Weight self-misperception and Obesity-related Knowledge, Attitudes, Lifestyle Behaviors and Cardio-metabolic Markers among Chinese School-aged Children and Adolescents

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Abbreviations

Blood pressure, BP; Body mass index, BMI; Total cholesterol, TC; Triglyceride, TG; Low-density lipoprotein cholesterol, LDL-C; High-density lipoprotein cholesterol, HDL-C

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Abstract

Objective: The relationships between childhood weight self-misperception and obesity-related factors particularly health markers have not been extensively discussed. This study aims to examine the associations between weight self-misperception and obesity-related knowledge, attitudes, lifestyles and cardio-metabolic markers among Chinese pediatric population.

Design: Cross-sectional study.

Setting: Data sourced from a national survey in Chinese seven provinces in 2013.

Participants: Children and adolescents aged 5-19 years.

Results: Of the total 14079 participants, there were 14.5% and 2.2% participants over-estimated and under-perceived their weight, respectively. Multi-variable logistic regression was applied to calculate odds ratio (OR) and 95% confidence interval (95% Cl) of obesity-related behaviors and cardio-metabolic markers by actual and perceived weight status. Individuals who perceived themselves as overweight/obese were more likely to have prolonged screen time, insufficient dairy intake, and over sugar-sweetened beverages consumption (all $P<0.05$), regardless of their weight. Furthermore, actual overweight/obese individuals had higher odds of abnormal cardio-metabolic markers, but a smaller magnitude of association was found among weight under-estimators. Among non-overweight/obese individuals, weight over-estimation was positively associated with abdominal obesity (OR: 10.49, 95% CI: 7.45, 14.76), elevated blood pressure (OR: 1.30, 95% CI: 1.12, 1.51), and dyslipidemia (OR: 1.43, 95% CI: 1.29, 1.58).

Conclusions: Weight over-perception was more prevalent than under-estimation, particularly in girls. Weight over-estimators tended to master better knowledge but behave more unhealthily, both weight over-perception and actual overweight/obesity status were associated with poorer cardio-metabolic markers. Future obesity intervention programs should additionally pay attention to the population with inaccurate estimation of weight who were easily overlooked.

Keywords: Weight perception, knowledge, behaviors, childhood cardio-metabolic markers, China

Implications and Contribution:

Children and adolescents who over-estimated their weight tended to master better knowledge but behave more unhealthily, both weight over-perception and actual overweight/obesity status were positively related with abdominal obesity, elevated BP and dyslipidemia. Future national obesity-related intervention programs in children and adolescents should additionally pay attention to the population with inaccurate estimation of body weight.

Introduction

The prevalence of childhood overweight and obesity increased at an alarming rate over the past decades in China[1]. Childhood overweight and obesity is correlated with elevated blood pressure (BP)[2] and other chronic disease[3]. Apart from the recognized physiological results, depression[4], anxiety[4], and low self-esteem[5] might also result from obesity.

Weight perception refers to an individual's evaluation of body image with all of the thoughts concerning weight and appearance. Misperception of weight status, defined as under- or over-estimating actual weight, is prevalent among pediatric population[6]. It was reported that over one-third of children misperceived their weight status in Guangzhou, China[7]. The discrepancy between one's perceived and actual weight classification may provide insight for healthy behaviors[7]. Weight over-perception seemed to be a major contributing factor for the increased prevalence of unhealthy dietary or exercise patterns[8], such as binge eating[9], skipping breakfast and not discussing nutrition topics over meals[10].

While multiple studies have examined the associations between weight misperception and lifestyles, only a few studies have examined the measurable health markers. Sonneville and his colleagues revealed that overweight/obese people who under-perceived their weight gained significantly less weight over time than those who perceive themselves as overweight[11]. In addition, overweight/obese adolescent girls who perceived themselves as normal weight had lower BP in adulthood[12]. Besides, after adjusting for an extensive range of confounders including socio-demographic profiles, body mass index, severe chronic conditions, and behaviors (smoking/drinking/exercise), weight status over-perception (vs. accurate perception) was positively associated with depressive symptoms in women with normal weight[13]. Among Korean samples, Kim *et al.* suggested that perception of being

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obese might be an unfavorable indicator of cardio-metabolic health regardless of actual body weight[14]. Among men, those who classified their weight as being obese (vs. normal) were more likely to have high BP and high TG, while women tended to develop low HDL-C[14]. In the population of Chinese, hypertension and dyslipidemia were negatively associated with weight underestimation[15], but Mogre et al. reported that participants with higher blood glucose were not significantly associated to underestimation of weight in Tamale, Ghana[16]. Nevertheless, there was a lack of evidence regarding the relationships between weight perception and measurable health markers in Chinese pediatric population. Given the identified associations between weight and multiple cardio-metabolic markers, we hypothesized that weight perception might play an important role in childhood obesity-related health outcomes.

Previous studies investigating the weight perception among Chinese younger-aged populations mainly focused on a single city, such as Guangzhou[7], Wuhan[17], Shandong and Qinghai[8], and Jilin[18]. Based on a national sample aged 6-17 years derived from China Health and Nutrition Survey, authors only focused on the effects on dietary intake[19] and dietary weight management behaviors[20], while lack of evidence regarding the impact on negative obesity-related diseases in Chinese pediatric population. To fill this research gap, we sought to examine the associations between weight self-misperception and obesity-related knowledge, attitudes, lifestyle behaviors and multiple cardio-metabolic markers (abdominal obesity, elevated BP, high blood glucose and dyslipidemia) among a nationally representative sample of school-aged children and adolescents, based on cross-sectional data in Chinese seven provinces. We also examined whether the associations differed across sex, age and residence area.

Methods

Study population and design

This study used data from a cross-sectional survey of children and adolescents in Chinese seven provinces/cities in 2013, including Hunan, Ningxia, Tianjin, Chongqing, Liaoning, Shanghai, Guangzhou. Briefly, we adopted a multi-stage cluster sampling method to determine the original population. We randomly selected several regions from each

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province, and chosen about 12 to 16 primary and secondary schools from each region. Two classes in each grade were randomly selected in these schools. We invited all students and their parents in these selected classes to participate in the survey. Among the original population of 16637 participants whose physical examination and blood samples were available, 2558 participants were excluded because of missing information on characteristics and weight perception, and the final sample size was 14079. The project was approved by the Ethical Committee of Peking University (No. IRB0000105213034). Written informed consent was obtained from both students and their parents or legal guardian.

Data collection and covariates

The child's questionnaire was performed to collect basic information and lifestyles. Besides, all parents were required to complete structured questionnaire. Both parental and child's questionnaire of children grade 1-3 were reported by parents. Children from or above the fourth grade would fill in child's questionnaire by themselves, while instructed by class teachers. After collection, we would recheck the questionnaires by 3% within one week for the same participants.

Parents were asked to report their own height (cm) and weight (kg), and body mass index (BMI) was calculated as the weight (kg) divided by the square of the height (m^2). According to the criteria of the Working Group on Obesity in China (WGOC) for Chinese adults[21], BMI cut-offs of 24 and 28 kg/m^2 were used to classify parental weight status into three categories: "normal", "overweight" and "obesity". Parental educational attainment was grouped into "primary school or below", "secondary or equivalent" and "junior college or above". In addition, we divided residence area into "rural" and "urban", and calculated monthly household income as the sum of monthly income (in CNY, Chinese yuan) of all household members and classified into <5000, or ≥5000 CNY.

Self-perception of weight status

Children's self-perception of weight status was assessed by asking: "How do you feel about your current weight status?", with five response options: "very thin", "rather thin", "average", "rather fat", and "very fat". Those who perceived themselves as "very thin", "rather thin" or "average" were combined into perceived non-overweight/obesity group, as the sample size of these was too small to analyze.

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Anthropometric measurement and group definition

Children's height (cm) and weight (kg) were measured by trained technicians following a standardized procedure. Height was measured using metal column height-measuring stands (200 cm long with 0.1 cm precision), and weight was measured using lever scales (weights to 120 kg with 0.1 kg precision). BMI (kg/m^2) was calculated by dividing weight (kg) by height (m) squared. Waist circumference (WC) was measured with an accuracy of 0.1 cm using a non-elastic tape at the end of a natural breath at the midpoint between the top of the iliac crest and the lower margin of the last palpable rib. Using a mercury sphygmomanometer (model XJ1ID, China) with the correct cuff size on the right arm of the participant in a relaxed and sitting position, blood pressure (BP) was measured. We measured each child twice at 1-min intervals, and used the average of the two readings for systolic blood pressure (SBP) and diastolic blood pressure (DBP) in final analysis. The stadiometers, lever type weight scales, non-elastic tape, and auscultation mercury sphygmomanometer were all calibrated, and the measuring instruments were similar at all investigated schools.

For students aged 5-17 years old, overweight/obesity was defined as BMI of children ≥ the referent age-and sex- specific 85th percentile according to the reference established by Working Group on Obesity in China (WGOC)[22]. For those aged 18-19 years, similar to adults, overweight/obesity was defined as BMI of greater than or equal to 28.0 kg/m^2. In order to avoid extreme few samples in the group of underweight, we categorized the actual weight status into non-overweight/obesity and overweight/obesity. We combined children's weight self-perception with actual weight, and divided participants into four groups: Group 1: non-overweight/obese participants with accurate estimation; Group 2: weight over-estimators; Group 3: weight under-estimators; Group 4: overweight/obese participants with accurate estimation. Since both the actual weight status and perceived weight status might influence the childhood obesity-related knowledge, attitudes, behaviors or health outcomes, Group 1 was therefore considered as a reference group.

Definition of abnormal cardio-metabolic markers

Abdominal obesity was defined as waist circumferences (WC) ≥ age- and sex-specific 90th percentile[23]. Children and adolescents with fasting blood glucose ≥5.6 mmol/L were defined as having high blood glucose. Elevated BP referred to SBP and/or DBP ≥90th

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percentile for sex, age, and height. In this study, the reference values for waist circumference and BP are based on the Chinese population[23, 24].

After fasting for 12 h, blood samples were obtained by venipuncture, centrifuged at 3000 rpm for 10 min and then stored at −80 °C. All biochemical analyses were carried out at a biomedical analyses company, which was accredited by Peking University[25]. Total cholesterol (TC), triglyceride (TG), low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C) were measured by an autoanalyzer (TBA-120FR, Toshiba, Tokyo, Japan), with TC and TG assayed by enzymatic method, while LDL-C and HDL-C measured using clearance method. Abnormal lipid was defined as follows[26]: High TC referred to TC ≥ 200 mg/dL. High TG was considered as TG ≥ 100 mg/dL in children 9 years old or younger, and ≥130 mg/dL in adolescents 10 years old and older. High LDL-C was defined as LDL-C ≥ 130 mg/dL, low HDL-C was regarded as HDL-C < 40 mg/dL. A participant with one or more abnormal lipid levels was defined as having dyslipidemia.

Weight-related knowledge, attitudes, and behaviors

Weight-related knowledge was assessed with 10 items. The responses of all items were: “true”, “false”, or “don’t know”. Total knowledge score was calculated by summing up the number of items which were correctly answered and deducting points which were incorrectly answered. If the answer was missing or “don’t know”, the score of this question was considered to be zero. Attitudes were evaluated with the questions: (1) “To what extent do you think obesity is bad for health?”. The responses for question (1) were “little”, “rather little”, “not sure”, “rather greatly”, or “greatly”. (2) “Are you satisfied with your weight status?” (3) “Do you want to change your present weight status?” and (4) “Do you believe you can achieve an ideal weight status through effort?”. The responses were “no”, “rather no”, “not sure”, “rather yes”, or “yes” for the questions (2)-(4).

For behaviors, the information of dietary behaviors was collected using questionnaires developed with reference to national Youth Risk Behavior Survey (YRBS) in 2005[27] (Additional information about the national YRBS is available at http://www.cdc.gov/yrbs.). All participants were asked the frequency (days) and servings of vegetables, fruits and sugar-sweetened beverages (SSBs) consumption[28]. To better understand the intake of

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fruit/vegetable, as previous published, one serving was defined as the size of an ordinary adult's closed fist and roughly equaled a medium-sized apple or orange (≈200 g)[29]. One serving of SSB was determined as a canned beverage (approximately 250 mL)[30]. The daily dietary intake of single food was calculated as: average daily intake=(days of consumption × servings in those days)/7. A daily consumption of 2~3 servings (300~500 g) of vegetables[31] and 2 servings (400 g) of fruits[32] is recommended for children and adolescents in China, insufficient vegetable and fruit consumption was therefore defined as <3 servings/day and <2 servings/day, respectively. In addition, based on Chinese dietary guidelines for children[33], we defined over SSBs consumption as >1 servings/week. Children also reported frequency (days or times) of breakfast, dairy products, and fried food (e.g., fried chicken and fried potatoes) intake over the preceding 7 days. Dairy products included low-/full-fat milk, cheese, yogurt and cottage cheese, except for the mixed foods that contain milk such as butter and ice-cream. Participants were asked "How many days, over the past 7 days, have you consumed dairy products?". Indeed, data on individual dairy products were not available. According to the dietary guidelines for school-age children in China (2016)[33], breakfast skipping and insufficient dairy intake were considered as <7 days/week, excessive fried food consumption was defined as >1 day/week.

For lifestyle behaviors, we recorded child's physical activity using the Chinese version of International Physical Activity Questionnaire-Short Form (IPAQ-C)[34], that is always a useful instrument for generating internationally comparable data on in Chinese population[35]. Moderate to vigorous physical activity (MVPA) was defined as any kind of aerobic activity that increased heart rate and breathing, such as running, basketball, football, swimming, etc. MVPA was asked by the following questions: "How many days, over the past 7 days, have you done MVPA? And how much time did you last on average?" Children reported the frequency (days) and duration (hours and minutes) for MVPA over the past 7 days, and the average daily time was calculated as follows: (days × duration in each of those days)/7. We defined physical inactivity as MVPA <1 h/day. The questionnaires collecting other lifestyle behaviors were developed based on the Information, Motivation and Behavioral skills Model[36]. Sitting and screen time were asked by the following question: "Over the past 7 days, how much time did you spend on sitting or lying down at school and at home (not

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including sleeping) / watching TV or playing computer or video games on average?", students reported the duration (hours and minutes) of sitting and screening per day, and both the prolonged sitting time and screen time were defined as ≥2 hours/day.

Unhealthy lifestyle score was calculated as follows: if one of the above-mentioned unhealthy lifestyles was satisfied, one point was added, otherwise one point was deducted.

Statistical analysis

Continuous and categorical variables were presented as mean ± standard deviation (SD) and frequency (percentage), respectively. Differences in demographic characteristics by four groups were examined by one-way ANOVA test for continuous variables and Pearson's Chi-squared test for categorical variables. Kappa test was used to evaluate the agreement between the perceived weight and actual weight status, with values of 0.00 to 0.20 considered slight, 0.21 to 0.40 fair, 0.41 to 0.60 moderate, 0.61 to 0.80 substantial, and 0.81 to 1.00 almost perfect agreement. We also adopted one-way ANOVA and Pearson's Chi-squared test to examine the difference between the four groups, with Bonferroni-corrected post hoc tests for multiple comparisons. The significance of Bonferroni formula was set at α=0.0125. Meanwhile, multivariate logistic regression model was applied to calculate odds ratios (ORs) [95% confidence level (95% CI)] of obesity-related behaviors and abnormal cardio-metabolic markers by actual and perceived weight status. Potential confounders were adjusted in the multivariate logistic regression model, including age, sex, residence area, ethnicity, family incomes, parental educational attainment, and parental weight status. Furthermore, stratified analyses were performed to explore the differences according to sex (boys, girls), age (5-9 years old, 10-14 years old, 15-19 years old), and residence area (rural, urban). Data were not shown if the number of participants in this group was too small to analyze. All statistical analyses were performed using Statistical Analysis System (SAS) software (version 9.4, SAS Institute, Cary, NC, USA), and we deemed *P*-values less than 0.05 to be statistically significant.

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Results

Characteristic of participants

Of the 14079 children, there were 2035 (14.5%) weight over-estimators and 309 (2.2%) under-estimators (**Table 1**). In general, weight over-estimators (Mean age=12.4 years, SD=3.0) tended to be older than those under-estimators (Mean age=9.2 years, SD=2.9) and accurate-estimators. The BMI values (kg/m^2) of children aged 5-9 years increased from 15.6 of non-overweight/obese children with accurate estimation to 18.1 of weight over-estimators. Similar escalating trend of BMI was observed in children aged 10-14 years and 15-19 years (P<0.01). In addition, most of individuals' parents in four groups attained education of secondary or equivalent, and most of the participants who over-perceived as overweight/obesity came from urban areas, while those who under-perceived their weight mostly came from rural areas. The multiple comparisons of baseline information between groups were described in **Supplementary Table 1**.

Consistency between perception of weight and actual weight status

Supplementary Table 2 presented the Kappa results showing the consistency between children's self-perception of weight and actual weight status. Of included children and adolescents, whilst there was a high degree of accuracy of weight status perception in those of non-overweight/obesity weight (70.8%), there was also a considerable proportion of individuals over-estimated their weight, approximately accounting for 14.5%. The consistency in the total population was of moderate agreement (Kappa=0.504, P<0.01). Similar moderate agreements were observed for boys (Kappa=0.554, P<0.01) and girls (Kappa=0.457, P<0.01), but such weight overestimation in those of non-overweight/obesity mainly occurred in girls than boys (girls: 16.3% *vs.* boys: 12.6%). Similar high rates of weight overestimation were also detected among 15-19-year-aged individuals and those with urban residence.

Prevalence of abnormal cardio-metabolic markers by actual and perceived weight status

Of the 14079 children and adolescents, most of the prevalence of abnormal cardio-metabolic markers, except for high blood glucose, differed by the four groups (P<0.01) (**Table 2**). Consistent with traditional cognition, individuals whose actual weight was overweight/obesity had higher prevalence of negative health outcomes. Besides, in the

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non-overweight/obesity groups, weight over-estimators also had higher prevalence of abnormal cardio-metabolic markers (high BP: 33.7%; dyslipidemia: 35.2%) than their counterparts who had accurate awareness of weight status (high BP: 24.1%; dyslipidemia: 27.0%). Age- and residence-specific prevalence of abnormal cardio-metabolic markers showed similar trends (**Supplementary Table 3**).

Obesity-related knowledge, attitude and behaviors by actual and perceived weight status

Table 3 presented obesity-related knowledge by weight estimation in two BMI categories. The correct rates of most knowledge items did not differ between four groups. However, for some items (e.g., meat and western fast food), children and adolescents who estimated themselves as overweight/obesity had higher correct rates than their counterparts, regardless of their actual weight status ($P<0.05$). In total, non-overweight/obese children's overestimation was associated with the highest knowledge scores of 9.68 (SD=2.3), while the overweight/obese children and adolescents who under-estimated their weight status had the lowest correct rates of 9.48 (SD=2.5). Girls and adolescents aged 15-19 years old were better at mastering weight-related knowledge.

Table 4 showed obesity-related attitudes by weight estimation in BMI categories. Participants who perceived themselves to be overweight/obese were more likely to be unsatisfied with their weight (71.5% for non-overweight/obese participants and 84.0% for overweight/obese participants), and had higher intention to change their present weight status (84.2% for non-overweight/obese participants and 90.2% for overweight/obese participants), especially for girls. In sub-group analysis (**Supplementary Table 4**), 15-19-year-aged adolescents showed higher unsatisfactory with their present weight.

Table 5 showed weight-related behaviors by weight perception in two BMI categories. Overall, children and adolescents who perceived to be overweight/obese, no matter they were overweight/obesity or not, were more likely to behave unhealthily, such as having prolonged screen time and unhealthy diet (e.g., insufficient dairy intake and over SSBs intake), compared to the reference group. On the contrary, the weight under-estimators (Group 3) tended to live healthier life such as more physical activities doing and fruit consumption ($P<0.05$). The total unhealthy lifestyle scores were the highest among weight over-estimators with normal weight/ underweight. Specifically, girls, children aged 5-9 years and with urban residence tended to behave healthily.

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Cardio-metabolic markers by actual and perceived weight status

The ORs for cardio-metabolic markers showed escalating trend among the four groups combining weight self-perception with actual weight status, especially for abdominal obesity, elevated BP and dyslipidemia (**Figure 1** and **Supplementary Table 5**). Consistent with conventional knowledge, the ORs of abnormal cardio-metabolic markers were more pronounced among overweight/obese individuals than non-overweight/obese groups, but smaller magnitudes of these associations were found among weight under-estimators with overweight/obesity, that was, though they were not aware of their overweight status, they still faced high likelihoods of abnormal cardio-metabolic markers (P<0.05). Notably, both perception of overweight/obesity and actual overweight/obesity status were associated with greater odds of adverse health outcomes, and the two had joint associations. Apart from the traditional target of overweight/obese individuals with accurate estimation, those weight over-estimators with normal weight and underweight were also at higher odds of abdominal obesity (OR: 10.49, 95% CI: 7.45, 14.76), elevated BP (OR: 1.30, 95% CI: 1.12, 1.51) and dyslipidemia (OR: 1.43, 95% CI: 1.29, 1.58), compared with those non-overweight/obese individuals with accurate estimation. Considering the sex differences, the ORs for abnormal cardio-metabolic markers in relation to the weight misperception seemed to be much larger among boys than girls.

Similar escalating ORs of abnormal cardio-metabolic markers in these four groups were detected among various subgroups divided by age and residence areas, but large ORs of abdominal obesity, elevated BP and dyslipidemia were more evident among children and adolescents aged 15-19 years old (P<0.05), and those came from rural area were more likely to have higher likelihoods of abdominal obesity and dyslipidemia associated with body weight misperception (P<0.05) (**Supplementary Table 6, 7 and Supplementary Figure 1, 2**).

Discussion

To our knowledge, there were 16.6% participants who misperceived their weight and the consistency between the perceived weight and actual weight was only of moderate agreement. Weight over-estimators tended to master better knowledge but behave more unhealthily, while weight under-estimators exactly the opposite. Both weight over-perception and actual

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overweight/obesity status were associated with greater odds of adverse health outcomes. That was, individuals who estimated them to be overweight/obese already faced potentially higher likelihoods of cardio-metabolic risks, even among those with normal weight.

Previous findings found that under-estimation of weight was much more prevalent than over-estimation among children in southern China[7], however, we concluded that over-estimation of weight was more prevalent than under-estimation across China, particularly among girls, adolescents aged 15-19 years old and individuals came from urban area. The only moderate agreement between the perceived weight and actual weight was not surprising, as girls tended to over-estimate their weight and selected a thinner ideal body shape[37], and adolescents aged older might be more sensitive about weight than younger counterparts. The above phenomenon was also applicable to students living in urban area, without the trouble and burden of other living aspects, they might be more conscious about their weight and body shape.

Findings indicated that individuals who perceived themselves as being overweight or obese were better at mastering obesity-related knowledge, had higher intention to lose weight but were more likely to adopt unhealthy lifestyles. Prior research also showed that weight over-estimators were more likely to adopt unhealthy behaviors[19] and were less physically active[38]. Most of participants who recognized their overweight/obesity status had higher intention to change weight because they realized that it was expected of them, but weight loss was not an intrinsic goal for them. For this reason, the self-estimation of weight could only influence their satisfactions but not their behaviors[39]. The results of sub-groups should be considered while tailoring suitable obesity intervention strategies. Specifically, female Chinese adolescents would prefer a thinner body figure as their ideal body image[37], thus girls might have higher prevalence of body-image concerns, higher scores of knowledge and more healthy lifestyles. Compared to younger children, adolescents were better at mastering obesity-related knowledge, as they might obtain more education in school. However, they tended to adopt unhealthy behaviors since they lived in schools and had freedom to lead their favorable lifestyles. In addition, we have to acknowledged that the economic transitions in China have been linked to shifts in beauty ideals in individuals living in metropolitan or rural areas, and the attitudes towards one's body are influenced by dominant culture. Since

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individuals living in urban area tended to be more conscious about their body shape, they would select healthy behaviors. Unfortunately, the current national survey could not distinguish the cultural differences, which prevent us to further investigate the impacts of culture patterns.

The evidence that misperception of weight was associated with unhealthy lifestyles raised the question of whether this misperception was associated with obesity-related markers. In the present study, those participants who over-perceived their weight were also at high odds of deleterious health outcomes. In addition to the unhealthy habits, we speculated that individuals with overweight/obesity are subject to discrimination, teasing, and negative comments from peers[40], leading to increased stress and other psychological disorders[41]. Data from UK birth cohorts found that the magnitude of association between overweight perception and depressive symptoms in girls had increased over the past 30 years[42]. Although the mechanism was not fully understood, such psycho-social stress could increase the likelihoods of elevated BP[43] and diabetes[44]. Weight-based self and social stigmatization was also a powerful risk factor for incident obesity[45].

Early identification of children's weight misperception along with healthy lifestyle promotion shaped a crucial role in abnormal obesity-related cardio-metabolic markers confrontation, therefore, public health campaigns should address weight stigma and avoid the use of body dissatisfaction as a motivator for weight change. Since the perception of overweight/obesity and actual overweight/obesity status were both positively associated with adverse health outcomes, and in line with the notion that "perception" was more powerful than "reality" in terms of weight[46], the traditional high-risk population with class III obesity should be updated. Schools and parents should take targeted measures to help children and adolescents increase their accurate awareness of weight. Apart from this, increasing efforts should consider strategies to reduce weight stigma as part of broader initiatives, such as providing stigma-reduction training for health care professionals. Sex, age and residence area differences should also be paid attention while tailoring suitable intervention programs.

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Strengths of this study included the large sample size and nationally multi-center and representative population. However, several limitations should be noted. Firstly, our results may not be applicable to other ethnic groups since most of the study population was of Han ethnicity. Secondly, BMI may overestimate fatness in children who were shorter, and may underestimate adiposity in those with reduced muscle mass[47]. Since body composition could better predict body size dissatisfaction[48], further investigation of weight categories should be based on the body composition. Thirdly, the self-reported lifestyle behaviors could lead to a certain degree of recall bias. On this process we carried out strict quality control to ensure the reliability. In addition, the behavior data recall of 7 days might represent the recent lifestyle habits; a pilot study using photo tracking could be used to accurately assess the dietary habits. Also, in order to fill the questionnaire in a minimum time, we could not rule out that excessive junk food (pastries, chocolates, candies, etc.) or insufficient protein foods, might also affect cardio-metabolic markers. In addition, parental weight and height were self-reported, but the self-reported data of Chinese adults had fairly good agreement with each other. For reasons of cost and practicality, self-reported data are still often used in epidemiological surveillance[49]. Fourthly, this study did not consider psychological factors which had been shown to influence weight perception, future studies stratified by personal psychological levels are needed. Apart from this, the whole-body silhouettes should be used to assess perceived body habitus. Fifth, culture preferences play a crucial role in body size estimation, but due to difficulties in the measurement of acculturation, the comparison remains problematic. Besides, the IPAQ questionnaire for physical activity was not completely suitable for children. However, the open-ended questions contained in IPAQ can represent the levels of childhood physical activities to some extent. Finally, the nature of cross-sectional study design may be less effective to investigate the direction of causal relationship.

In conclusion, weight over-estimators tended to master better knowledge but behave more unhealthily, while weight under-estimators exactly the opposite. Both weight over-perception and actual overweight/obesity status were positively associated with abdominal obesity, elevated BP and dyslipidemia. Future national obesity-related intervention programs should additionally pay attention to the population with inaccurate estimation of body weight.

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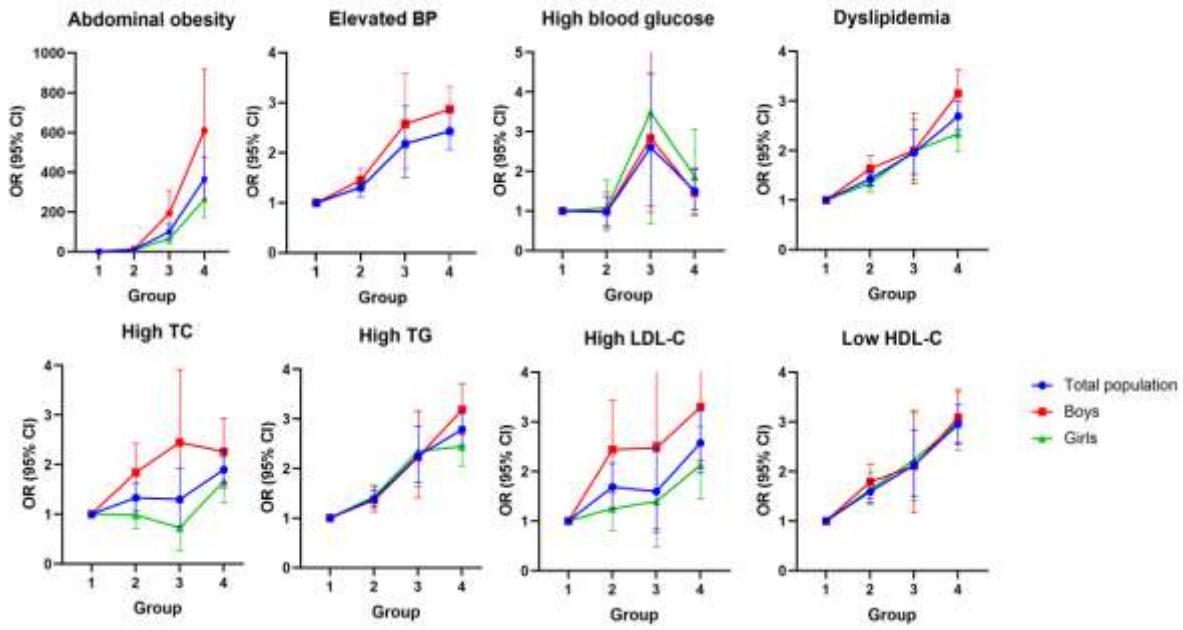

Figure 1. Multivariate odds ratios (OR) and 95% confidence intervals (CI) for abnormal cardio-metabolic markers by groups of self-perception combined with actual weight status, stratified by sex. (Group 1: non-overweight/obese participants with accurate estimation; Group 2: weight over-estimators; Group 3: weight under-estimators; Group 4: overweight/obese participants with accurate estimation. Group 1 was considered as a reference group; BP, blood pressure; TC, total cholesterol; TG, triglyceride; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol. 95%CI did not contain 1 referred to $P<0.05$.)

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Table 1. Baseline characteristic of included population.

Characteristics	Actual weight: Non-Overweight/ obesity		Actual weight: Overweight/ obesity		*P-value*†
	Group 1: Perceived Non-Overweight/ Obesity (n=9996)	Group 2: Perceived Overweight/ Obesity (n=2035)	Group 3: Perceived Non-Overweight/ Obesity (n=309)	Group 4: Perceived Overweight/ Obesity (n=1739)	
Age, year, Mean (SD)	10.9 (3.3)	12.4 (3.0)	9.2 (2.9)	11.4 (3.3)	<0.01
BMI values, Mean (SD)					
5-9 years old	15.6 (1.6)	18.1 (1.8)	21.1 (3.4)	22.6 (2.9)	<0.01
10-14 years old	17.6 (2.0)	20.4 (1.8)	24.4 (3.2)	26.0 (2.9)	<0.01
15-19 years old	19.3 (1.9)	21.9 (2.0)	26.5 (2.4)	28.1 (3.1)	<0.01
Sex, n (%)					<0.01
Boys	5135 (51.37)	892 (43.83)	134 (43.37)	898 (51.64)	
Girls	4861 (48.63)	1143 (56.17)	175 (56.63)	841 (48.36)	
Residence area, n (%)					<0.01
Urban	5154 (51.6)	1147 (56.4)	157 (50.8)	1013 (58.3)	
Rural	4842 (48.4)	888 (43.6)	152 (49.2)	726 (41.8)	
Ethnicity, n (%)					0.005
Han	9248 (92.5)	1875 (92.1)	295 (95.5)	1623 (93.3)	
Hui	354 (3.5)	83 (4.1)	5 (1.6)	41 (2.4)	
Tibetan	20 (0.2)	8 (0.4)	0 (0.0)	3 (0.2)	
Mongolian	145 (1.5)	17 (0.8)	0 (0.0)	21 (1.2)	
Other	229 (2.3)	52 (2.6)	9 (2.9)	51 (2.9)	
Paternal weight status, n (%)					<0.01
Normal	6062 (60.6)	1108 (54.5)	133 (43.0)	703 (40.4)	
Overweight	3122 (31.2)	679 (33.4)	119 (38.5)	697 (40.1)	
Obesity	812 (8.1)	248 (12.2)	57 (18.5)	339 (19.5)	
Maternal weight status, n (%)					<0.01
Normal	8246 (82.5)	1540 (75.7)	220 (71.2)	1166 (67.1)	
Overweight	1462 (14.6)	403 (19.8)	72 (23.3)	427 (24.6)	

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Obesity	288 (2.9)	92 (4.5)	17 (5.5)	146 (8.4)	
Paternal educational attainment, n (%)					0.495
Primary school or below	665 (6.7)	126 (6.2)	18 (5.8)	96 (5.5)	
Secondary or equivalent	5838 (58.4)	1183 (58.1)	189 (61.2)	1046 (60.2)	
Junior college or above	3493 (34.9)	726 (35.7)	102 (33.0)	597 (34.3)	
Maternal educational attainment, n (%)					0.434
Primary school or below	884 (8.8)	175 (8.6)	28 (9.1)	133 (7.7)	
Secondary or equivalent	5740 (57.4)	1148 (56.4)	188 (60.8)	1016 (58.4)	
Junior college or above	3372 (33.7)	712 (35.0)	93 (30.1)	590 (33.9)	
Monthly household income, n (%)					0.047
< 5000 CNY	8425 (84.3)	1729 (85.0)	252 (81.6)	1428 (82.1)	
≥50000 CNY	1571 (15.7)	306 (15.0)	57 (18.5)	311 (17.9)	

*Abbreviation: BMI, body mass index; CNY, Chinese yuan.

†Differences of items between children and adolescents in four groups were evaluated using one-way ANOVA and Pearson Chi-Square tests.

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Table 2. Prevalence of abnormal cardio-metabolic markers by self-perception combined with actual weight status.

Cardio-metabolic markers, n (%)	Actual weight: Non-Overweight/ Obesity		Actual weight: Overweight/ Obesity		*P*-value	Significant multiple group comparisons*
	Group 1: Perceived Non-Overweight/ Obesity	Group 2: Perceived Overweight/ Obesity	Group 3: Perceived Non-Overweight/ Obesity	Group 4: Perceived Overweight/ Obesity		
Total population	(n=9996)	(n=2035)	(n=309)	(n=1739)		
Abdominal obesity	52 (0.5)	100 (4.9)	113 (36.6)	1135 (65.3)	<0.01	Group 4 > 3 > 2 > 1
Elevated BP	2412 (24.1)	685 (33.7)	104 (33.7)	795 (45.7)	<0.01	Group 4 > 3 > 1; Group 4 > 2 > 1;
High blood glucose	170 (1.7)	34 (1.7)	9 (2.9)	45 (2.6)	0.032	Group 3 > 2, Group 3 > 1
Dyslipidemia	2701 (27.0)	716 (35.2)	125 (40.5)	861 (49.5)	<0.01	Group 3 > 1; Group 4 > 2 > 1;
High TC	486 (4.9)	116 (5.7)	20 (6.5)	145 (8.3)	<0.01	Group 4 > 2; Group 4 > 1
High TG	1695 (17.0)	457 (22.5)	92 (29.8)	613 (35.3)	<0.01	Group 4 > 2 > 1; Group 3 > 1
High LDL-C	243 (2.4)	73 (3.6)	12 (3.9)	100 (5.8)	<0.01	Group 4 > 2; Group 4 > 1
Low HDL-C	994 (9.9)	330 (16.2)	49 (15.9)	433 (24.9)	<0.01	Group 4 > 3 > 1; Group 2 > 1;
Boys	(n=5135)	(n=892)	(n=134)	(n=898)		
Abdominal obesity	18 (0.4)	35 (3.9)	55 (41.0)	598 (66.6)	<0.01	Group 4 > 3 > 2 > 1
Elevated BP	1364 (26.6)	327 (36.7)	48 (35.8)	450 (50.1)	<0.01	Group 4 > 2 > 1; Group 4 >3 > 1
High blood glucose	124 (2.4)	21 (2.4)	6 (4.5)	31 (3.5)	0.146	NS
Dyslipidemia	1289 (25.1)	321 (36.0)	49 (36.6)	461 (51.3)	<0.01	Group 4 > 2 > 1; Group 3 > 1
High TC	203 (4.0)	57 (6.4)	14 (10.5)	74 (8.2)	<0.01	Group 4 > 1; Group 3 > 1; Group 2 > 1
High TG	774 (15.1)	176 (19.7)	34 (25.4)	321 (35.7)	<0.01	Group 4 > 2 > 1; Group 3 > 1
High LDL-C	98 (1.9)	37 (4.2)	6 (4.5)	53 (5.9)	<0.01	Group 4 > 1; Group 3 > 1
Low HDL-C	553 (10.8)	165 (18.5)	19 (14.2)	239 (26.6)	<0.01	Group 4 > 2 > 1; Group 4 > 3
Girls	(n=4861)	(n=1143)	(n=175)	(n=841)		
Abdominal obesity	34 (0.70)	65 (5.7)	58 (33.1)	537 (63.9)	<0.01	Group 4 > 3 > 2 > 1
Elevated BP	1048 (21.6)	358 (31.3)	56 (32.0)	345 (41.0)	<0.01	Group 4 > 2 > 1, Group 3 > 1
High blood glucose	46 (1.0)	13 (1.1)	3 (1.7)	14 (1.7)	0.242	NS
Dyslipidemia	1412 (29.1)	395 (34.6)	76 (43.4)	400 (47.6)	<0.01	Group 4 > 2 > 1; Group 3 > 1
High TC	283 (5.8)	59 (5.2)	6 (3.4)	71 (8.4)	0.005	Group 4 > 3
High TG	921 (19.0)	281 (24.6)	58 (33.1)	292 (34.7)	<0.01	Group 4 > 1; Group 3 > 1
High LDL-C	145 (3.0)	36 (3.2)	6 (3.4)	47 (5.6)	0.002	Group 4 > 1
Low HDL-C	441 (9.1)	165 (14.4)	30 (17.1)	194 (23.1)	<0.01	Group 4 > 2 > 1; Group 3 > 1

* Chi-squared test with Holm Bonferroni correction was used to account for multiple comparisons. NS, not significant.

BP, blood pressure; TC, total cholesterol; TG, triglyceride; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol.

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Table 3. Children's weight-related knowledge by actual and perceived weight status.

Knowledge items/scores	Actual weight: Non-Overweight/ Obesity		Actual weight: Overweight/ Obesity		Significant multiple group comparisons*
	Group 1: Perceived Non-Overweight/ Obesity	Group 2: Perceived Overweight/ Obesity	Group 3: Perceived Non-Overweight/ Obesity	Group 4: Perceived Overweight/ Obesity	
Knowledge items, n (%)	(n=9996)	(n=2035)	(n=309)	(n=1739)	
It is harmful to watch TV, play computer games and surf the internet for a long time. [yes]	9208 (92.4)	1874 (92.3)	278 (90.6)	1589 (91.6)	NS
It is not necessary to exercise every day. [no]	8929 (89.8)	1861 (91.6)	282 (92.2)	1567 (90.4)	NS
Fruits and vegetables should be eaten every day. [yes]	9756 (97.8)	1991 (98.1)	301 (97.4)	1706 (98.3)	NS
Meat contains fat and protein and the more you eat meat, the better. [no]	8983 (90.2)	1926 (94.8)	285 (92.8)	1631 (94.0)	Group 2 > 1; Group 4 > 1
It is healthier to drink plain boiled water than sugar-sweetened beverages. [yes]	8480 (85.1)	1735 (85.4)	250 (81.2)	1480 (85.3)	NS
You don't have to eat breakfast as long as you eat more lunch. [no]	9708 (97.4)	1986 (97.7)	297 (96.1)	1683 (97.0)	NS
It is harmful to eat too much fried food. [yes]	9216 (92.5)	1893 (93.2)	278 (90.3)	1620 (93.3)	NS
Western fast food (i.e, KFC, McDonald's, etc) is more nutritious. [no]	9335 (93.7)	1939 (95.4)	288 (93.2)	1645 (94.8)	Group 2 > 1
It is beneficial to your health to drink milk every day. [yes]	9523 (95.6)	1915 (94.3)	291 (94.5)	1636 (94.4)	NS
It is beneficial to your health to eat more high-energy snacks. [no]	9501 (95.3)	1958 (96.4)	295 (95.5)	1678 (96.7)	NS
Often eating out is not good for your health. [yes]	8343 (83.8)	1675 (82.8)	257 (83.2)	1454 (84.1)	NS
Of the "Chinese Residents' Balanced Diet Pagoda", the food at the bottom should be eaten more. [no]	3468 (35.3)	770 (38.3)	124 (41.2)	651 (38.0)	NS
Knowledge scores, Mean (SD)					
Total	9.50 (2.5)	9.68 (2.3)	9.48 (2.5)	9.64 (2.4)	NS
Boys	9.40 (2.6)	9.43 (2.5)	9.35 (2.8)	9.59 (2.5)	NS
Girls	9.62 (2.4)	9.87 (2.1)	9.57 (2.3)	9.69 (2.4)	Group 2 > 1
5-9 years old	9.37 (2.6)	9.39 (2.6)	9.42 (2.6)	9.48 (2.7)	NS
10-14 years old	9.48 (2.5)	9.63 (2.3)	9.40 (2.5)	9.65 (2.4)	NS
15-19 years old	9.83 (2.2)	9.92 (2.2)	10.22 (1.7)	9.84 (2.2)	NS
Rural area	9.46 (2.6)	9.73 (2.2)	9.57 (2.6)	9.75 (2.4)	NS
Urban area	9.55 (2.4)	9.64 (2.4)	9.39 (2.4)	9.56 (2.5)	NS

*One-way ANOVA and Chi-squared test with Holm Bonferroni correction was used to account for multiple comparisons. NS, not significant.

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Table 4. Children's weight-related attitudes by actual and perceived weight status

Weight-related attitudes, n (%)	Actual weight: Non-Overweight/ Obesity		Actual weight: Overweight/ Obesity		Significant multiple group comparisons*
	Group 1: Perceived Non-Overweight/ Obesity	Group 2: Perceived Overweight/ Obesity	Group 3: Perceived Non-Overweight/ Obesity	Group 4: Perceived Overweight/ Obesity	
Total population	(n=9996)	(n=2035)	(n=309)	(n=1739)	
To what extent do you think obesity is bad for health? [greatly or rather greatly]	7751 (77.5)	1637 (80.4)	247 (80.0)	1402 (80.6)	Group 2 > 1, Group 4 > 1
Are you satisfied with your weight status? [no or rather no]	2957 (29.6)	1455 (71.5)	91 (29.5)	1461 (84.0)	Group 4 > 2 > 3, Group 4 > 2 > 1
Do you want to change your present weight status? [yes or rather yes]	4192 (41.9)	1713 (84.2)	169 (54.7)	1569 (90.2)	Group 4 > 2 > 3 > 1
Do you believe you can achieve an ideal weight status through effort? [yes or rather yes]	6622 (66.3)	1394 (68.5)	220 (71.2)	1226 (70.5)	Group 3 > 1
Boys	(n=5135)	(n=892)	(n=134)	(n=898)	
To what extent do you think obesity is bad for health? [greatly or rather greatly]	3897 (75.9)	692 (77.6)	114 (85.1)	744 (82.9)	Group 3 > 1
Are you satisfied with your weight status? [no or rather no]	1518 (29.6)	528 (59.2)	35 (26.1)	752 (83.8)	Group 4 > 2 > 1, Group 4 > 2 > 3
Do you want to change your present weight status? [yes or rather yes]	2057 (40.1)	685 (76.8)	63 (47.0)	824 (91.9)	Group 4 > 2 > 1, Group 4 > 2 > 3
Do you believe you can achieve an ideal weight status through effort? [yes or rather yes]	3371 (65.6)	622 (69.7)	97 (72.4)	662 (73.8)	Group 4 > 1
Girls	(n=4861)	(n=1143)	(n=175)	(n=841)	
To what extent do you think obesity is bad for health? [greatly or rather greatly]	3839 (79.0)	914 (80.0)	148 (84.6)	689 (81.9)	NS
Are you satisfied with your weight status? [no or rather no]	1432 (29.5)	890 (77.9)	63 (36.0)	746 (88.7)	Group 4 > 2 > 1, Group 4 > 2 > 3
Do you want to change your present weight status? [yes or rather yes]	2124 (43.7)	991 (86.7)	117 (66.9)	782 (93.0)	Group 4 > 3 > 1, Group 2 > 1
Do you believe you can achieve an ideal weight status through effort? [yes or rather yes]	3237 (66.6)	743 (65.0)	137 (78.3)	593 (70.5)	NS

* Chi-squared test with Holm Bonferroni correction was used to account for multiple comparisons. NS, not significant.

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Table 5. Multivariate odds ratios (OR) and 95% confidence intervals (CI) for unhealthy lifestyle by groups of self-perception combined with actual weight status.

Unhealthy Lifestyle	Actual weight: Non-Overweight/ Obesity		Actual weight: Overweight/ Obesity		Significant multiple group comparisons‡
	Group 1: Perceived Non-Overweight/ Obesity	Group 2: Perceived Overweight/ Obesity	Group 3: Perceived Non-Overweight/ Obesity	Group 4: Perceived Overweight/ Obesity	
OR (95%CI), Model†	(n=9996)	(n=2035)	(n=309)	(n=1739)	
Physical inactivity	1 (Reference)	1.10 (0.95-1.27)	0.73 (0.55-0.98)**	1.05 (0.90-1.22)	\
Prolonged screen time	1 (Reference)	1.13 (1.01-1.26)*	0.98 (0.75-1.29)	1.20 (1.07-1.35)**	\
Prolonged sitting time	1 (Reference)	1.09 (0.96-1.25)	0.87 (0.66-1.15)	0.99 (0.86-1.14)	\
Insufficient sleep duration	1 (Reference)	1.11 (0.98-1.26)	1.38 (0.97-1.96)	0.97 (0.84-1.12)	\
Breakfast skipping	1 (Reference)	1.35 (1.20-1.52)**	0.88 (0.61-1.27)	1.11 (0.96-1.27)	\
Insufficient dairy intake	1 (Reference)	1.14 (1.03-1.27)**	0.98 (0.78-1.24)	1.16 (1.04-1.29)**	\
Excessive fried food	1 (Reference)	0.97 (0.88-1.07)	1.25 (0.99-1.59)	0.98 (0.88-1.09)	\
Insufficient vegetable intake	1 (Reference)	1.05 (0.93-1.19)	0.96 (0.72-1.28)	0.95 (0.83-1.08)	\
Insufficient fruit intake	1 (Reference)	1.21 (1.08-1.36)**	0.76 (0.60-0.97)**	0.96 (0.85-1.08)	\
Over sugar-sweetened beverages	1 (Reference)	1.13 (1.01-1.26)*	0.85 (0.63-1.16)	1.21 (1.07-1.36)**	\
Unhealthy lifestyle scores, Mean (SD)					
Total**	1.7 (3.4)	2.6 (3.5)	0.9 (3.0)	2.0 (3.5)	Group 2 > 1 > 3, Group 4 > 3
Boys**	2.0 (3.4)	2.6 (3.7)	1.0 (2.8)	2.3 (3.5)	Group 2 > 3, Group 4 > 3
Girls**	1.4 (3.3)	2.6 (3.3)	0.8 (3.1)	1.8 (3.3)	Group 2 > 1 > 3, Group 4 > 3
5-9 years old**	0.9 (3.0)	1.5 (3.1)	0.8 (2.9)	1.3 (3.2)	Group 2 > 3
10-14 years old**	1.7 (3.4)	2.2 (3.5)	0.8 (3.0)	1.9 (3.6)	Group 2 > 3, Group 4 > 3
15-19 years old	3.3 (3.3)	3.7 (3.3)	2.4 (3.2)	3.3 (3.2)	NS
Rural area	1.8 (3.3)	2.7 (3.3)	0.9 (2.7)	2.2 (3.5)	NS
Urban area	1.6 (3.4)	2.4 (3.6)	0.9 (3.2)	1.9 (3.4)	NS

*$P < 0.05$, ** $P < 0.01$.

†Model: adjusted for sex, age, residence area, ethnicity, incomes, parental educational attainment, parental weight.

‡One-way ANOVA with Holm Bonferroni correction was used to account for multiple comparisons. NS, not significant.

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