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Original article

Possible role of birth weight on general and central obesity in Chinese children and adolescents: a cross-sectional study

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ABSTRACT

Purpose: According to the developmental origins of health and disease theory, fetal nutrition is associated with obesity and chronic diseases in children and adults. However, previous findings regarding the association between birth weight and childhood obesity have been inconsistent. The aim of the present study was to investigate the relationship between birth weight and childhood obesity in China.

Methods: The 16,580 subjects (8477 boys and 8103 girls) aged 7–17 years, who participated in this study were recruited from a cross-sectional study in six cities in China. Epidemiological data, including birth information, were collected through face-to-face interviews, and anthropometric indices were measured by trained physicians. Overweight and obese cases were defined using sex-specific and age-specific 85th and 95th percentile body mass index (BMI) cutoffs for Han children and adolescents. Central obesity was defined using sex-specific waist-to-height ratio (WHtR) cutoffs (WHtR $\geq$0.48 in boys and WHtR $\geq$0.46 for girls).

Results: The overall rate of overweight status and obesity was 20.3% in the Chinese children and adolescents and that of central obesity was 18.9%. Subjects were stratified into eight groups according to weight at birth. J-shaped relationships were observed between birth weight and BMI for age Z-score and WHtR. After adjusting for confounders such as gender, gestational age, parental factors, and dietary factors, the risk of overweight and obese status was still higher in the children with higher birth weights than in children with birth weights of 3000–3499 g (3500–3999 g: odds ratio [OR] = 1.14, 95% confidence interval [CI] = 1.02–1.28; 4000–4499 g: OR = 1.39, 95% CI = 1.19–1.63; and 4500–4999 g: OR = 1.36, 95% CI = 1.06–1.76). Moderately high birth weight also increased the risk of central obesity. Relative to the children with normal birth weights (3000–3499 g), the adjusted OR and 95% CI were 1.33 (1.13–1.56) in children with birth weights of 4000–4499 g. Children with very low birth weight (lower than 1500 g) had the highest risk of central obesity. The adjusted OR was 2.30 (95% CI: 1.03–5.14) relative to children with birth weights of 3000–3499 g.

Conclusions: Birth weight was associated with obesity in Chinese children and adolescents. J-shaped relationships were observed between birth weight and BMI and WHtR in childhood, and very low birth weight was associated with a mild increase in the risk of central obesity in Chinese children and adolescents.

The authors declare that they have no competing interest.

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Background

The prevalence of obesity in children has increased at an alarming rate in both developed and developing countries [1–4]. Childhood obesity is of particular concern because it has been widely reported to have adverse consequences on mortality and morbidity in adulthood [5–9].There has been an increasing focus that early life events might play an important role in childhood obesity [10–12]. The Developmental origins of health and disease (DOHaD) hypothesis, initially proposed by David Barker, states that poor fetal nutrition causes adaptations that increase future propensity to obesity, diabetes, and cardiovascular diseases [13,14]. Prenatal features, such as abnormal birth weight (low birth weight or high birth weight), which are used in many studies as proxies for fetal growth, might be directly associated with body mass index in childhood [12].

After this hypothesis, a number of epidemiological studies have examined the association between birth weight and later obesity. However, the results of previous works have been inconsistent. Curhan et al. [15] observed a U-shaped relationship in the Nurses' Health Study I. This relationship was replicated in the Nurses' Health Study II and another study on American women [16]. A study from China showed the incidences in obesity and overweight status in adolescence to be 33.3% in subjects with high birth weight and 38.9% in those with low birth weight, both significantly higher than in subjects with normal birth weight (16.2%) [17]. However, other investigators have been unable to show either high birth weight or low birth weight to be associated with an increased propensity for obesity [18–20]. Linear relationships (positive and inverse) have also been reported. For example, inverse relationships were found between birth weight and BMI, waist-hip ratio, and total abdominal fat [21–24]. However, other studies have suggested that birth weight is positively associated with BMI in later life [25–28]. For instance, Hirschler performed a study in Argentina, where she found high birth weight (HBW; birth weight $\geq$4000 g) to be associated with an increased risk of overweight status and obesity (OW/OB; odds ratio [OR] = 2.48, 95% confidence interval [CI] = 1.62–3.81) and metabolic syndrome (OR = 3.16, 95% CI = 1.38–7.24) and found low birth weight (LBW, birth weight $<$2500 g) to be a protective factor for OW/OB [25]. One study performed on Canadian children found that the risk of obesity increased with an OR of 1.05 (95% CI = 1.00–1.09) for every 100 g of birth weight [26]. The differences in the results might be due to the different ranges of birth weight used in these studies. Owing to the limited sample sizes, previous studies did not examine the associations between different ranges of LBW with obesity. The aim of this study was to evaluate the relationship between birth weight and obesity using a relatively large-scale sample of Chinese children and adolescents.

Methods

Subject

The subjects in this study were recruited from a previous cross-sectional investigation of metabolic syndrome in children and adolescents. This investigation was conducted in 2010 on the students aged 7–17 years in China and has been described in detail previously [29]. The study protocols were approved by the Research Ethics Committees at School of Public Health and Medical Ethics Committees at the Children's Hospital of the Zhejiang University College of Medicine. All the participants and their guardians provided written informed consent.

Data collection and measurements

Anthropometric measurements

Anthropometric indices, including weight, height, and waist circumference (WC), were measured by well-trained investigators, after a standard protocol [29]. Height and weight were measured with the participants wearing light clothing and without shoes. WC was measured at the midpoint between the iliac crest and lowest rib. The anthropometric indices are here reported as the average of three repeated measurements. BMI was calculated as the individual's body weight in kilograms divided by the square of his or her height in meters. Waist-to-height ratio (WHtR) was calculated as WC in centimeters divided by the height in centimeters.

Definitions

Body mass index (BMI) was calculated as body weight divided by height squared (kg/m^2), and WHtR was calculated as WC in centimeters divided by the height in centimeters. BMI was used for age Z-score (BAZ) to standardize the value of BMI across different ages and genders. Given a child's age, gender, BMI, and an appropriate reference standard, a BMI Z-score could be calculated [30]. Here BAZs were established using BMI reference material issued by the World Health Organization 2007 (5–19 years) [31].

Overweight status was defined as body mass index (BMI) $\geq$85th percentile and $<$95th percentile of the BMI reference data for Han children and adolescents according to age and gender. Obesity was defined as BMI $\geq$95th percentile of the BMI reference data [32]. Central obesity was defined as WHtR is 0.48 or more in boys and WHtR is 0.46 or more in girls according to the definition of metabolic syndrome by Chinese Medical Association [33]. Subjects were divided into eight categories by birth weight: $<$1500 g, 1500–1999 g, 2000–2499 g, 2500–2999 g, 3000–3499 g, 3500–3999 g, 4000–4499 g, and $\geq$4500 g.

Potential confounding factors

Demographic variables including gender, age, gestational age, stage of pubertal development, area of residence, parental BMI, parental smoking status, food preference (meat-dominant diet, balanced diet, and vegetable-dominant diet), and salt intake (light salt, moderate salt, and heavy salt) were determined in face-to-face interviews with the participants and their parents. Stage of pubertal development was assessed using parents' descriptions of their children's secondary sex characteristics associated with the five standard Tanner stages [34,35].

Statistical analyses

Normally distributed variables were expressed as means $\pm$ standard deviation and were compared using Student's t test. Categorical variables are here expressed as frequencies (percentages); they were compared using χ^2 tests. Analysis of variance was used to compare BAZ and WHtR among different groups of birth weight. Binary logistic regression was used to analyze associations of birth weight with OW/OB and central obesity in childhood. All the tests were two sided, and results were considered significant at 0.05. Statistical analyses were performed using SPSS for Windows (SPSS 17.0 Inc., Chicago, IL).

Results

Subject characteristics

Here, 16,580 subjects aged 7–17 years participated in this study. The demographic data and anthropometric variables of the subjects