BMI was calculated as weight in kilograms divided by height in meters squared (kg/m^2). The obesity criterion was based on the 2005 China national BMI growth chart and reference dataset.³¹ This chart outlines BMI cut-off criteria for classifying overweight and obesity for Chinese children and provides sex-specific smoothed BMI percentiles for single years of age from 2 to 18 years. We utilized this reference dataset to classify preschool children into three categories: normal weight (BMI between the 5th and 85th BMI-for-age percentile), overweight (BMI between the 85th and 94.9th BMI-for-age percentile), and obese (BMI \geq 95th BMI-for-age percentile).^{32–37}

For children under 24 months of age, following the recommendation of the Committee on Nutrition of the American Academy of Pediatrics (AAP), we utilized the WHO weight-for-length (WFL) charts to identify those who might be at risk for developing obesity. The threshold for identifying overweight children was set at the 97.7th percentile (or ± 2 standard deviations).^{38–40}

We conducted appropriate descriptive statistics for all exposure, outcome, and covariate variables, calculating means, standard deviations, frequencies, and percentages to assess normality. The physical measurements, which are normally distributed continuous variables, were reported as means along with their respective standard deviations (SDs) and frequencies. Medians with interquartile ranges were utilized for continuous variables that were not normally distributed ([Supplemental Table 2](#)).

To compare continuous variables across age-sex groups (eg, BMI-for-age growth profiles), we employed analysis of variance (ANOVA). For comparisons between specific groups, namely, the normal, overweight, and obesity groups, we conducted *t*-tests to determine significant differences. These differences were reported in terms of means and SDs. For categorical data, we calculated proportions and presented them as total numbers and percentages. To assess whether the prevalence of overweight and obesity differed significantly between subgroups, we utilized Chi-square tests. Statistical significance was determined at the conventional level ($P < 0.05$).

To analyze associations between potential risk factors and obesity, we classified the child's BMI-based overweight/obesity status as a binary variable, with 0 denoting "normal" and 1 denoting "overweight/obese".³⁶ We selected putative risk factors based on clinical knowledge and previously reported associations, using common stopping rules and logistic regression algorithms.^{41,42} We conducted univariate regression analysis to identify variables related to overweight/obesity, applying a significance threshold of $P < 0.05$ for each potential risk factor to be included in the candidate set of variables.⁴³ Next, we employed the least absolute shrinkage selection operator (LASSO) regression model to shrink the coefficients of unimportant predictors to 0, automatically selecting candidate variables with non-zero coefficients. Using LASSO regression analysis, we further screened variables related to overweight/obesity. Finally, we performed multivariate regression analysis to identify optimal key variables associated with overweight/obesity, adjusting for important potential confounding variables. The individual effects of childhood risk factors significantly associated with childhood obesity ($P \leq 0.05$) in the logistic regression model were presented as standardized regression coefficients and estimated adjusted odds ratios (ORs).² To examine whether the effect of a variable on the outcome (overweight/obesity) depended on the level of the sex variable, we performed logistic regression analyses, including interaction terms between sex and each independent variable.^{44,45} Significant pairwise interaction terms between sex and the identified variable factors were then explored. All analyses were conducted using R (version 4.2.0).

Ethical Considerations

This study received approval from the Institutional Review Board at Hainan Women and Children Healthcare Hospital for Education and Research (HNWCMC Ethical Approval 2016[16]). Potential participants received a package containing information about the study's objectives and a research consent form. Interested participants were requested to return the signed consent form. Informed consent to participate was obtained from the parents/guardians of the children.

Results

Characteristics of the Study Population

The study included 13,896 participants who underwent concurrent weight and length measurements between the ages of 0 to 6 years. The sample comprised 52.8% boys and 47.2% girls. Of these, 11.5% were classified as infants, 18.1% as toddlers, and the remaining 70.5% as preschoolers ([Supplemental Table 1](#)). In addition, we analyzed 26 numerical variables and 39 categorical variables. The distributions of numerical data are presented in [Supplemental Table 2](#), while the distributions of categorical data are detailed in [Supplemental Table 1](#).

Comparison of BMI Growth Profiles

To analyze the BMI distribution, we categorized BMI values based on age and gender ([Table 1](#)). BMI increased from infancy to toddlerhood and subsequently declined from toddlerhood to the preschool stage ([Figure 1](#)). The highest median BMI values, 17.8 for boys and 17.3 for girls, were observed at the age of 1 year. BMI then declined to its lowest points of 15.9 for boys at the age of 5 and 15.5 for girls at the age of 6 ([Table 1](#)).

Compared with the 2005 national growth curves for Chinese children,³¹ BMI values for toddlers and preschoolers in this study closely resembled the corresponding national median BMI values, with only minimal differences. However, infants born in 2016 exhibited higher BMI values than those reported in the 2005 national reference BMI, with increases of 4.3 for boys and 3.9 for girls. This indicates that infants born in 2016 had higher BMI values than their 2005 counterparts ([Figure 1](#)).

The BMI growth profiles for boys and girls followed a similar pattern ([Figure 1](#)), but BMI values for boys were significantly higher than those for girls ($P < 0.001$). A rapid decrease in BMI was observed between the ages of 1 and 2, with a reduction of 1.4 for boys and 1.1 for girls. Following this period, BMI gradually declined from ages 2 to 6.

Table 1 BMI Statistics of Children and Adolescents in China

Age	Gender	Mean	SD	Minimal	Lower Quartiles	Median	Higher Quartiles	Maximal
0	Boys	17.4	1.9	9.9	16.2	17.4	18.6	29.8
	Girls	17.0	1.8	10.9	15.8	16.9	18.2	27.7
1	Boys	17.9	1.7	8.6	16.9	17.8	18.9	28.4
	Girls	17.4	1.6	8.1	16.4	17.3	18.4	24.2
2	Boys	16.6	1.5	12.6	15.7	16.4	17.3	27.7
	Girls	16.3	1.4	11.4	15.5	16.2	17.0	23.0
3	Boys	16.3	1.5	12.2	15.3	16.2	17.0	25.6
	Girls	15.9	1.4	11.3	14.9	15.8	16.7	21.7
4	Boys	16.1	1.9	8.6	15.0	16.0	17.0	26.9
	Girls	15.8	1.7	10.1	14.7	15.6	16.8	26.1
5	Boys	16.1	2.1	10.0	14.9	15.9	17.0	28.8
	Girls	15.7	1.8	10.1	14.6	15.6	16.6	27.2
6	Boys	16.7	2.7	11.1	14.9	16.0	17.7	35.8
	Girls	16.0	2.3	11.6	14.4	15.5	16.9	29.6

Notes: BMI distribution was expressed as mean, standard deviation (SD), minimal, lower quartiles, median, higher quartiles, and maximal BMI. BMI in quartiles were defined according to BMI percentiles (lower quartiles = 25th percentile, median = 50th percentile, higher quartiles = 75th percentile).

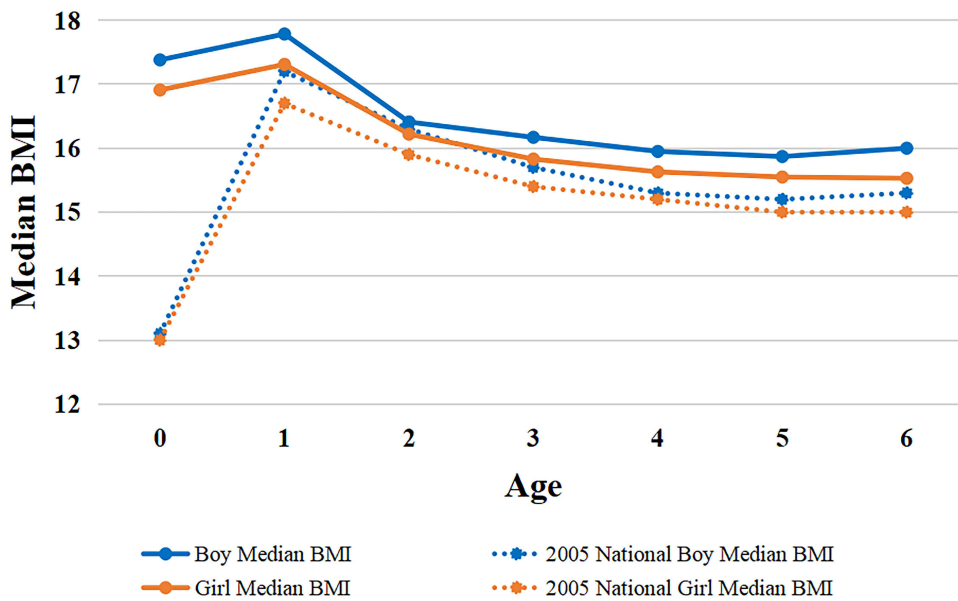


Figure 1 Comparison of BMI-for-age growth curves. The BMI-for-age graph displays two longitudinal BMI data lines (solid lines) for 2016 in China, alongside the China national reference data from 2005 (dashed lines). The enclosed circles on the Y-axis indicate BMI medians for respective ages. Each set of circles connected by a line across ages (years) at the X-axis represents the BMI-for-age growth profiles for either boys (the blue solid/dashed lines) or girls (the Orange solid/dashed lines).

Evaluation of Prevalence of Overweight and Obesity

A total of 1,595 infants, 2,510 toddlers, and 9,791 preschoolers were evaluated for overweight and obesity ([Supplemental Table 1](#)). [Table 2](#) provides a comparison of the prevalence of normal weight, overweight, and obesity among Chinese children during infancy, toddlerhood, and preschool years.

The overall prevalence of overweight increased by 10.9%, rising from 7.5% during infancy/toddlerhood to 18.4% during preschool ([Table 2](#)). This highlights a more pronounced issue of overweight prevalence in the preschool period. Similarly, the difference in total obesity prevalence between preschool and infancy/toddlerhood was substantial, further supporting this observation. Overweight prevalence in boys was significantly higher than in girls, and obesity prevalence among preschool boys exceeded that of preschool girls. These findings indicate a higher likelihood of overweight and obesity in boys, particularly during the preschool years.

Correlation Between Physical Measurements and Obese Statuses

To examine potential correlations between overweight/obesity and physical measures, we initially compared systolic and diastolic blood pressure across the normal weight, overweight, and obesity groups. Among preschoolers ([Figure 2](#)), no significant differences in blood pressure were observed between the overweight and normal weight groups ($P>0.05$).

Table 2 Prevalence of Normal Weight, Overweight, and Obesity

Stages		Prevalence (%) of Normal Weight	Prevalence (%) of Overweight	Prevalence (%) of Obesity
Infancy and toddlerhood	Boys	91.4	8.6	0
	Girls	93.7	6.3	0
	Total	92.5	7.5	0.0
	P value		< 0.01	
Preschool	Boys	67.1	20.2	12.6
	Girls	76.0	16.3	7.7
	Total	71.3	18.4	10.3
	P value		< 0.001	< 0.001

Notes: Chi-square test compared the overweight rates of boys and girls at each stage: Infants and toddlers (<2 years old) and preschoolers (2–6 years old).

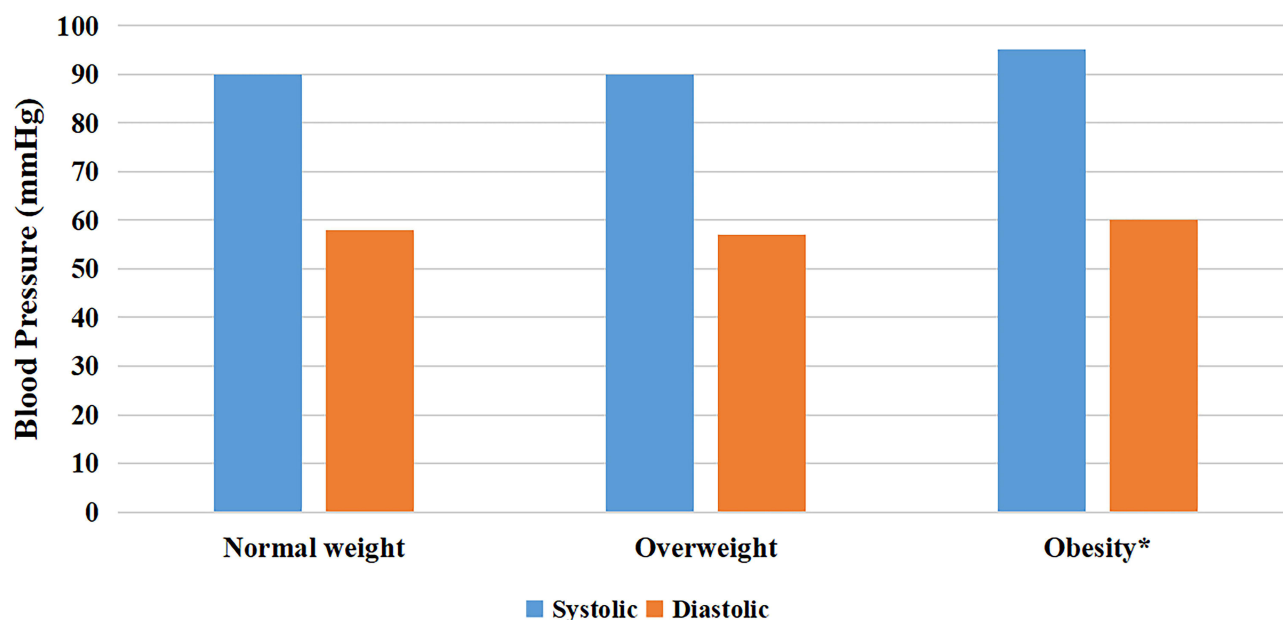


Figure 2 Comparison of blood pressures in the normal weight, overweight, and obesity groups. Blood pressure measurements (mmHg) are presented as bar graphs along the Y-axis and were compared across the normal weight, overweight, and obesity groups on the X-axis. Within each group, distinctions were made between systolic (blue bars) and diastolic (Orange bars) blood pressures. The lengths of individual bars symbolize the mean blood pressures. A star marker (*) appended to the “obesity*” group name signifies significant blood pressure differences between the obesity and normal weight groups, as well as between the overweight and obesity groups.

However, the obesity group exhibited significantly higher mean blood pressure values ($p < 0.001$), with systolic pressure increasing by approximately 5 mmHg and diastolic pressure rising by 2–3 mmHg than the normal weight and overweight groups.

Subsequently, we established the 95th percentile systolic blood pressure value as the threshold for identifying significantly high blood pressure. Among participants aged 2–6, 4.3% of normal-weight preschoolers and 3.1% of overweight preschoolers exhibited significant high blood pressure, while the obesity group had a prevalence of 13% (Figure 3). The prevalence of significant high blood pressure was 8.7% and 9.9% higher ($P < 0.001$) in the obesity group than in the normal weight and overweight groups, respectively, for preschoolers.

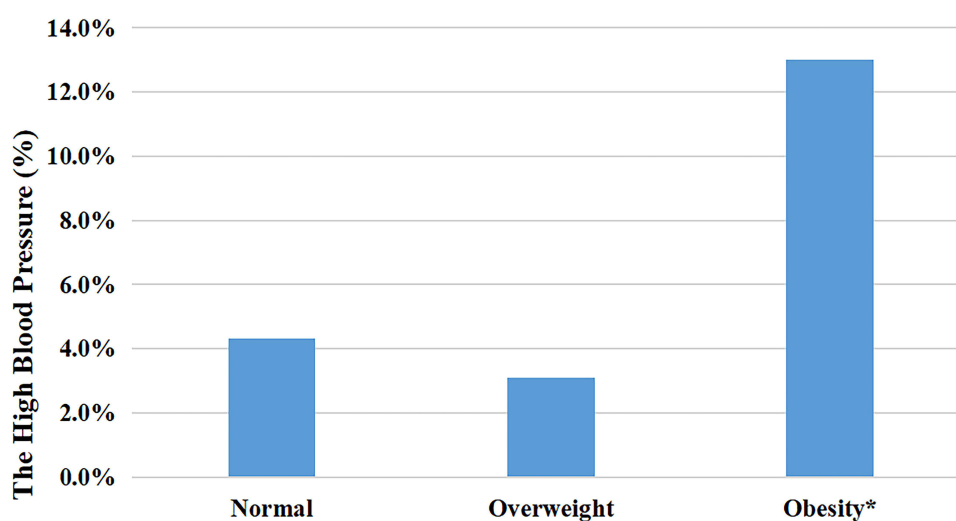


Figure 3 Prevalence of high systolic blood pressure. Bar graphs illustrate the prevalence of high systolic blood pressure along the Y-axis. Prevalence was compared among the normal weight, overweight, and obesity groups, indicated by the length of individual bars. An asterisk (*) attached to the “obesity*” group label signifies significant differences in prevalence between the obesity and normal weight or overweight group.

Table 3 Comparison of Physical Measurements Among the Normal Weight, Overweight, and Obesity Groups

Groups	Waist		Hips	
	Size (cm)	SD	Size (cm)	SD
Normal	50.6	5.0	55.7	6.2
Overweight	54.2	5.7	59.4	6.7
Obesity	60.5	8.1	66.2	9.0
P values	< 0.0001		< 0.0001	

Lastly, we compared two additional physical measurements—waist and hip sizes—across the normal weight, overweight, and obesity groups. Statistically significant increases were observed between the overweight and normal weight groups, as well as between the obesity and overweight groups (Table 3, $-P < 0.0001$). Obese children exhibited a waist size difference of 9.9 cm compared with the normal weight group and 6.3 cm compared with the overweight group. Similarly, hip size increased by 3.7 cm and 10.5 cm when comparing the normal weight group to the overweight and obesity groups, respectively.

Identification of the Most Influential Data Factors

Multivariate logistic regression analysis identified nine significant variables (Figure 4 and Supplemental Table 3). Odds ratios (ORs) were arranged in descending order. An OR value greater than 1.0 ($OR > 1.0$) indicates a positive association with overweight or obesity, while an OR value < 1.0 suggests a negative correlation.

Six variables were identified as risk factors for overweight or obesity, while three variables were associated with a reduced likelihood of overweight or obesity, including guardian (parents or grandparents), father's height, and the frequency of weekly candy consumption.

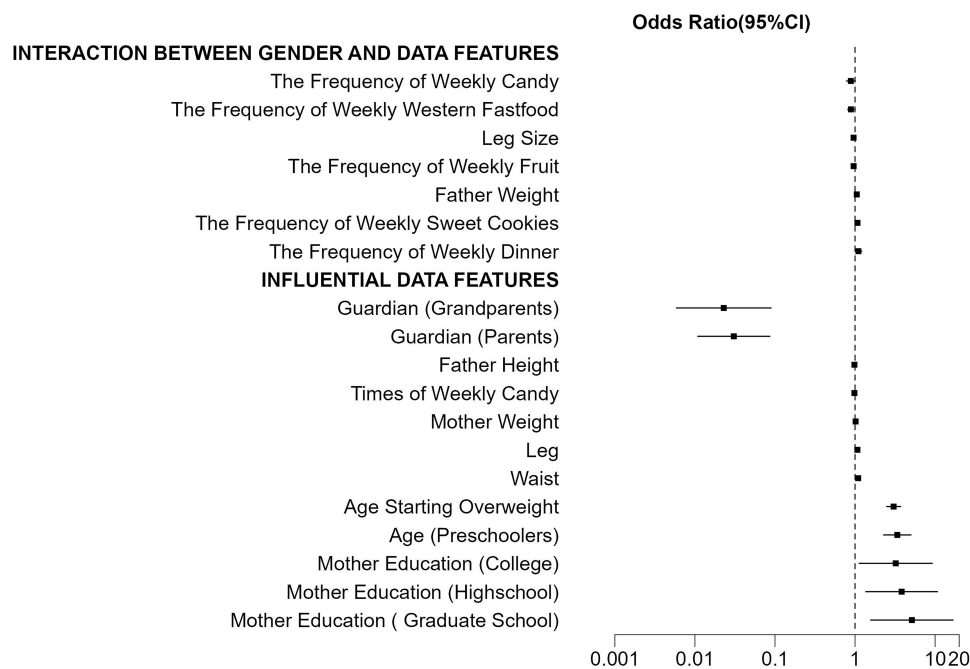


Figure 4 Ranking of the most influential data factors for overweight or obesity. The most influential data factors are listed on the Y-axis. Within each group, the odds ratios (ORs) for individual data factors are represented using bar graphs and organized in descending order along the X-axis.

Age group (preschool) and age at the onset of overweight consistently emerged as strong predictors of BMI classification. For instance, the preschool age group had an OR of 3.37, indicating a statistically significant difference between preschoolers and infants ($P < 0.0001$, [Supplemental Table 3](#)). In contrast, no significant difference was observed between infancy and toddlerhood ($P > 0.05$). These results suggest that the likelihood of overweight or obesity events becomes more pronounced during the preschool years.

Sex Differences in the Risk of Overweight/Obesity: Interaction with Independent Variables

To explore whether associations between potential risk factors and overweight/obesity varied by sex, multivariate logistic regression analyses including interaction terms were conducted. Seven significant interaction terms were identified, indicating sex-specific differences in these relationships ([Figure 4](#)). Four interaction terms, including the frequency of weekly candy consumption, Western fast food consumption, leg size, and fruit consumption, were negatively associated with overweight/obesity in girls. Conversely, three interaction terms, including father's weight, frequency of sweet cookie consumption, and weekly dinners, were positively associated with overweight/obesity in girls.

Dietary habits accounted for four out of the seven interaction terms ([Figure 4](#)), suggesting that sex moderates the relationship between dietary factors and overweight/obesity.

For instance, frequent candy or fruit consumption had a smaller impact on girls than boys. Girls were 11% less likely to be overweight or obese than boys with more frequent candy consumption ([Supplemental Table 3](#)). Similarly, each additional weekly serving of fruit was associated with a 4% greater reduction in the likelihood of being overweight in girls compared with boys. Thus, the negative associations between weekly candy/fruit consumption and overweight/obesity were less pronounced in girls. In contrast, the interaction terms for sweet cookies and dinner consumption showed positive associations with overweight/obesity in girls. In contrast, each additional weekly serving of sweet cookies or dinners was associated with a 7% or 10% increase in the likelihood of being overweight or obese in girls compared with boys, respectively ([Supplemental Table 3](#)).

Discussion

In this study, we conducted a cross-sectional analysis of 13,896 Chinese children aged 0–6 years in 2016 to investigate the prevalence and risk factors for overweight and obesity in preschool children. This represents the first comprehensive examination of overweight and obesity risks among this age cohort in China, utilizing a large sample size and a broad range of measurement indicators to intricately estimate weight-for-height (WhtR) and BMI ratios, identifying early risks for overweight and obesity in children.

Our results indicate that children born in 2016 exhibit a notably higher BMI than those born in 2005. Specifically, BMI was significantly elevated in male children compared with female children, highlighting an increased risk of overweight and obesity during the preschool years among males.⁴ Through our analysis of various risk factors pertinent to early childhood overweight and obesity, we identified nine risk factors ([Figure 4](#)).

A review of the literature from the past decade illustrates an upward trend in the prevalence of overweight and obesity among Chinese children. For instance, research by Piernas et al (2011) recorded that among Chinese children aged 2–6 years, overweight prevalence was 10% and obesity prevalence was 12%.⁴ Consistent with these findings, China's Center for Disease Control and Prevention reported that approximately 120 million children under the age of 18 were overweight or obese in 2012.² In alignment with global data, a Canadian study published in 2015 highlighted that 18.8% of children were at risk of being overweight.¹ Our findings identify the prevalence of overweight and obesity among Chinese preschool children in 2016 as 18.4% and 10.3%, respectively—a prevalence comparable to that of low-income African American children in the US.²¹

Upon further examination of prevalence rates, we observed significantly higher rates of overweight and obesity among preschool boys than girls, at 3.9% and 4.9%, respectively, suggesting a gender-specific risk factor for childhood obesity. The periods of fetal growth and the first two years post-birth may serve as critical windows for obesity

development and associated behavioral habit formation, underscoring the essential nature of early intervention in infants identified at risk of obesity.

By employing logistic regression, we examined the association between potential risk factors and overweight/obesity in preschool children. We found that, relative to infants and toddlers, the odds of overweight/obesity risk during the preschool years were significantly amplified, highlighting this period as critical for combating early childhood overweight and obesity.

These BMI patterns are consistent with findings from other studies. It is well-established that BMI rapidly increases during the first year of life, then decreases and reaches its nadir around 6 years of age. This point, known as the “adiposity nadir”, marks the stage at which body fatness is at its lowest level.⁴⁶ Supporting our findings, US research has highlighted that the incidence of overweight in preschool children surpasses that seen in infants and toddlers. National surveys estimate that 8.1% of infants and toddlers have a weight exceeding the standard for their length, compared with 25.6% of preschool children being overweight, as reported in a Canadian cohort study.⁴⁷

Our study is pioneering in shedding light on the association between the age of onset for obesity and the propensity for obesity in preschool children. Previous research has established that early-onset obesity is associated with a greater overall fat mass and body fat percentage in adulthood, as well as a heightened risk of severe obesity.⁴⁸ Preventing or postponing the onset of obesity and, subsequently, reducing cumulative exposure to an obesity-conducive environment could significantly lessen the risk of developing diabetes later in life.⁴⁹

The importance of parental BMI as a risk factor was corroborated in our research. Children with overweight or obese parents were found to be at a greater risk of becoming overweight or obese than those with parents of normal BMI. Numerous studies have reinforced the correlation between parental obesity and childhood overweight/obesity, such as the Iranian study from 2019, research by Bider-Canfield et al, the German childhood obesity study by Danielzik et al,⁵⁰ and the 2020 Bosnian study.³⁷ These studies collectively suggest that parental obesity status is linked to childhood overweight/obesity.

The familial environment and parental behavioral patterns also appear to influence a child’s weight status. Parental affinity for high-fat foods, high-sugar snack consumption, and sedentary lifestyles can all drive childhood weight gain. Parental obesity’s effect on childhood overweight/obesity is influenced by genetic predisposition⁵¹ and behavioral imitation.⁵²

The relationship between candy consumption and weight gain was not unequivocally established, although it might intuitively be assumed. Contrarily, in preschool girls, there was a negative correlation between the frequency of candy consumption and overweight/obesity status ([Supplemental Table 3](#) and [Figure 4](#)).

In line with our data, a study analyzing the influence of chocolate or candy consumption on children aged 2–13 years (n=7049) found that candy consumption correlated with a lower likelihood of being overweight, lower BMI, reduced waist circumference, and lower weight-for-age percentile/standard deviation scores compared with non-consumers. Candy consumers were 22% and 26% less likely to be overweight or obese, respectively, suggesting that candy consumption does not negatively impact health risk markers in children and adolescents.⁵³ A longitudinal Swedish study also reported a negative correlation between candy intake and overweight/obesity, adjusted for potential confounders.⁵⁴

However, “sweets” consumption, which includes a broader range of products beyond candy, has frequently been linked to an increased risk of overweight status.⁵⁵ Further, several studies have identified the rising consumption of added sugars, particularly high-fructose corn syrup in American foods, as a contributing factor to escalating obesity rates.^{56–59}

Given the significant gender differences in the prevalence of overweight and obesity ([Table 2](#)), the impact of some risk factors may seem minor when evaluated individually in a multivariate logistic regression model. However, these effects can become more pronounced through interactions with gender. Most association studies focus on significant risk factors individually, often overlooking smaller effects and potential interactions between factors.⁶⁰

In addition to the two known variables (weekly candy consumption and leg size), we identified five additional variables with small individual effects but significant interactions with gender regarding overweight/obesity outcomes ([Figure 4](#)). Of these interaction terms, 71% (5 out of 7) relate to dietary habits, indicating possible differences in how boys and girls metabolize foods like candy, sweet cookies, fruit, and Western fast foods. Three of the five dietary interaction terms suggested that the negative associations between these dietary patterns and overweight/obesity were less pronounced in girls than in boys ([Figure 4](#)).

Conversely, the adverse effect of consuming sweet cookies or having dinner more frequently on overweight/obesity diagnosis was more severe in girls.

The mechanisms of gender interactions in childhood overweight/obesity outcomes are unclear, although some evidence exists from adult studies. Known sex differences in dietary habits can influence the impact of gender-related biological factors on glucose tolerance.^{61–63} Prospective studies and randomized controlled trials consistently indicate that increased fruit intake significantly contributes to weight loss in women.⁶⁴ Men and women exhibit different food cravings, with men typically craving savory foods and women craving sweet foods. The ketogenic diet, high in fat and protein and low in carbohydrates, has been shown to aid weight control in overweight individuals.⁶⁵

Our study does bear certain limitations that should be acknowledged. Firstly, the cross-sectional design and use of a convenience sample limit the establishment of causality and the assessment of long-term obesity risks. Additionally, while incorporating 65 data variables in estimating overweight/obesity risk, several factors were not considered, such as parental characteristics, feeding patterns, or body composition data, which were unavailable in the present study. Moreover, the sample was drawn from a limited number of cities and regions in northern and southern China, primarily involving centralized childcare, leading to the underrepresentation of many ethnic minority groups and limiting the generalizability of study findings.

Future studies should consider broader and more diverse samples across varied geographical regions. Research should also include objective measurements of parental weight, height, waist circumference, and genetic susceptibility, as well as explore the impact of parental roles and societal status on children's health. The adoption of longitudinal study designs would further elucidate the relationship between predictive factors and children's obesity status over time.

Conclusion

This study investigated BMI growth profiles and compared the prevalence of normal weight, overweight, and obesity in infants, toddlers, and preschool children from different age cohorts in China. Significant correlations were observed between children's weight status and nine data variables or seven gender interaction terms. Based on the risk factors analyzed, there is a manifest necessity for early intervention programs targeting children with overweight or obese parents to foster healthier lifestyles.

Data Sharing Statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethical Approval and Consent to Participate

The Institutional Review Board at Hainan Women and Children Healthcare Hospital for Education and Research approved the study (HNWCMC Ethical Approval 2016 [16]). The study was conducted in accordance with the Declaration of Helsinki.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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