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Body Weight Misperception and Weight Disorders among Chinese Children and Adolescents: A Latent Class Analysis*

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Summary: Body misperception plays an important role in the development of weight and dietary disorders among children and adolescents. A school-based health promotion program (2014–2015) was conducted to promote the school health education and improve the teenagers' physical health among Chinese children and adolescents. Based on this program, we intended to examine weight status and weight misperception among Chinese children and adolescents and to explore the relationship between weight misperception and lifestyle behaviors. A total of 10 708 Chinese children and adolescents in 3rd and 7th grade from Shandong and Qinghai province participated in the program. The participants' dietary and activity patterns were clustered by latent class analysis (LCA). Logistic regression analysis was undertaken to explore the relationship between weight perception and demographic factors or dietary and activity patterns. Given the gender-specific difference of children and adolescents, analyses were separately conducted among boys and girls. The total prevalence of weight misperception was 44.50%. Boys, especially those in higher grade and living in wealthier district, were more likely to misperceive body weight. Girls were more likely to overestimate their weight (26.10%) while boys tended to underestimate the weight (28.32 %). Three latent dietary and activity patterns including obesogenic pattern, malnourished pattern and healthy pattern were derived. The participants who had weight misperception were more likely to choose unhealthy dietary and exercise activities. The high prevalence of weight misperception was closely related to the unhealthy weight pattern and unhealthy dietary or exercise patterns. Our research found that most children and adolescents failed to perceive their weight correctly and boys tended to underestimate their weight while girls were subjected to overestimation. So, comprehensive intervention programs should focus on improving self-weight awareness, and appropriate guidance should be made to lead the adolescents to more healthy weight pattern.
Key words: weight perception; children and adolescents; obesity; lifestyle behavior pattern; latent class analysis

Adolescence is a critical period of human life and it is characterized by dramatic changes in physical appearance, especially the body weight changing most[1]. Weight disorders (overweight/obesity or under−weight) at this period have been recognized as a risk factor for the healthy development of children and adolescents, and they occur with a high incidence[2–4]. As reported by previous national surveys, the increase of adolescents' overweight and obesity was much more rapidly in the developing countries during the past decades[5]. In China, almost 30.43 million children and adolescents aged 7–18 years were overweight or obese based on the 2010 national survey[6].

Weight perception is how an individual perceives his or her body weight and it plays an important part of self-representation during the period of adolescence[7–9]. Weight perception, rather than actual weight status, was more closely related to the attitude of weight management. Inaccurate weight perception, which is also called weight misperception, is a risk factor leading to unhealthy weight control behaviors and thus has bad influence on healthy development of children and adolescents. For example, children and adolescents

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with normal weight misperceive themselves to be overweight or obesity and they might take improper weight control behaviors to pursue thinner figure[10], while the overweight or obese children and adolescents who misperceive their weight status as normal weight might pay less attention to weight management[11]. Previous studies had reported that long exposure to weight misperception could influence children and adolescents' self-esteem, self-cognition, or even cause depression[12–14].

Weight misperception is a prevalent phenomenon among children and adolescents[15–18]. In China, this phenomenon is also obvious. One study reported 30% of girls and 25% of boys failed to perceive their weight accurately, but this analysis just included 624 teenagers from Jiangsu Province[19]. Therefore, it would be much meaningful to use a larger representative sample to examine the weight perception patterns as well as the prevalence of weight disorders among Chinese children and adolescents. Previous studies have shown that the weight perception of children and adolescents can be affected by various factors, including socio-demographic and environmental factors, such as age, ethnicity, location of residence, household income, peer weight norms, parental perceptions, and health-related factors such as eating behaviors and physical activities[20–23]. The aims of the present study were to examine the current prevalence of abnormal weight status (including underweight, overweight and obesity) and weight perception among Chinese children and adolescents by using a large sample. We also explored the associated health-related risk factors of weight perception among Chinese children and adolescents, attempting to gain beneficial insights on promoting the healthy growth of children and adolescents. Considering the multidimensional measures of the dietary habits and physical exercise, we intended to apply a comprehensive latent class analysis (LCA) model to identify children and adolescents' dietary and exercise patterns in latent subgroups[24] and then further to dissect their associations with weight perception among Chinese children and adolescents.

1 MATERIALS AND METHODS

1.1 Participants and Procedure

"The Chinese Urban Youth Sports and Dietary Intervention Project" was a school-based longitudinal health promotion program and announced by the Chinese Health Education Center. The project was completed by 2 cohorts in 3rd and 7th graders (3785 *vs.* 6923) from 2014 to 2015 in Shandong Province (a rich coastal province) and Qinghai Province (a poor interior province) of China. A stratified sampling strategy was adopted to randomly select a pilot city with low, middle, and high residential economics from each pilot province. In the same district of the pilot city, a primary school and a middle school were randomly selected as the intervention group. To ensure the representative of the study population, the sample proportion in each region was equal. A structured questionnaire was designed to collect information. The interviews were conducted in the classroom settings by the specialized interviewers. The cross-sectional data obtained from the baseline survey (2014) were included in this analysis and a total of 10 708 students entered in the final analyses. The response rates in the primary school and middle school were 98% and 95%, respectively. Informed consent was provided by all participants, their parents and schools prior to interviewing. The protocol of the survey was approved by the Ethical Committee of School of Public Health, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China [No.(2013)05].

1.2 Actual Body Weight, Self-perceived Body Weight and Classification of Weight Misperception

Participants' actual weight was determined by the measured height (m) and weight (kg). BMI-for-age Z-scores derived from the gender- and age-specific growth charts of the WHO Child Growth Standards for 5–19 years were used and a four-category weight status variable was created by the WHO BMI standard deviation scores (SDs): underweight (−2 SDs); normal weight (−2 SDs to 1 SDs); overweight (+1 SD); and obesity (+2 SDs)[25]. Then a further computed BMI category was recorded as: –1 as underweight, 0 as normal weight and 1 as overweight or obesity.

Self-perceived body weight was assessed by asking students to describe their body shape with the question of "how do you think about your body weight?" in terms of the following response choices: very thin, slightly thin, normal, slightly fat, and very fat. Then the weight perception was recorded as: –1 as underweight ("very thin" and "slightly thin"), 0 as normal weight ("normal") and 1 as overweight or obesity ("slightly fat" and "very fat").

Compared with the computed BMI categories, two weight perception groups (discordant *vs.* concordant) were produced. The discordant weight perception group was further categorized into two sub-groups: underestimated group (subjects who reported their perceived weight status at least one category below their actual weight status) and overestimated group (subjects who reported their perceived weight status at least one category above their actual weight status).

1.3 Dietary Patterns, Physical Activity, Sedentary Behavior

In order to obtain the dietary patterns of the participants, students were asked to answer the questions about the frequencies of having breakfast, consuming fruits, vegetables, fast food, fried snacks, drinking sweetened soft drinks, milk, and late-night

eating (always defined by eating before going to bed or nocturnal snacking) over the past month. Each item was reclassified as a dichotomized variable (healthy *vs.* unhealthy eating pattern) for the aim of analyses. For example, more (≥once/day) frequencies of having breakfast, eating fruits and vegetables, drinking milk, as well as less (<once/day) consumption of fast foods, fried food, unhealthy snacks, sugar sweetened beverages, and midnight snack were considered as healthy eating patterns.

Physical activities were obtained by asking students to answer their average exercise time every day, including curricular and extracurricular physical activities, such as running, playing balls, fast walking, bicycling, rope skipping, and so on. According to the recommendations, physical activity was dichotomized: <60 min/day and ≥60 min/day[26].

Sedentary behaviors were measured by asking the students how many hours they usually spent in their free time (1) watching TV (including videos and DVDs); (2) reading or doing homework; (3) using computers for chatting online, suffering the Internet, e-mailing, doing homework and so on; (4) playing games on computers or games console (such as Play Station, Xbox, GameCube, Nintendo and so on); (5) talking on the phone or cell phone/text messaging for both typical weekdays and weekend days. Response categories ranged from none to three hours or more. Consisted with the recommendations of the American Academy of Pediatrics, a weighted average sedentary behavior was dichotomized: >1 h/day; and ≤ 1 h/day[27].

1.4 Demographic Covariates

Demographic covariates included gender, grade (3rd and 7th), nationality (Han, and others), district (Shandong and Qinghai province), family structure (living with grandparents, parents, and both), and parental education levels, which were directly obtained from the questionnaire.

1.5 Data Analysis

The agreement between self-perceived body weight and BMI-based body weight was measured by weighted kappa statistics based on the survey weighted percentages, and the kappa coefficient with 95% confidence intervals (CI) was calculated. A kappa value between 0.41 and 0.60 indicates "moderate" agreement, and 0.21–0.40 indicates "fair" agreement[28]. In addition, the correlation between self-perceived body weight and BMI-based body weight was measured by the Kendall's tau-*b* correlation coefficient.

A comprehensive LCA model, which is often used to estimate the number of latent homogeneous classes in a heterogeneous sample based on the pattern of responses to two or more observed variables[29], was used to identify latent subgroups of participants' dietary and exercise patterns[30]. Logistic regression analyses with consideration of complex sampling were conducted to examine the difference between discordant weight perception and concordant weight perception across socio-demographic factors, after adjustment for primary sample units, stratification and sample weights of the study. The multinomial logistic regression was utilized to examine the association between weight misperception and dietary and exercise patterns after adjustment for demographic covariates based on previous studies[31, 32].

All statistical analyses including the LCA procedures[33] were performed using the 9.3 version of the SAS statistical analysis package (SAS Institute, Inc., USA). Two-sided hypothesis testing was used for all analyses and the significance was set at $P<0.05$. Given that body image is characteristic of a gender-specific difference[34], all analyses were conducted by gender in order to explore the gender-specific differences.

2 RESULTS

2.1 BMI-based Weight Status and Gender Difference

Among the 10 708 participants who completed the baseline survey, 5654 (52.84%) were boys, 6923 (64.56%) were 7th graders and 5943 (55.50%) were from Shandong province. The average age of 3rd graders and 7th graders was 9 (IQR: 8–9) and 13 (IQR: 12–13) years, respectively. The majority of students were of normal weight (66.69%) and the underweight were minority (13.78%). The prevalence of overweight or obesity was 19.53% (95% CI: 0.19–0.20). 26.46% participants thought they were overweight or obese while 26.02% participants thought they were underweight (table 1).

Chi-square data were calculated to assess the distribution of BMI-based weight (table 2). Significant differences were observed in the BMI-based weight across different genders (χ^2=416.71, $P<0.001$), district (χ^2=677.50, $P<0.001$), grades (χ^2=267.37, $P<0.001$), nationalities (χ^2=75.43, $P<0.001$), self-perceived weight (χ^2=2137.07, $P<0.0001$), parental education (χ^2=69.30, $P<0.001$), as well as the family structure (χ^2=21.48, P=0.002).

2.2 Agreement between BMI-based Weight and Self-perceived Weight

Table 3 displays a cross-tabulation of BMI-based weight against self-perceived weight. Overall, 44.49% of the participants misperceived their body weight, of which 43.20% were boys and 45.98% were girls. Among 7141 participants with normal weight, 24.94% perceived themselves as underweight (underestimation) and 20.71% perceived themselves to be overweight or obese (overestimation). In addition, among the overweight participants, 60.54% perceived their body weight correctly while 9.95% thought there were underweight. As for the underweight group, 46.00% participants did not think they were underweight and

Table 1 Participant characteristics by sex (Chinese, *n*=10 708)

Variables	Total, *n* (%)	Boys, *n* (%)	Girls, *n* (%)	χ^2	*P* value
Gender					
Boy	5654 (52.80)	–	–		
Girl	5054 (47.20)	–	–		
Grade					
3rd grader	3785 (35.35)	2032 (53.69)	1753 (46.31)	1.835	0.176
7th grader	6923 (64.65)	3622 (52.32)	3301 (47.68)		
District					
Shang Dong	5943 (55.5)	3210 (54.01)	2733 (45.99)	7.864	<0.001
Qing Hai	4765 (44.5)	2444 (51.29)	2321 (48.71)		
BMI*					
Underweight	1476 (13.78)	689 (46.68)	787 (53.32)	416.670	<0.001
Normal	7141 (66.69)	3444 (48.23)	3697 (51.77)		
Overweight	1305 (12.19)	938 (71.88)	367 (28.12)		
Obesity	786 (7.34)	583 (74.17)	203 (25.83)		
Nationality					
Han	9508 (88.81)	5034 (52.94)	4474 (47.06)	0.694	0.405
Others	1198 (11.19)	619 (51.67)	579 (48.33)		
Self-perceived weight					
Underweight	2786 (26.02)	1548 (55.56)	1238 (44.44)	17.636	<0.001
Normal	5089 (47.53)	2585 (50.80)	2504 (49.20)		
Overweight/obesity	2833 (26.46)	1521 (53.69)	1312 (46.31)		
Parental education△					
High	2678 (25.01)	1396 (52.13)	1282 (47.87)	0.780	0.677
Middle	5999 (56.02)	3174 (52.91)	2825 (47.09)		
Low	2031 (18.97)	1084 (53.37)	947 (46.63)		
Family structure					
Living with grandparents	449 (4.19)	242 (53.90)	207 (46.10)	18.759	<0.001
Living with parents	3972 (37.09)	1955 (49.22)	2017 (50.78)		
Living with both#	5326 (49.74)	2858 (53.66)	2468 (46.34)		

*Calculated by the WHO growth reference for school-aged children and adolescent: underweight (<–2SDs); normal weight (−2 SDs to 1 SDs); overweight/obesity(>+1 SD);

△Three education groups: low, both parents < high school education; middle, one of their parents > college education; high, both parents > college education.

#Living with both means living with parents and grandparents.

5.96% of them even thought they were overweight. Our result reflected the significant correlation between the BMI-based weight and self-perceived weight (*k* value=0.31, 95% CI: 0.29–0.32, *P*<0.001). With gender-specific difference taken into account, the weight-adjusted Kappa statistic (*k* value) was 0.36 (95% CI: 0.34–0.38, *P*<0.001) for boys and 0.24 (95% CI: 0.22–0.26, *P*<0.001) for girls, respectively.

2.3 Association of Socio-demographic Factors with Weight Misperception

The prevalence of weight misperception was different across gender, nationality, grade, region, parental education, objective body weight, and family structure. 28.32% of the boys underestimated their body weight and the overestimation accounted for 14.84%. Among girls, the rates of underestimation and overestimation were 19.89% and 26.10%, respectively. By comparison, boys were more likely to misperceive their body weight than girls (OR=1.12, 95% CI: 1.04–1.21). Furthermore, the participants in higher grade (OR=1.21, 95% CI: 1.12–1.31), living in a wealthier region (OR=1.18, 95% CI: 1.09–1.27) or with higher level of body weight (OR=1.27, 95% CI: 1.12–1.43 for overweight; OR=1.33, 95% CI: 1.14–1.54 for obesity) were also more likely to misperceive their body weight.

Further analyses showed that boys were more likely to underestimate their body weight than girls. Moreover, the participants with higher BMI, from Han nationality, or living in wealthy region (Shandong province) showed a greater tendency to underestimate their body weight, while those elder participants were shown to be more likely to overestimate their weight (table 4).

2.4 LCA Class Profiles

In consideration of model selection criteria and conceptual implications, the 3-class model was thought to be the optimal model and used in subsequent analyses (table 5, fig.1). The first latent class (Class 1) representing about 61.98% of the participants had healthful dietary and activity (physical activities/ sedentary behaviors) habits, which was labeled as healthy pattern. This class had the highest proportion of meeting the criteria of physical activity (58.92%), and the highest proportions of having breakfast (97.40%),

Table 2 Difference analysis of BMI-based body weight status (*n*=10 708)

Variables	BMI-based weight status[$]				*P* value
	Underweight	Normal weight	Overweight	Obesity	
Gender[**bc]					<0.001
Boys	689 (12.19)	3444 (60.91)	938 (16.59)	583 (10.31)	
Girls	787 (15.57)	3697 (73.15)	367 (7.26)	203 (4.02)	
District[**abc]					<0.001
Shangdong	461 (7.76)	3931 (66.15)	908 (15.28)	643 (10.82)	
Qinghai	1015 (21.30)	3210 (67.37)	397 (8.33)	143 (3.00)	
Grade[**abc]					<0.001
3rd grader	537 (14.19)	2242 (59.23)	540 (14.27)	466 (12.31)	
7th grader	939 (13.56)	4899 (70.76)	765 (11.05)	320 (4.62)	
Nationality[**abc]					<0.001
Han	1235 (12.99)	6334 (66.62)	1195 (12.57)	744 (7.82)	
Others	240 (20.03)	806 (67.28)	110 (9.18)	42 (3.51)	
Parental education[**ab△]					<0.001
High	338 (12.62)	1776 (66.32)	360 (13.44)	204 (7.62)	
Middle	772 (12.87)	3991 (66.53)	772 (12.87)	464 (7.73)	
Low	366 (18.02)	1374 (67.65)	173 (8.52)	118 (5.81)	
Self-perceived weight status[**abc]					<0.001
Underweight	797 (28.61)	1781 (63.93)	103 (3.70)	105 (3.77)	
Normal	591 (11.61)	3881 (76.26)	417 (8.19)	200 (3.93)	
Overweight/obesity	88 (3.11)	1479 (52.21)	785 (27.71)	481 (16.98)	
Family structure[*ac]					<0.001
Living with Grandparents	78 (17.37)	303 (67.48)	45 (10.02)	23 (5.12)	
Living with Parents	493 (12.41)	2744 (69.08)	477 (12.01)	258 (6.50)	
Living with both[#]	748 (14.04)	3514 (65.98)	657 (12.34)	407 (7.64)	

[*]*P*<0.05, [**]*P*<0.001;
[△]Three education groups: low, both parents < high school education; middle, one of their parents > college education; high, both parents > college education;
#Living with both means living with parents and grandparents;
[a]underweight compared with the normal weight and *P*<0.01;
[b]overweight compared with the normal weight and *P*<0.01;
[c]obesity compared with the normal weight and *P*<0.01;
[$]calculated by the WHO growth reference for school-aged children and adolescent, underweight (<−2SDs); normal weight (−2 SDs to 1 SDs); overweight/obesity(>+1 SD)

Table 3 Agreement between BMI-based weight status and self-perceived weight status among Chinese children and adolescents[*] (*n*=10 708)

BMI-based weight status[△]	Overall	Self-perceived weight status			Overall agreement, %	Weighted kappa (95% CI)	Kendall's tau-b coefficient, *r*
		Underweight	Normal weight	Overweight/ obesity			
All (*n*=10708)							
Underweight	1476 (13.78)	797 (7.44)	591 (5.52)	88 (0.82)	55.50	0.31 (0.29, 0.32)	0.368[#]
Normal weight	7141 (66.69)	1781 (16.63)	3881 (36.24)	1479 (13.81)			
Overweight/obesity	2091 (19.53)	208 (1.94)	617 (5.76)	1266 (11.82)			
Boys (*n*=5654)							
Underweight	689 (12.19)	399 (7.06)	258 (4.56)	32 (0.57)	56.85	0.36 (0.34, 0.38)	0.437[#]
Normal weight	3444 (60.91)	1020 (18.04)	1875 (33.16)	549 (9.71)			
Overweight/obesity	1521 (26.90)	129 (2.28)	452 (7.99)	940 (16.63)			
Girls (*n*=5054)							
Underweight	787 (15.57)	398 (7.88)	333 (6.59)	56 (1.11)	54.02	0.24 (0.22, 0.26)	0.299[#]
Normal weight	3697 (73.15)	761 (15.06)	2006 (39.69)	930 (18.40)			
Overweight/obesity	570 (11.28)	79 (1.56)	165 (3.26)	326 (6.45)			

[*]Results were presented as *n* (%). [△]calculated by the WHO growth reference for school-aged children and adolescent, underweight (<–2SDs); normal weight (−2 SDs to 1 SDs); overweight/obesity(>+1 SD). [#]*P* value <0.0001 across weight perceptions for all

Table 4 Association between weight misperception and demographic factors[#△] (Logistic regression, *n*=10 708)

BMI-based weight status[△]	Total (*n*=10 708)		Boys (*n*=5 654)		Girls (*n*=5 654)	
	Underestimated OR (95% CI)	Overestimated OR (95% CI)	Underestimated OR (95% CI)	Overestimated OR (95% CI)	Underestimated OR (95% CI)	Overestimated OR (95% CI)
Gender						
Girls (reference)	1.000	1.000	–	–	–	–
Boys	1.353 (1.232, 1.486)*	0.540 (0.489, 0.597)*	–	–	–	–
Body mass index (kg/m^2)[a]	1.441 (1.341, 1.549)*	0.777 (0.729, 0.827)*	1.500 (1.364, 1.648)*	0.762 (0.689, 0.842)*	1.471 (1.308, 1.656)*	0.750 (0.691, 0.814)*
Nationality/ethnicity						
Others (reference)	1.000	1.000	1.000	1.000	1.000	1.000
Han	1.184 (1.013, 1.383)*	0.725 (0.627, 0.838)*	1.104 (0.903, 1.35)	0.658 (0.528, 0.820)*	1.304 (1.018, 1.671)*	0.786 (0.646, 0.956)*
Grade						
3rd grader (reference)	1.000	1.000	1.000	1.000	1.000	1.000
7th grader	0.490 (0.448, 0.538)*	1.754 (1.564, 1.968)*	0.580 (0.513, 0.656)*	1.276 (1.079, 1.509)*	0.370 (0.319, 0.430)*	2.232 (1.902, 2.618)*
Region						
Qinghai (reference)	1.000	1.000	1.000	1.000	1.000	1.000
Shandong	1.268 (1.154, 1.394)*	0.527 (0.477, 0.582)*	1.322 (1.168, 1.496)*	0.455 (0.389, 0.532)*	1.181 (1.019, 1.368)*	0.583 (0.511, 0.666)*
Parental education[b]						
Low (reference)	1.000	1.000	1.000	1.000	1.000	1.000
High	1.054 (0.914, 1.215)	0.794 (0.685, 0.920)*	1.00 (0.832, 1.201)	0.824 (0.656, 1.034)	1.172 (0.933, 1.472)	0.763 (0.627, 1.495)
Middle	1.075 (0.949, 1.218)	0.829 (0.731, 0.942)*	0.999 (0.852, 1.173)	0.836 (0.688, 1.015)	1.220 (0.996, 1.495)	0.824 (0.695, 0.977)*
Family structure						
Living with parents (reference)	1.000	1.000	1.000	1.000	1.000	1.000
Living with grandparents	1.032 (0.811, 1.313)	1.137 (0.889, 1.453)	1.002 (0.735, 1.367)	1.397 (0.971, 2.010)	1.037 (0.705, 1.525)	1.026 (0.733, 1.436)
Living with both[c]	1.037 (0.938, 1.146)	0.992 (0.892, 1.103)	0.893 (0.783, 1.020)	1.079 (0.912, 1.278)	1.241 (1.062, 1.450)*	1.000 (0.869, 1.150)

*P<0.05. △Gender was removed in the gender-stratified analysis. #Odds ratio refers to the odds of incorrect perception of weight status (overestimate or underestimate). [a]calculated by the WHO growth reference for school-aged children and adolescent. [b]Three education groups, low: both parents < high school education; middle: one of their parents > college education; high: both parents > college education. [c]Living with both means living with parents and grandparents.

Table 5 Model fit statistics of the 1- to 6-class LCA models

Number of class	Loglikelihood	Degree of freedom	G2	Akaike (AIC)	Bayesian (BIC)	CAIC	Sample-size (ABIC)	Entropy
All								
1	–68341.614	8178	7880.228	7906.227	8000.851	8013.851	7959.539	1.00
2	–67236.834	8164	5670.669	5724.668	5921.195	5948.195	5835.392	0.74
3	–66548.525	8150	4294.051	4376.051	4662.917	4715.479	4544.186	0.85
4	–66477.793	8136	4152.586	4262.586	4674.479	4717.917	4488.134	0.79
5	–66422.910	8122	4042.821	4180.820	4683.054	4752.054	4463.781	0.75
6	–66382.669	8108	3962.338	4128.338	4732.474	4815.474	4468.711	0.74
Boys								
1	–36755.400	8178	5477.381	5503.381	5589.702	5602.702	5548.392	1.00
2	–36160.634	8164	4287.849	4341.849	4521.133	4548.133	4435.335	0.73
3	–35762.970	8150	3492.522	3574.522	3846.766	3887.766	3716.481	0.84
4	–35717.461	8136	3401.503	3511.504	3876.710	3931.710	3701.937	0.77
5	–35680.430	8122	3327.443	3465.443	3923.611	3992.612	3704.350	0.75
6	–35657.575	8108	3281.732	3447.732	3998.861	4081.862	3735.113	0.80
Girls								
1	–31379.197	8178	4551.449	4577.449	4662.312	4675.312	4621.002	1.00
2	–30837.034	8164	3467.124	3521.124	3697.378	3724.378	3611.581	0.81
3	–30549.171	8150	2891.399	2973.399	3241.044	3282.044	3110.760	0.86
4	–30507.02	8136	2807.115	2917.115	3276.151	3331.151	3101.379	0.83
5	–30475.705	8122	2744.466	2882.466	3332.893	3401.893	3113.635	0.86
6	–30448.855	8108	2690.766	2856.766	3398.584	3481.584	3134.839	0.84

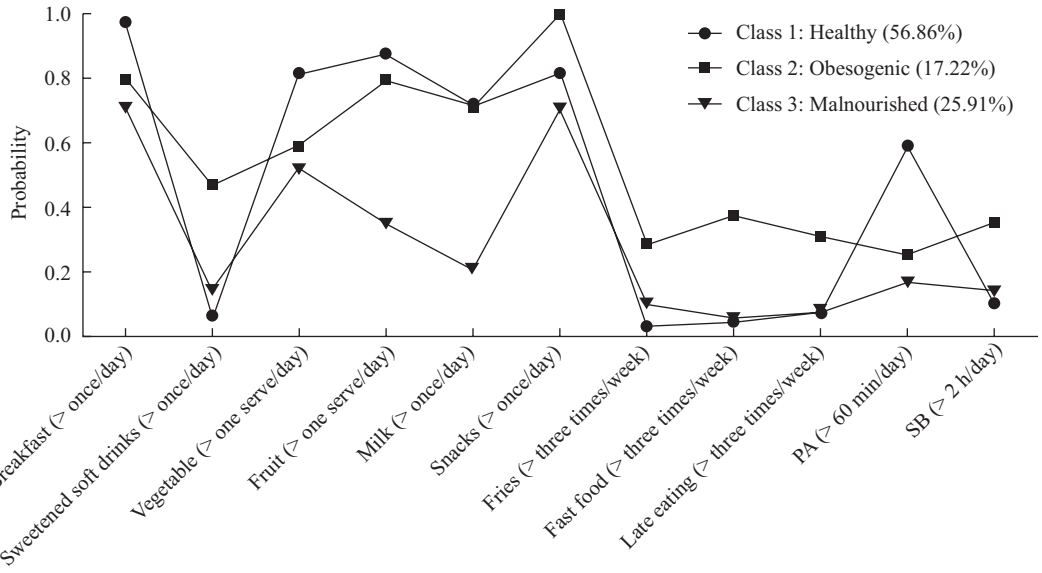

Fig. 1 Item probability of each health behavior in each latent class
PA: physical activity; SB: sedentary behavior

vegetables (81.73%) and fruits (87.68%) at least once per day. Besides, the pattern also had lowest proportions of reporting >2 h/day of sedentary behaviors (10.44%), drinking sweetened soft drinks >once/day (6.30%), consuming fries (2.81%) or fast food (4.64%) >three times/week.

Approximately 14.62% of the participants were classified into Class 2, which was labeled as obesogenic pattern. The main feature of Class 2 was that they would like to intake more but do moderate physical activities. They had the highest frequencies of consuming unhealthy food (sweetened soft drinks: 47.01%, fries: 28.53%, fast food: 34.35%, snacks: 99.96%), and then healthy food (vegetables: 59.37% and fruits: 79.60%). In addition, they preferred sedentary behaviors (35.49%) to others, and also, they were fully interested in moderate physical activities (25.38%).

The rest of the 23.39% participants belonged to Class 3, which was defined as malnourished pattern. Participants in Class 3 had the lowest proportion of having breakfast (70.90%), eating vegetables (51.95%) and fruits (34.82%), and drinking milk (20.75%). They were also less likely to eat the snacks (70.66%), fast

food (5.59%), fries (9.48%). Besides, they preferred less physical activity (16.89%) and sedentary behaviors (14.06%).

Obesogenic pattern group had the highest overweight rate (25.03%) and the lowest underweight rate (11.17%) compared to others, while the highest underweight rate (18.56%) and the lowest overweight rate (15.25%) appeared in malnourished pattern group. The healthy pattern group was less likely to be overweight or obese than obesogenic pattern group (19.84% *vs.* 25.03%, $P<0.001$). Similarly, the malnourished pattern group was more likely to be underweight than healthy pattern group (18.56% *vs.*12.60%, $P<0.001$). Compared with the concordant weight perception group, the weight overestimated students showed higher propensity to choose malnourished pattern after adjustment for socio-demographic factors. According to the results of stratified analysis, the underweight students who overestimated their body weight showed no obvious preference to obesogenic pattern or less-eating. Overweight or obese students who underestimated their weight were more likely to choose malnourished pattern, and this trend was also significant for girls (table 6).

3 DISCUSSION

Based on the present study, approximately half of the Chinese children and adolescents misperceived their body weight. Boys accounted for the most part of weight misperception compared to girls. Girls were more likely to overestimate their body weight and boys to underestimate their weight regardless of their actual BMI-based weight status, which may be related to the body norms of children and adolescents changing with the rapid development of opened mass media. Besides, weight disorder is another serious problem found in this study. Among the children and adolescents in this analysis, the high prevalence rate of overweight and obesity was 12.19% and 7.34%, respectively. The boys, especially those from wealthy regions (such as Shandong province), and those whose parents with high education level, had higher prevalence of overweight or obesity. Furthermore, a coexisting problem of underweight among Chinese children and adolescents was also worthy of attention, for almost 13.78% of children and adolescents were underweight, indicating they were suffering malnutrition. The prevalence rate of underweight children and adolescents from less wealthy district (e.g. Qinghai province) was as high as 21.30%. The minorities and those whose parents were of low education levels also showed a relative high prevalence of underweight. The high prevalence rate of overweight/obesity as well as underweight among Chinese children and adolescents indicated that both over-nutrition and mal-nutrition should be concerned when efficacious interventions are made to improve the healthy development of children and adolescents.

Weight misperception is an independent risk factor of unhealthy lifestyles and can accelerate the weight disorders among the children and adolescents in the stage of growth and development. In the Asian culture, the slim ideal image to girls and muscular ideal image to boys have been rooted in the hearts of children and adolescents[35–37]. Coupled with the influence from opened mass media, the pressure from peers also aggravates the girls' desire to be more slender and the boys' desire to be muscular[38]. Under the stress of beauty norm of thinness, girls might attempt to lose weight inappropriately regardless of the fact they were actually thin[39]. Similarly, for boys, they may take wrong actions to gain weight to pursue a stronger appearance[40]. Consequently, the prevalence of underweight among girls and the overweight or obesity among boys presented to be higher.

Additionally, students in higher grade, from wealthy district, and with higher BMI status (overweight and obesity) showed more likely to misperceive their body weight. Because of the high overweight/obesity rate, students from Han nationality were more likely to underestimate the body weight than the others. High prevalence of overweight or obesity may also influence weight norms. As more and more children and adolescents become overweight and obese, they might neglect their unhealthy weight status and perceive themselves to be normal weight[41].

Epidemiological studies have confirmed that body weight misperception was an important risk factor of abnormal eating behaviors among adolescents[7]. Previous study showed that adolescents who overestimated their body weight were more likely to choose unhealthy dieting habits[42]. Similar to previous research, the result of the LCA procedure revealed that participants with their weight misperceived were more likely to choose unhealthy dietary and exercise patterns, mainly including the obesogenic pattern and the malnourished pattern. Moreover, the participants who overperceived their weight had a greater tendency to choose malnourished pattern than the ones who underestimated the weight. Weight underestimated boys and weight overestimated girls tended to choose obesogenic pattern and malnourished pattern. Weight misperception may lead to inappropriate weight control practice among this special crowd. Especially for girls, those overestimating their weight may be confused with their "unsatisfied" weight and attempted to lose weight blindly, while those underestimating the weight may be relieved for the "satisfied" weight and neglect the weight control.

Considering the above problems, effective intervention programs should focus on guiding children and adolescents to accurately perceive their

Table 6 Association between dietary and activity patterns and weight perception stratified by BMI-based weight status (Logistic regression△, *n*=10 708)

Weight perception#	Total (*n*=10 708)		Boys (*n*=5 654)		Girls (*n*=5 654)	
	Obesogenic pattern OR (95% CI)**	Malnourished pattern OR (95% CI)**	Obesogenic pattern OR (95% CI)**	Malnourished pattern OR (95% CI)**	Obesogenic pattern OR (95% CI)**	Malnourished pattern OR (95% CI)**
Underweight						
Correct-estimated (reference)	1.000	1.000	1.000	1.000	1.000	1.000
Underestimated	–	–	–	–	–	–
Overestimated	1.100 (0.798, 1.516)	1.100 (0.845, 1.432)	1.001 (0.625, 1.603)	1.324 (0.903, 1.943)	1.175 (0.769, 1.795)	1.030 (0.699, 1.519)
Normal weight						
Correct-estimated (reference)	1.000	1.000	1.000	1.000	1.000	1.000
Underestimated	1.229 (1.034, 1.460)*	1.320 (1.130, 1.541)*	1.384 (1.104, 1.735)*	1.359 (1.109, 1.665)*	1.008 (0.766, 1.325)	1.346 (1.062, 1.707)*
Overestimated	1.112 (0.920, 1.343)	1.427 (1.217, 1.673)*	0.900 (0.663, 1.220)	1.463 (1.151, 1.860)*	1.346 (1.062, 1.706)*	1.507 (1.217, 1.866)*
Overweight						
Correct-estimated (reference)	1.000	1.000	1.000	1.000	1.000	1.000
Underestimated	1.255 (0.936, 1.682)	1.513 (1.168, 1.960)*	1.377 (0.980, 1.935)	1.335 (0.997, 1.788)	0.980 (0.552, 1.742)	1.906 (1.119, 3.247)
Overestimated	–	–	–	–	–	–
Total						
Correct-estimated (reference)	1.000	1.000	1.000	1.000	1.000	1.000
Underestimated	1.225 (1.062, 1.414)*	1.329 (1.170, 1.510)*	1.336 (1.115, 1.602)*	1.318 (1.122, 1.548)*	1.042 (0.824, 1.318)	1.394 (1.135, 1.713)*
Overestimated	1.186 (1.015, 1.387)*	1.365 (1.198, 1.555)*	1.047 (0.822, 1.335)	1.459 (1.205, 1.765)*	1.311 (1.073, 1.601)*	1.365 (1.140, 1.635)*

*$P<0.05$; △adjusted for gender grade, region, nationality, parental education and family members, but gender was removed in the gender-stratified analysis; #calculated by the WHO growth reference for school-aged children and adolescent; **odds ratio refers to the odds of incorrect perception of weight status (overestimate or underestimate) with the correct-estimated group being the reference

body weight. For example, at school-level, healthy atmosphere should be established to help students set up correct weight norms. Some pragmatic approach, such as putting automatic BMI measuring instruments in the classroom to monitor the weight for children and adolescents should be applied. At family-level, family members should assist participants in developing healthy dietary habits and exercise patterns. More programs focusing on health education would do much benefit.

The present study investigated the body weight perception and its influencing factors in children and adolescents in China by using a robust and large sample size. Our results in the large sample of 10 708 Chinese children and adolescents represent an important contribution to the knowledge of body weight perception and dietary and activity patterns of children and adolescents on the basis of international context. However, some limitations should be noted. Firstly, the weight perception is a subjective scale reflecting the satisfaction of self-image and a series of complex psychological problems. It would be more meaningful to add some psychological factors such as stress, depressed mood in current study for comprehensive understanding of the psychological problems of children and adolescents. Besides, the weight perception was obtained by only one question, which would be somewhat subjective and influence the accuracy of the result. Thirdly, the weight control practice, which contributes to explaining the relationship between weight misperception and lifestyle behaviors, were neglected in investigation. In future studies, more useful programs will be launched to further explore the relationship among psychological activities, behavioral factors and healthy ouctomes among Chinese children and adolescents.

Weight misperception is a prevalent phenomenon among children and adolescents and it is closely related to the unhealthy weight pattern. Understanding weight misperception patterns among children and adolescents and their association with socio-demographic and lifestyle behaviors and promoting health programs to help children and adolescents develop accurate weight perception and maintain healthful dietary and exercise activity habits will have practical significance. Appropriate guidance should be formulated to improve self-awareness of weight status and develop healthy weight behaviors, which would be conducive to physical and mental health among this particular demographic.

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Conflict of Interest Statement

The authors of this paper declare they have no conflict of interest.

REFERENCES

1 Hogan MJ, Strasburger VC. Body image, eating disorders, and the media. Adolesc Med State Art Rev, 2008,19(3):521-464
2 McDonald CM, Olofin I, Flaxman S, *et al*. The effect of multiple anthropometric deficits on child mortality: meta-analysis of individual data in 10 prospective studies from developing countries. Am J Clin Nutr, 2013,97(4):896-901
3 Park MH, Falconer C, Viner RM, *et al*. The impact of childhood obesity on morbidity and mortality in adulthood: a systematic review. Obes Rev, 2012,13(11):985-1000
4 Reilly JJ, Kelly J. Long-term impact of overweight and obesity in childhood and adolescence on morbidity and premature mortality in adulthood: systematic review. Int J Obes, 2011,35(7):891-898
5 Organization WH. Preventing Chronic Diseases. A Vital Investment: WHO Global Report Geneva: World Health Organization, 2005.
6 Lo WS, Ho SY, Mak KK, *et al*. Weight misperception and psychosocial health in normal weight Chinese adolescents. Int J Pediatr Obes, 2011,6(2-2):e381-e389
7 Chisuwa N, O'Dea JA. Body image and eating disorders amongst Japanese adolescents. A review of the literature. Appetite, 2010,54(1):5-15
8 Mogre V, Mwinlenna PP, Oladele J. Distorted self-perceived weight status and its associated factors among civil servants in Tamale, Ghana: a cross-sectional study. Arch Public Health, 2013,71(1):30
9 Shirasawa T, Ochiai H, Nanri H, *et al*. Association between distorted body image and changes in weight status among normal weight preadolescents in Japan: a population-based cohort study. Arch Public Health, 2016,74:39
10 Felts WM, Parrillo AV, Chenier T, *et al*. Adolescents' perceptions of relative weight and self-reported weight-loss activities: analysis of 1990 YRBS (Youth Risk behavior Survey) national data. J Adolesc Health, 1996,18(1):20-26
11 Edwards NM, Pettingell S, Borowsky IW. Where perception meets reality: self-perception of weight in overweight adolescents. Pediatrics, 2010,125(3):e452-e458
12 Lee K, Valeria B, Kochman C, *et al*. Self-assessment of height, weight, and sexual maturation: validity in overweight children and adolescents. J Adolesc Health, 2006,39(3):346-352
13 Pich J, Bibiloni Mdel M, Pons A, *et al*. Weight self-regulation process in adolescence: The relationship between control weight attitudes, behaviors, and body weight status. Front Nutr, 2015,2:14
14 Rawana JS. The relative importance of body change strategies, weight perception, perceived social support, and self-esteem on adolescent depressive symptoms: longitudinal findings from a national sample. J Psychosom Res, 2013,75(1):49-54
15 Kim Y, Kawachi I. School- and Individual-level

Predictors of Weight Status Misperception among Korean Adolescents: A National Online Survey. PloS one, 2016, 11(5):e0154826
16 Martin MA, Frisco ML, May AL. Gender and race/ethnic differences in inaccurate weight perceptions among U.S. adolescents. Womens Health Issues, 2009,19(5):292
17 Park E. Overestimation and underestimation: adolescents' weight perception in comparison to BMI-based weight status and how it varies across socio-demographic factors. J Sch Health, 2011,81(2):57-64
18 Shirasawa T, Ochiai H, Nanri H, *et al*. The relationship between distorted body image and lifestyle among Japanese adolescents: a population-based study. Arch Public Health, 2015,73(1):32
19 Shi Z, Lien N, Nirmal Kumar B, *et al*. Perceptions of weight and associated factors of adolescents in Jiangsu Province, China. Public Health Nutr, 2007,10(3):298-305
20 Lim H, Wang Y. Body weight misperception patterns and their association with health-related factors among adolescents in South Korea. Obesity, 2013,21(12):2596-2603
21 Ha Y, Choi E, Seo Y, *et al*. Relationships among subjective social status, weight perception, weight control behaviors, and weight status in adolescents: findings from the 2009 Korea Youth Risk Behaviors Web-Based Survey. J Sch Health, 2013,83(4):273-280
22 Chen X, Wang Y. Is ideal body image related to obesity and lifestyle behaviors in African American adolescents? Child Care Health Dev, 2012,38(2):219-228
23 Petracci E, Cavrini G. The effect of weight status, lifestyle, and body image perception on health-related quality of life in children: a quantile approach. Qual Life Res, 2013, 22(9):2607-2615
24 Patnode CD, Lytle LA, Erickson DJ, *et al*. Physical activity and sedentary activity patterns among children and adolescents: a latent class analysis approach. J Phys Act Health, 2011,8(4):457-467
25 de Onis M, Onyango AW, Borghi E, *et al*. Development of a WHO growth reference for school-aged children and adolescents. Bull World Health Organ, 2007,85(9):660-667
26 Menschik D, Ahmed S, Alexander MH, *et al*. Adolescent physical activities as predictors of young adult weight. Arch Pediatr Adolesc Med, 2008,162(1):29-33
27 Strasburger VC, Hogan MJ, Mulligan DA, *et al*. Children, Adolescents, and the Media. Pediatrics, 2013,132(5):958-961
28 Landis JR KG. The measurement of observer agreement for categorical data. Biometrics, 1977,33:159-174
29 Hagenaars JA, McCutcheon AL. Applied latent class analysis. New York: Cambridge University Press, 2002.
30 Patnode CD, Lytle LA, Erickson DJ, *et al*. Physical activity and sedentary activity patterns among children and adolescents: a latent class analysis approach. J Phys Act Health, 2011,8(4):457-467
31 Xie B, Chou CP, Spruijt-Metz D, *et al*. Weight perception, academic performance, and psychological factors in Chinese adolescents. J Phys Act Health, 2006,30(2):115-124
32 Xie B, Chou CP, Spruijt-Metz D, *et al*. Longitudinal analysis of weight perception and psychological factors in Chinese adolescents. Am J Health Behav, 2011,35(1):92-104
33 Lanza ST, Collins LM, Lemmon DR, *et al*. PROC LCA: A SAS Procedure for Latent Class Analysis. Struct Equ Modeling, 2007,14(4):671-694
34 Smolak L. Body image in children and adolescents: where do we go from here? Body Image, 2004,1(1):15-28
35 Avila, C. Media's portrayal of the "ideal image" with emphasis on the "thin ideal" and its effects on women's body image. Diss, 2015.
36 Calado M, Lameiras M, Sepulveda AR, *et al*. The association between exposure to mass media and body dissatisfaction among Spanish adolescents. Womens Health Issues, 2011,21(5):390-399
37 McLean SA, Paxton SJ, Wertheim EH. Does Media Literacy Mitigate Risk for Reduced Body Satisfaction Following Exposure to Thin-Ideal Media? J Youth Adolesc, 2016,45(8):1678-1695
38 Helfert S, Warschburger P. A prospective study on the impact of peer and parental pressure on body dissatisfaction in adolescent girls and boys. Body Image, 2011,8(2):101-109
39 Gondoli DM, Corning AF, Salafia EH, *et al*. Heterosocial involvement, peer pressure for thinness, and body dissatisfaction among young adolescent girls. Body Image, 2011,8(2):143-148
40 Labre MP. Adolescent boys and the muscular male body ideal. J Youth Adolesc, 2002,30(4):233-242
41 Robinson E, Kersbergen I. Overweight or about right? A norm comparison explanation of perceived weight status. Obes Sci Pract, 2017,3(1):36-43
42 Shirasawa T, Ochiai H, Nanri H, *et al*. The relationship between distorted body image and lifestyle among Japanese adolescents: a population-based study. Arch Public Health, 2015,73(1):32

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