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Prevalence and correlates of overweight and obesity among adolescent of northeastern China: a cross-sectional study

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Abstract

Objectives: To estimate the prevalence of overweight/obesity in adolescents and to evaluate the associated factors among this group in Changchun City, Northeastern China.

Methods: A cross-sectional study of 1955 adolescents aged 11–18 years was conducted in Changchun City, using stratified cluster sampling. Parents and caretakers of children completed the questionnaires as requested without protest, which included demographic characteristics and anthropometric parameters. Univariate and multivariate logistic regression were performed to analyze the relationship between overweight /obesity and related factors.

Results: In total, the prevalence of overweight was 12.7% (male 17.4%; female 10.1%), and the prevalence of obesity was 4.9% (male 8.8%; female 3.1%) in Changchun, Jilin province. The prevalence of overweight and obesity were both higher in men than women (p <0.001). Multivariate logistic regression showed that overweight and obesity were significantly associated with male, age, preterm birth, parental obesity and diet habits (fruit frequency per week, eating picky and eating concentration).

Conclusion: The prevalence of overweight and obesity among adolescents in Changchun was relatively higher compared with that in Xi'an and Nanjing in recent years. Gender, age, birth history, diet habits, and parental weight were important factors for overweight and obesity in adolescents. Further research should be

conducted about the health of adolescents in China and further intervening measures should be done to decrease the prevalence of overweight/obesity.

Keywords: overweight; obesity; adolescent; association

Strengths and limitations of this study

- The strength of this study is precise physical measurement, which improved the validity of the results.
- The analysis results might exist some information and confounding bias due to the nature of cross-sectional data.
- The results were from Changchun only and therefore cannot representative of the specific circumstance in Jilin Province.

Introduction

The prevalence of obesity has increased dramatically among children, adolescents and adults during the past decades all over the world[1]. Overall, the global proportion of adolescents with obesity has risen significantly from just 4% in 1975 to just over 18% in 2016[2]. There is compelling evidence implicating that a significantly higher proportion of adolescents who were overweight or obese was found, which reached alarming levels in recent years.

In recent years, many scholars have conducted plenty of studies on overweight and obesity. As we all know, overweight and obesity have been predisposing factors for

many chronic diseases, such as type 2 diabetes, cardiovascular diseases, respiratory diseases, musculoskeletal disorders, and various types of cancer[3]. Yan Rong et found that the association of adolescent obesity with nonalcoholic fatty liver disease (NAFLD) and the incidence of NAFLD rose subsequently with body weight's increasing[4]. Quentin Lisan compared patients with obesity and severe obstructive sleep apnea (OSA) with and without prescription of positive airway pressure (PAP) therapy, found that participants with PAP prescriptions had a higher BMI than participants not prescribed PAP[5] . It has been estimated that overweight and obesity are the fifth leading cause of death worldwide, accounting for nearly 3.4 million deaths annually[6]. In addition, Obesity was considered as a risk factor for the development of chronic kidney disease[7]. In this condition, the American Medical Association classified obesity as a disease to get physicians to pay more attention[8]. As the largest developing country, China had nearly one-third of overweight or obese adolescents until 2016; and that the obesity prevalence rate had risen from 0.10% in 1976 to 8.50% in 2016. Sun HP found the prevalence of obesity and of overweight and obesity combined was 8.1% and 19.2% among children and adolescents 7–18y in age[9]; Zhang XY reported the prevalence of overweight and obesity among primary school children was 15.2% and 11.7% in Jiangsu Province[10]. Therefore, it is of key importance to make sure the risk factors of overweight and obesity to prevent adolescents from the disease.

We investigated the physical condition of adolescents among 11-18 years from six middle schools in Changchun which is the capital of Jilin province. The aim of the current study was to reveal the prevalence of overweight and obesity and to analyze some associated factors among adolescents of overweight and obesity in Changchun, Jilin.

Methods

Subjects

The study sample comprised students from six middle schools (three in urban and three in rural areas) randomly in Changchun City, the capital of Jilin Province in Northeast China, using stratified cluster sampling. Overall, 1955 students aged 11–18 years were contained in this cross-section survey; subjects with overweight/obesity due to known metabolic and endocrine diseases were excluded. Students were also excluded if they had mental or physical impairments severe enough to cause abnormal behaviors, including congenital disease, intellectual disability, and a psychiatric disorder[11]. The study was approved by the ethics committee of the First Hospital of Jilin University (Reference Number: 2013-031). The investigation has received informed consent from students and parents. We used the SRQR reporting guidelines[12] in this study.

Key Variables

Body mass index (BMI) is used here as the necessary indicator for overweight and obesity of adolescent and adult. Weight category was defined using age- and sex-specific cutoff points by the international standard for BMI among adolescents[13]. As for adult, the criterion 'BMI⩾24' was defined as overweight and obesity [14, 15]. Parents and caretakers provided adolescents' weight (to the nearest 1 kg) and height (to the nearest 1 cm). Overall children were classified by age as 3 groups (<13, 13-15, >15) , region as 2 groups (urban, rural) and gender as 2 groups (male, female). Participants who slept less than 8 h over 3 days a week were classified as 'sleep <8 h', and those who slept more than 10 h over 3 days a week were defined as 'sleep >10 h'[16]. Participants who were classified as 'picky eater' were defined as adolescents who had eaten something too simple in a week. According to students' eating habits, we categorized these behaviors by whether they were done over twice a week, like eating fresh fruits, dessert, breakfast and fast-food. And students whether eating with concentration or not was a significant classification standard. Based on students' daily exercise frequency, we took students into 3 groups (never, sometimes and often).

Statistical analysis

Data input was established using Epidata 3.1and statistical analysis was performed using SPSS 24.0. Frequency distributions were used to characterize subjects, and percentage data were used to report prevalence. The relationship between each factor

and the adolescents' weight status was reflected by χ^2 tests, univariate and multivariate logistic regression. In univariate analysis, when $p < 0.10$, significant correlation factors were included in a forward stepwise multivariate logistic regression to exclude confounding factors. In all analyses, two-tailed P value < 0.05 was considered statistically significant.

Data availability

Data referenced in this study are available in the project named "Effect and mechanism of weight loss on upper airway collapsibility in obese patients with OSAS". We selected a portion of the data in the database, including body measurements of adolescent from six middle schools in Changchun City. The data that support the findings of this study are available on request from the corresponding author [HY]. The data are not publicly available due to them containing information that could compromise research participant privacy or consent.

Patient and public involvement

No patient involved.

Results

On the basis of the inclusion and exclusion criteria, we chose 1955 adolescents from Changchun, of which 1825 participants were finally analyzed in this study. The participants with missing information on height or weight or extreme BMI values

were excluded from the study. According to the analysis of the frequency distribution, we found that there were 837 boys and 988 girls included; the median age of the students was 15.30 years, ranging from 11 to 18 years; of all these subjects, 42.9% were from rural regions and 57.1% were from urban regions; most of the subjects were Han Chinese, accounted for 98.2%, with only a few minority ethnicities.

According to the BMI classification in the worldwide, the overall prevalence of overweight was 12.7% (male 17.4%; female 10.1%), and the prevalence of obesity was 4.9% (male 8.8%; female 3.1%) in Changchun city, Jilin province (Table 1). The overweight and obese rate were both higher in males than in females (p <0.001), respectively. A higher prevalence of overweight was found in subjects whose ages ranged from 11-12 years, and the prevalence of obesity was higher in the age groups 13-15 (p =0.008). Children from an urban area showed a significantly higher proportion of being overweight. Full-term birth subjects had a higher prevalence rate than others (p =0.014). In addition, Students who had poor diet habits, such as ate fruits less than twice a week (p =0.029), enjoyed fast-food and desserts, ate without concentration (p =0.004) and those picky eaters (p =0.028), were much more likely to be overweight or obese. What's more, a higher prevalence of overweight was found in subjects who never exercised than others. As for genetic factors, we found that parental weight showed significant improvement in compared with childhood weight.

Table 1

Prevalence of overweight and obesity according to demographic characteristics

Variables	n	Overweight			Obesity		
		PR (%)	χ^2	*p*	*PR* (%)	χ^2	*p*
Gender							
Male	837	17.4	19.81	<0.001	8.8	23.843	<0.001
Female	988	10.1			3.1		
Area							
Urban	1042	14.4	2.178	0.14	5.6	0.03	0.863
Rural	783	12			5.8		
Age							
<13	168	19.3	9.658	0.008	5.1	0.407	0.816
13-15	1157	11.6			5.9		
>15	500	15.5			5.2		
Birth history							
Full-term birth	1621	14.2	8.525	0.014	6	2.513	0.285
Preterm birth	133	5.2			3.2		
Post-term birth	71	10.1			3.1		
Fresh fruits≤2/week							
Yes	1259	12.2	4.776	0.029	4.8	5.393	0.02
No	566	16.1			7.7		
Dessert≤2/week							
Yes	887	12.4	1.315	0.252	5.2	0.477	0.49
No	938	14.3			6		
Breakfast≤2/week							
Yes	1673	13.9	1.758	0.185	5.8	0.475	0.491
No	149	11.1			4.8		
Fast food≤2/week							
Yes	264	7.6	2.786	0.095	7.6	0.703	0.402
No	1561	13.7			5.5		
Eat with concentration							
Yes	1174	11.6	8.253	0.004	5.4	0.464	0.496
No	651	16.5			6.2		
Picky eater							
Yes	1133	14.8	4.851	0.028	6.7	4.876	0.027
No	692	11.1			4		
Exercise							
Never	451	15.9	3.28	0.194	4.2	2.31	0.315
Sometimes	478	12			6.6		
Often	896	12.8			5.8		
Highest parental degree							
Primary school or low	95	8	4.688	0.196	8	1.322	0.724
Junior high school	799	13			5.1		
Senior high school	468	15.8			6		

University and above	463	12.7			5.7		
Sleep (hours/night)							
<8	884	13.6	0.423	0.809	5.3	2.392	0.302
⩾8	861	13.3			5.6		
>10	80	11			9.7		
Fatherly weight							
Normal	827	15.5	5.575	0.018	7.6	9.426	0.002
Overweight and obesity	998	11.6			4.1		
Maternal weight							
Normal	1099	15.2	7.504	0.006	5.5	0.06	0.807
Overweight and obesity	726	10.6			5.8		

Note: *PR* (%), Prevalence rate

In order to facilitate regression analysis, we divided the participants into two groups: underweight and normal; overweight and obese. Table 2 shows the univariate analysis of correlates of overweight and obesity in adolescents. As is impressively demonstrated in this table, the following factors all had a significant effect: gender, age, birth history, the frequency of eating fruits, eating habits (eat with concentration, picky eaters), parental weights (p <0.05). According to the results, we added all these significant factors to a forward stepwise multivariate logistic regression model.

Table 2

Univariate analysis of correlates of overweight and obesity in adolescents in Changchun

Variables	Wald χ^2	p	*OR*	95% *CI*
Gender				
Female	35.972	<0.001	1	
Male			2.125	1.661-2.719
Area				
Urban	1.288	0.256	1	
Rural			1.15	0.902-1.473
Age				
<13	5.21	0.07	1	
13-15	4.163	0.041	0.66	0.448-0.984
>15	0.915	0.339	0.81	0.532-1.243

Birth history				
Full-term birth	9.756	0.008	1	
Preterm birth	8.418	0.004	0.39	0.21-0.739
Post-term birth	1.58	0.209	0.63	0.312-1.29
Fresh fruits≤2/week				
Yes	8.571	0.003	1	
No			1.46	1.132-1.87
Dessert≤2/week				
Yes	1.663	1.197	1	
No			1.17	0.921-1.493
Breakfast≤2/week				
Yes	2.076	0.15	1.00	
No			0.79	0.571-1.089
Fast food≤2/week				
Yes	1.978	0.16	1	
No			1.08	0.972-1.19
Eat with concentration				
Yes	7.303	0.007	1	
No			0.713	0.558-0.911
Picky eater				
Yes	8.48	0.004	1	
No			0.68	0.526-0.882
Exercise				
Never	0.601	0.74	1	
Sometimes	0.45	0.502	0.89	0.638-1.246
Often	0.491	0.484	0.90	0.672-1.207
Highest parental degree				
Primary school or low	2.878	0.411	1	
Junior high school	0.284	0.594	1.18	0.648-2.136
Senior high school	1.444	0.229	1.45	0.79-2.678
University and above	0.306	0.58	1.19	0.642-2.206
Sleep (hours/night)				
<8	0.074	0.964	1	
≥8	0.004	0.952	0.99	0.776-1.27
>10	0.061	0.805	1.08	0.598-1.938
Fatherly weight				
Normal	11.902	0.001	1	
Overweight and obesity			0.65	0.513-0.832
Maternal weight				
Normal	4.582	0.032	1	
Overweight and obesity			0.76	0.591-0.977

Table 3 shows the results of logistic regression models comparing the prevalence of the potential risk factors: gender, age, birth history, the frequency of eating fruits, eating habits (eat with concentration, picky eaters), parental weights. In this forward stepwise multivariate logistic regression model, males were more likely to be overweight and obese than females (OR=2.002, 95%CI: 1.557-2.573). Students aged from 13-15 (OR=0.642, 95%CI: 0.428-0.962) were less likely to be overweight than 11-12 years old. Compared with full-term birth subjects, those who were preterm birth (OR=0.442, 95%CI: 0.234-0.835) tended to be normal weight. Participants who ate fruits less than twice a week (OR=1.335, 95%CI: 1.03-1.73) were 1.335 times more likely to be overweight and obese. What's more, the prevalence of overweight would be enhanced if students ate with concentration (OR=1.387, 95%CI: 1.077-1.788). Picky eaters were much more likely to be overweight than the subjects who ate a healthy diet (OR=0.682, 95%CI: 0.523-0.889), respectively.

Table 3

Multivariate regression analysis of correlates of overweight and obesity in adolescents in Changchun

Variables	Wald χ^2	*p*	*β*	SE	*OR*	95% *CI*
Gender						
Female					1	
Male	29.35	<0.001	0.694	0.128	2.002	1.557-2.573
Age						
<13					1	
13-15	4.615	0.032	-0.444	0.207	0.642	0.428-0.962
>15	2.468	0.116	-0.351	0.223	0.704	0.454-1.091

Birth history						
Full-term birth					1	
Preterm birth	6.321	0.012	-0.816	0.325	0.442	0.234-0.835
Post-term birth	1.354	0.245	-0.43	0.369	0.651	0.316-1.342
Fresh fruits≤2						
Yes					1	
No	4.761	0.029	0.289	0.132	1.335	1.03-1.73
Eat with concentration						
Yes					1	
No	6.409	0.011	0.327	0.129	1.387	1.077-1.788
Picky eater						
Yes					1	
No	8.022	0.005	-0.383	0.135	0.682	0.523-0.889
Fatherly weight						
Normal					1	
Overweight and obesity	11.764	0.001	-0.433	0.126	0.649	0.507-0.831

Discussion

To describe the epidemiology of overweight and obesity in Changchun city and analyze the influence factors in adolescents, we conducted this survey of middle school students aged 11–18 years from urban and rural areas and found that location, gender and parental weight have a significant impact on a child's weight.

Based on the data, we found the prevalence of overweight was 12.7% (male 17.4%; female 10.1%), and of obesity was 4.9% (male 8.8%; female 3.1%) among adolescents in Changchun city, Jilin province. However, in recent studies, the overall prevalence of obesity in school-aged children in Xi'an was 4.11%, and the rate of overweight was 6.6% in Nanjing adolescents, which were both lower than data in Changchun. This difference may be caused by sample size, sex, and age of the studied population[17, 18]. In addition, demographics distribution and environmental factors

are probable cause too[19]. As we all know, the economics in northeast China was less development compared with that in east and south China to some extent[20]. Rates of overweight and obesity were also higher in rural areas in the north than in the south[21]. Depending on the season, people in the north might eat high-energy foods to combat the cold, what is said "energy balance related behaviors [22, 23]". In our data, boys were more often obese than girls, in general, which were in agreement with previous reports[23-26]. On the one hand, in traditional Chinese culture, the preference for boys may be the reason for the differences in diet, and older believe that fat boys are more powerful than thin ones. By contrast, girls with well-groomed and fit are more favored by Chinese society[27-29]. Girls, on the other hand, tend to be more concerned about their weight than boys.

We also found that adolescents who ate few fruits in general and were picky about foods were more likely to be overweight and obese in our survey. According to the present cross-sectional observation, children who were picky about foods would prefer more fast food, fried food, sweet food and so on. Nowadays, several studies have considered that food intake is a primary factor that determines body weight[30-32]. Y. Li et al concluded that overweight Chinese children reported high energy and fat intakes, excessive intake of cooking oil might be one of the risk factors of overweight[33]. Consistent with a previous study in Tianjin[30], overweight students preferred significantly to more sweet foods and take-out food rather than their counterparts with normal weight. The result might be influenced by many

elements, such as peer influence, food price, convenience or not, online influence and so on, based on recent report[34]. In order to decrease the fat rate, a series of interventions have been conducted such as controlling the TV time and increasing the sport time.

In our research, we found that if fathers were overweight, adolescents were less likely to be overweight, which was opposite to the previous conclusion[35-37]. Studies [25, 38]have found that the higher BMI in the father increased the risk of overweight/ obesity among males and females. However, the finding is not consistent across studies. In a previous study, the researchers found that the relationship between parents' and kids' BMI not existed when longitudinal analyses of changes in BMI over four years were performed[39]. This may explain why a short period of periodic surveys alone does not fully demonstrate a parent-child link to obesity, and we still need a long-term research if we want to explore the relationship between the two factors further. What's more, children's growing environment and living habits will also affect their own obesity level, which will have an impact on our results; for example, in order to adapt to the small groups in school, students always eat unhealthy food with their peers[34]. Further prospective studies that assess both energy expenditure and energy intake in children meanwhile are more likely to clarify this question. In addition, the use of BMI to assess parental weight status may be a limitation of this study, as BMI did not always reflect a person's body fat percentage, nor did we take into account parental waist circumference in this survey[38].

There are several limitations to this study. First, the analysis results were restricted by the less sample size, and we interpolated missing values in the data resulting in random errors eventually. Second, the conclusion might seem a little limited in assessing whether children were obese or not due to BMI, this single index and the potential bias. If we could analyze the risk factors of obesity in teenagers from multiple perspectives based on the height-for-age Z-score (HAZ), we might get a more accurate conclusion, which is also a problem we need to improve in the future. Third, the contents of the questionnaire were most recalled by the parents or guardians, and there might be information bias and confounding bias in this survey. Fourth, our data came from six schools in Changchun, which was not representative of the specific circumstance in Jilin Province. Further research should be conducted to complete the conclusion.

Conclusions

To sum up, in this cross-section study, we found the prevalence of overweight and obesity among adolescents in Changchun, Jilin Province is relatively high compared with other cities such as Xi'an and Nanjing. Gender, age, birth history, diet habits, and parental weight were important factors for overweight and obesity in adolescents. Therefore, reasonable lifestyle and effective weight control are necessary condition to prevent from overweight or obese for adolescent. There are still several limitations in this study, we need to conduct more information accurately and more specific analysis

on it. Further research should be conducted about the health of adolescents in China and further intervening measures should be tailored on decreasing the prevalence of obesity.

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Footnotes

Contributors: RD, CK and HY conceived the study, participated in the design of the study. HY, JJ and XL collected data. RD carried out the measurements, analyzed the data and drafted the manuscript. XY and BZ participated in the coordination of the study and interpreted the data. WB and YL revised the manuscript. All authors have approved the final article.

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Competing interests: None declared.

Ethical approval: The investigation was conducted by the First Hospital of Jilin University in April 2016, our data collected from the questionnaire in the survey as well. The study was approved by the ethics committee of the First Hospital of Jilin University (Reference Number: 2013-031). The investigation has received informed

consent from students and parents.

Data sharing: No additional data are available.

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Reporting checklist for qualitative study.

Based on the SRQR guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

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		Reporting Item	*Page Number*
Title			
	#1	*Concise description of the nature and topic of the study identifying the study as qualitative or indicating the approach (e.g. ethnography, grounded theory) or data collection methods (e.g. interview, focus group) is recommended*	*1*
Abstract			
	#2	*Summary of the key elements of the study using the abstract format of the intended publication; typically includes background, purpose, methods, results and conclusions*	*2-3*
Introduction			
Problem formulation	*#3*	*Description and signifcance of the problem / phenomenon studied: review of relevant theory and empirical work; problem statement*	*3-4*
Purpose or research question	*#4*	*Purpose of the study and specific objectives or questions*	
Methods			
Qualitative approach and research paradigm	*#5*	*Qualitative approach (e.g. ethnography, grounded theory, case study, phenomenolgy, narrative research) and guiding theory if appropriate; identifying the research paradigm (e.g. postpositivist, constructivist / interpretivist) is also recommended; rationale. The rationale should briefly discuss the justification for choosing that theory, approach, method or technique rather than other options available; the assumptions and limitations implicit in those choices and how those choices influence study conclusions and transferability. As appropriate the rationale for several items might be discussed together.*	*4-5*

Researcher characteristics and reflexivity	#6	*Researchers' characteristics that may influence the research, including personal attributes, qualifications / experience, relationship with participants, assumptions and / or presuppositions; potential or actual interaction between researchers' characteristics and the research questions, approach, methods, results and / or transferability*	*5-6*
Context	#7	*Setting / site and salient contextual factors; rationale*	*5-6*
Sampling strategy	#8	*How and why research participants, documents, or events were selected; criteria for deciding when no further sampling was necessary (e.g. sampling saturation); rationale*	*4-5*
Ethical issues pertaining to human subjects	#9	*Documentation of approval by an appropriate ethics review board and participant consent, or explanation for lack thereof; other confidentiality and data security issues*	*5-7*
Data collection methods	#10	*Types of data collected; details of data collection procedures including (as appropriate) start and stop dates of data collection and analysis, iterative process, triangulation of sources / methods, and modification of procedures in response to evolving study findings; rationale*	*4-6*
Data collection instruments and technologies	#11	*Description of instruments (e.g. interview guides, questionnaires) and devices (e.g. audio recorders) used for data collection; if / how the instruments(s) changed over the course of the study*	*4*
Units of study	#12	*Number and relevant characteristics of participants, documents, or events included in the study; level of participation (could be reported in results)*	*4*
Data processing	#13	*Methods for processing data prior to and during analysis, including transcription, data entry, data management and security, verification of data integrity, data coding, and anonymisation / deidentification of excerpts*	*6*
Data analysis	#14	*Process by which inferences, themes, etc. were identified and developed, including the researchers involved in data analysis; usually references a specific paradigm or approach; rationale*	*6*
Techniques to enhance trustworthiness	#15	*Techniques to enhance trustworthiness and credibility of data analysis (e.g. member checking, audit trail, triangulation); rationale*	*6*
Results/findings			
Syntheses and interpretation	#16	*Main findings (e.g. interpretations, inferences, and themes); might include development of a theory or model, or integration with prior research or theory*	*7-12*
Links to empirical data	#17	*Evidence (e.g. quotes, field notes, text excerpts, photographs) to substantiate analytic findings*	*n/a*
Discussion			
Intergration with prior work, implications, transferability and contribution(s) to the field	#18	*Short summary of main findings; explanation of how findings and conclusions connect to, support, elaborate on, or challenge conclusions of earlier scholarship; discussion of scope of application / generalizability; identification of unique contributions(s) to scholarship in a discipline or field*	*12-15*

Limitations	*#19*	*Trustworthiness and limitations of findings*	*15*
Other			
Conflicts of interest	*#20*	*Potential sources of influence of perceived influence on study conduct and conclusions; how these were managed*	*16*
Funding	*#21*	*Sources of funding and other support; role of funders in data collection, interpretation and reporting*	*16*

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Prevalence and correlates of overweight and obesity among adolescents in northeastern China: a cross-sectional study

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Abstract

Objectives: To estimate the prevalence of overweight/obesity among adolescents and to evaluate the associated factors in this group in Changchun City, northeastern China.

Methods: A cross-sectional study of 1955 adolescents aged 11–18 years was conducted in Changchun City, using stratified cluster sampling. Parents and caregivers of children completed the questionnaires as requested without objection; the questionnaire included demographic characteristics and anthropometric parameters. Univariate and multivariate logistic regression analyses were performed to analyze the relationship between overweight /obesity and related factors.

Results: In total, the prevalence of overweight was 12.7% (male 17.4%; female 10.1%), and the prevalence of obesity was 4.9% (male 8.8%; female 3.1%) in Changchun, Jilin Province. The prevalence of overweight and obesity was higher in males than that in females (P <0.001). Multivariate logistic regression showed that overweight and obesity were significantly associated with sex (OR=1.912, 95% CI: 1.481-2.469), weekly frequency of fruit consumption (OR=1.413, 95% CI: 1.085-1.840), picky eating (OR=0.691, 95% CI: 0.528-0.902), slowness in eating (OR=1.373, 95% CI: 1.060-1.778), paternal weight (OR=0.665, 95% CI: 0.516-0.857) and maternal weight(OR=0.723, 95% CI: 0.523-0.999).

Conclusion: The prevalence of overweight and obesity among adolescents in Changchun was high in recent years. The prevalence of overweight and obesity among males was higher than that among females. Sex, dietary habits (weekly

frequency of fruit consumption, picky eating and slowness in eating) and parental weight were important factors for overweight and obesity in adolescents. Further research should be conducted on the health of adolescents in China and further intervention measures should be implemented to reduce the prevalence of overweight/obesity.

Keywords: overweight; obesity; adolescent; association

Strengths and limitations of this study

- There have been few studies on obesity among adolescents in North China, so we studied the risk factors for obesity in adolescents.
- The strength of this study is the precise physical measurement, which improved the validity of the results.
- The analysis results might contain some confounding bias due to the cross-sectional natural of the data.
- The results were from Changchun, the capital of Jilin Province and therefore cannot be representative of the specific circumstances in all of China.
- The results were mainly discussed in relation to previous Chinese studies, combined with Chinese geographical environment, dietary patterns and adolescent lifestyle.

Introduction

The prevalence of obesity has increased dramatically among children, adolescents and adults worldwide in recent decades [1]. Overall, the global proportion of adolescents with obesity has increased significantly from just 4% in 1975 to just over 18% in 2016[2]. There is compelling evidence revealing a significantly higher proportion of overweight or obese adolescents in recent years, which has reached alarming levels.

Recently, scholars have conducted many studies on overweight and obesity. Overweight and obesity are predisposing factors for many chronic diseases, such as type 2 diabetes, cardiovascular diseases, respiratory diseases, musculoskeletal disorders, and various types of cancer[3]. Yan R et al. found an association of adolescent obesity with nonalcoholic fatty liver disease (NAFLD) and revealed that the incidence of NAFLD increased with increasing body weight[4]. Lisan Q et al. compared patients with obesity and severe obstructive sleep apnoea (OSA) with and without prescription of positive airway pressure (PAP) therapy and found that participants with PAP prescriptions had a higher BMI (Body mass index) than participants not prescribed PAP [5] . It has been estimated that overweight and obesity are the fifth leading cause of death worldwide, accounting for nearly 3.4 million deaths annually[6]. In addition, obesity is considered a risk factor for the development of chronic kidney disease [7]. In this context, the American Medical Association classified obesity as a disease to get physicians to pay more attention to the condition [8].

In China, the largest developing country, nearly one-third of adolescents were overweight or obese in 2016, and the obesity prevalence rate increased from 0.10% in 1976 to 8.50% in 2016. Sun HP found that the prevalence of obesity and of overweight and obesity combined was 8.1% and 19.2%, respectively, among children and adolescents at the age of 7–18 [9]. Zhang XY reported that the prevalence rates of overweight and obesity among primary school children were 15.2% and 11.7%, respectively, in Jiangsu Province[10]. Therefore, it is of key importance to understand the risk factors for overweight and obesity to prevent adolescents from developing the disease.

We investigated the physical condition of adolescents aged 11-18 years from six middle schools in Changchun which is the capital of Jilin Province. The aim of the current study was to reveal the prevalence of overweight and obesity and to analyze various associated factors among adolescents with overweight and obesity in Changchun, Jilin.

Methods

Subjects

The study sample comprised middle and high school students from six middle schools (three in urban areas and three in rural areas), selected randomly using stratified cluster sampling, in Changchun City, the capital of Jilin Province in Northeast China. Overall, 1955 students aged 11–18 years were included in this cross-sectional survey;

subjects with overweight/obesity due to known metabolic and endocrine diseases were excluded. Students were also excluded if they had mental or physical impairments severe enough to cause abnormal behaviors, including congenital disease, intellectual disability, and a psychiatric disorder [11]. The study was approved by the ethics committee of the First Hospital of Jilin University (Reference Number: 2013-031). The investigation received informed consent from students and parents. We used the STOBE checklist in this study.

Data collection

The study was carried out by the First Hospital of Jilin University in April 2016. The project was named "Effect and mechanism of weight loss on upper airway collapsibility in obese patients with OSAS" and studied the associations of overweight, obesity and related factors with sleep-related breathing disorders and snoring in adolescents. In this database, we focused on the relevant indicators of overweight and obesity in adolescents and analyzed the risk factors for obesity in adolescents. The interviewers from the First Hospital of Jilin University helped parents or guardians complete the questionnaire and provided the data. The questionnaire included demographic characteristics (age, sex, area, dietary habits, sleep, exercise, highest parental education, birth history, BMI classification, paternal weight and maternal weight), anthropometric parameters (weight, height) and a paediatric sleep questionnaire- the Sleep-Related Breathing Disorder (PSQ-SRBD).

The data about sleep duration and dietary habits (frequency of fresh fruits consumption, frequency of dessert consumption, frequency of breakfast consumption, frequency of fast food consumption, slowness in eating, picky eating) were selected from the PSQ-SRBD scale according to various reports[12-14] about adolescent obesity.

Key variables

Body mass index (BMI) is used here as an indicator of overweight and obesity in adolescents and adults. Weight category was defined using age- and sex- specific BMI cutoff points specifically developed for the Chinese adolescent population [15]. We used the 85th and 95th percentiles to define overweight and obesity in adolescents. Therefore, BMI values of 24 and 28 were used as cut-off points for overweight and obesity, both for males and females aged 18 years, which were consistent with Chinese adults. In our study, parental overweight was divided into 2 groups: normal (BMI<24) and overweight or obese (BMI≥24) [14, 16]. Parents and caregivers provided information on adolescents' weight (to the nearest 1 kg) and height (to the nearest 1 cm). Overall children were classified by age into 3 groups (<13 years, 13-15 years, >15 years), by region into 2 groups (urban, rural) and by sex into 2 groups (male, female). Participants who slept less than 8 hours 3 days a week were classified as 'sleep <8 h', and those who slept more than 10 hours 3 days a week were defined as 'sleep >10 h'[17]. Birth history was divided into 3 groups: preterm

birth (infants born alive before 37 weeks of pregnancy), full-term birth (infants born alive after 37 completed weeks to less than 42 completed weeks) and post-term birth (infants born alive at 42 completed weeks or after) [18]. Parental educational level was divided into 4 groups: primary school or lower (including those who had never attended school and those with elementary schooling only), junior high school, senior high school (including those with 3 years of secondary vocational schooling) and university or above [17]. According to the contents of the questionnaire, we classified the participants'eating habits. According to the Food Guide Pagoda [19], fruit intake should be 200-350 g/d, and sugar intake should be no more than 50 g/d, so we used eating "fresh fruits two or more days per week (350 g/d)", "dessert two or more days per week", "breakfast two or more days per week", and "fast food two or more days per week" as cut-offs. Participants who were classified as "picky eating" were defined as adolescents who had selectivity for a particular kind of food [20]. "Slowness in eating" was defined as adolescents with higher masticatory performance and who ate slowly [21]. Groups were formed according to the number of exercise days (aerobic, strength training or both for at least 30 minutes a day), including never (participate in sports $\leqslant$1 day per week), sometimes (participate in sports 2-3 days per week) and often (participate in sports $\geqslant$4 days per week) [22, 23].

Statistical analysis

Data input was performed using Epidata 3.1, and statistical analysis was performed

using SPSS 24.0. Frequency distributions are used to characterize subjects, and percentage data are used to report prevalence. The relationship between each factor and the adolescents' weight status was reflected by χ^2 tests and univariate and multivariate logistic regression. In univariate analysis, when $P < 0.10$, significant correlation factors were included in a forward stepwise multivariate logistic regression to exclude confounding factors. In all analyses, a two-tailed P value < 0.05 was considered statistically significant. Since the database was manually collated, some variables in the database had missing values, which resulted in waste and bias of data resources. The missing value was numeric, and the data were approximately normally distributed. The mean interpolation method was adopted in this study. Therefore, we used the "replace missing value" function in SPSS 24.0 and selected the "mean of nearby points" method to interpolate the missing values.

Data availability

Data referenced in this study are available in the project titled "Effect and mechanism of weight loss on upper airway collapsibility in obese patients with OSAS". We selected a portion of the data from the database, including body measurements of adolescents from six middle schools in Changchun City. The data that support the findings of this study are available on request from the corresponding author [HY]. The data are not publicly available because they contain information that could compromise research participant privacy or consent.

Patient and public involvement

The interviewers from the First Hospital of Jilin University helped parents or guardians complete the questionnaire and provided the data. The adolescents were not involved in the design, recruitment or conduction of the study.

Results

On the basis of the inclusion and exclusion criteria, we chose 1955 adolescents from Changchun, and of these adolescents, 1825 were finally analyzed in this study. Participants with missing BMI values were excluded from the study. Since the survey was already completed, we were unable to verify the source of data errors, so we deleted data with missing BMI values. According to the analysis of the frequency distribution, we found that there were 837 boys and 988 girls included; the median age of the students was 15.30 years, ranging from 11 to 18 years; of all these subjects, 42.9% were from rural regions and 57.1% were from urban regions; and most of the subjects were Han Chinese, accounting for 98.2%, with only a few participants with minority ethnicities.

According to the worldwide BMI classification, the overall prevalence of overweight was 12.7% (male 17.4%; female 10.1%), and the prevalence of obesity was 4.9% (male 8.8%; female 3.1%) in Changchun City, Jilin Province (Table 1). The overweight and obese rates were both higher in males than that in females (P <0.001). A higher prevalence of overweight was found in subjects whose ages ranged from

11-12 years, and the prevalence of obesity was higher in the age group from 13-15 years (P =0.008). Children from urban areas showed a significantly higher proportion of overweight. Full-term birth subjects had a higher prevalence of overweight than others (P =0.014). In addition, students' dietary habits, such as those who ate fruits less than twice a week (P =0.029), ate slowly (P =0.004) and those who were picky (P =0.028) had significant differences in overweight in the study. Paternal weight (P =0.018) and maternal weight (P =0.006) also had an effect on the children's weight.

Table 1

Prevalence of overweight and obesity according to demographic characteristics

		Overweight		Obesity	
Variables	n	*PR* (%)	*p*	*PR* (%)	*p*
Sex					
Male	837	17.4(14.9-20.3)	<0.001	8.8(6.9-11.2)	<0.001
Female	988	10.1 (8.3-12.2)		3.1(2.2-4.5)	
Area					
Urban	1042	14.4(12.4-16.7)	0.14	5.6(4.2-7.3)	0.863
Rural	783	12(9.8-14.5)		5.8(4.3-7.8)	
Age					
<13	168	19.3(13.9-26.1)	0.008	5.1(2.5-10.3)	0.816
13-15	1157	11.6(9.8-13.6)		5.9(4.6-7.5)	
>15	500	15.5(12.5-19.0)		5.2(3.4-7.7)	
Birth history					
Full-term birth	1621	14.2(12.5-16.0)	0.014	6.0(4.9-7.4)	0.285
Preterm birth	133	5.4(2.6-11.0)		3.2(1.2-8.2)	
Post-term birth	71	10.1(4.9-19.8)		3.1(0.8-11.7)	
Fruit≤2 times/week					
Yes	1259	12.2(10.5-14.2)	0.029	4.8(3.7-6.2)	0.02
No	566	16.1(13.2-19.5)		7.7(5.6-10.4)	
Dessert ≤ 2 times/week					
Yes	887	12.4(10.4-14.8)	0.252	5.2(3.9-7.0)	0.49
No	938	14.3(12.1-16.7)		6.0(4.6-7.9)	
Breakfast ≤ 2					

times/week					
Yes	1478	13.9(12.2-15.8)	0.185	5.8(4.7-7.3)	0.491
No	347	11.1(8.2-15.0)		4.8(2.9-7.9)	
Fast food ⩽ 2 times/week					
Yes	264	10.0(6.8-14.3)	0.095	5.4(3.2-9.1)	0.402
No	1561	13.9(12.3-15.8)		5.7(4.6-7.1)	
Slowness in eating					
Yes	1174	16.5(13.8-19.7)	0.004	6.2(4.5-8.5)	0.496
No	651	11.6(9.9-13.6)		5.4(4.1-6.9)	
Picky eating					
Yes	1133	14.8(12.8-17.1)	0.028	6.7(5.3-8.4)	0.027
No	692	11.1(8.9-13.7)		4.0(2.7-5.9)	
Exercise					
Never	451	15.9(12.7-19.6)	0.194	4.2(2.6-6.7)	0.315
Sometimes	478	12(9.3-15.3)		6.6(4.6-9.4)	
Often	896	12.8(10.7-15.2)		5.8(4.4-7.7)	
Highest parental education					
Primary school or lower	95	8.0(3.8-15.8)	0.196	8.0(3.8-15.8)	0.724
Junior high school	799	13.0(10.8-15.6)		5.1(3.7-7.1)	
Senior high school	468	15.8(12.7-19.5)		6.0(4.1-8.8)	
University or above	463	12.7(9.9-16.2)		5.7(3.8-8.4)	
Sleep (hours/night)					
<8	884	13.6(11.5-16.1)	0.809	5.3(3.9-7.2)	0.302
⩾8	861	13.3(11.1-15.8)		5.6(4.2-7.5)	
>10	80	11.0(5.6-20.4)		9.7(4.7-19.0)	
Paternal weight					
Normal	827	15.4(13.1-18.1)	0.018	7.6(6.0-9.8)	0.002
Ow or ob	998	11.6(9.6-13.7)		3.8(2.7-5.4)	
Maternal weight					
Normal	1099	14.8(13.0-16.8)	0.006	5.6(4.4-7.0)	0.807
Ow or ob	726	8.5(6.1-11.7)		5.8(3.9-8.7)	

Note: *PR* (%), Prevalence rate; Ow or ob, Overweight or obese

To facilitate regression analysis, we divided the participants into two groups: underweight and normal and overweight and obese. Table 2 shows the univariate analysis of correlates of overweight and obesity in adolescents. As impressively

demonstrated in this table, the following factors all showed significant differences between two groups: sex, age, birth history, frequency of eating fruits, eating habits (slowness in eating, picky eating), and parental weights (P <0.05). According to the results, we added all these significant factors to a forward stepwise multivariate logistic regression model.

Table 2

Univariate analysis of correlates of overweight and obesity in adolescents in Changchun

Variables	*p*	*OR*	95% *CI*
Sex			
Female	<0.001	1	
Male		2.125	1.661-2.719
Area			
Urban	0.256	1	
Rural		1.150	0.902-1.473
Age			
<13	0.070	1	
13-15	0.041	0.664	0.448-0.984
>15	0.339	0.813	0.532-1.243
Birth history			
Full-term birth	0.008	1	
Preterm birth	0.004	0.394	0.21-0.739
Post-term birth	0.209	0.634	0.312-1.29
Fresh fruits≤2 times/week			
Yes	0.003	1	
No		1.455	1.132-1.87
Dessert≤2 times/week			
Yes	1.197	1	
No		1.172	0.921-1.493
Breakfast≤2 times /week			
Yes	0.15	1	
No		0.789	0.571-1.089
Fast food≤2 times /week			
Yes	0.16	1	

No		1.080	0.972-1.19
Slowness in eating			
Yes	0.007	1	
No		0.713	0.558-0.911
Picky eating			
Yes	0.004	1	
No		0.691	0.526-0.882
Exercise			
Never	0.74	1	
Sometimes	0.502	0.892	0.638-1.246
Often	0.484	0.901	0.672-1.207
Highest parental education			
Primary school or lower	0.411	1	
Junior high school	0.594	1.176	0.648-2.136
Senior high school	0.229	1.454	0.79-2.678
University or above	0.58	1.190	0.642-2.206
Sleep (hours/night)			
<8	0.964	1	
⩾8	0.952	0.992	0.776-1.27
>10	0.805	1.077	0.598-1.938
Paternal weight			
Normal	0.001	1	
Ow or ob		0.639	0.513-0.832
Maternal weight			
Normal	0.011	1	
Ow or ob		0.666	0.487-0.912

Note: Ow or ob, Overweight or obesity

Table 3 shows the results of logistic regression models comparing the prevalence of the potential risk factors: sex, age, birth history, frequency of eating fruits, dietary habits (slowness in eating, picky eating) and parental weight. In this forward stepwise multivariate logistic regression model, males were more likely to be overweight and obese than females (OR=1.912, 95% CI: 1.481-2.496). Students aged 13-15 years (OR=0.634, 95% CI: 0.420-0.957) were less likely to be overweight than those aged 11-12 years. Compared with full-term birth, preterm birth (OR=0.450, 95% CI:

0.238-0.851) was associated with normal weight. Participants who ate fruit more than twice a week (OR=1.413, 95% CI: 1.085-1.840) were more likely to be overweight or obese. Moreover, the prevalence of overweight was lower in students who ate slowly (OR=1.373, 95% CI: 1.060-1.778). Students who were picky (OR=0.691, 95%CI: 0.528-0.902) were much more likely to be overweight than the subjects who ate a healthy diet.

Table 3

Multivariate regression analysis of correlates of overweight and obesity in adolescents in Changchun

Variables	*p*	*β*	SE	*OR*	95% *CI*
Sex					
Female				1	
Male	<0.001	0.648	0.130	1.912	1.481-2.496
Age					
<13				1	
13-15	0.030	-0.455	0.210	0.634	0.420-0.957
>15	0.121	-0.351	0.226	0.704	0.452-1.097
Birth history					
Full-term birth				1	
Preterm birth	0.014	-0.798	0.325	0.450	0.238-0.851
Post-term birth	0.337	-0.355	0.370	0.701	0.339-1.448
Fresh fruits≤2 times/week					
Yes				1	
No	0.010	0.346	0.135	1.413	1.085-1.840
Slowness in eating					
Yes				1	
No	0.016	0.317	0.132	1.373	1.060-1.778
Picky eating					
Yes				1	
No	0.007	-0.370	0.137	0.691	0.528-0.902
Paternal weight					

Normal				1	
Ow or ob	0.002	-0.408	0.130	0.665	0.507-0.831
Maternal weight					
Normal					
Ow or ob	0.049	-0.324	0.165	0.723	0.523-0.999

Note: Ow or ob, Overweight or obese

Discussion

To describe the epidemiology of overweight and obesity in Changchun City and analyze the influencing factors in adolescents, we conducted this survey of middle school students aged 11–18 years from urban and rural areas. We found that sex, dietary habits and parental weight had a significant impact on the children's weight.

Based on the data, we found that the prevalence of overweight was 12.7% (male 17.4%; female 10.1%) and that the prevalence of obesity was 4.9% (male 8.8%; female 3.1%) among adolescents in Changchun City, Jilin Province. However, in recent studies, the overall prevalence of obesity in school-aged children in Xi'an was 4.11%, and the rate of overweight was 6.6% among Nanjing adolescents; these rates were both lower than the corresponding rates in Changchun. This difference may be caused by the sample size, sex, and age of the studied population [24, 25]. In addition, demographic distribution and environmental factors are probable factors [26]. The economy in northeast China is less developed than that in east and south China to some extent [27]. Rates of overweight and obesity in rural areas were also higher in the north than that in the south [28]. Depending on the season, people in the north might eat high-energy foods to combat the cold, which is referred to “energy balance

related behaviors [29, 30]". In our data, boys were more often obese than girls, in general, which was in agreement with previous Chinese reports [30-32]. A Swedish report [33] predicted that there was an alarming increase in the prevalence of overweight and obesity among adolescent boys, which was consistent with our finding. On the one hand, in traditional Chinese culture, the preference for boys may be the reason for the differences in diet, and the elderly believe that fat boys are more powerful than thin boys. On the other hand, well-groomed and fit girls are more favored by Chinese society [34-36]. Girls also tend to be more concerned about their weight than boys.

We also found that adolescents who were picky, ate more fruits in general and ate quickly were more likely to be overweight or obese according to our survey. In recent reports [37, 38], a greater fruit intake was a protective factor against overweight, which was opposite of our result. Based on the results of our study, it was reasonable to speculate that the children were already full in addition to the excessive intake of fruits with high sugar content. However, the heavy study demand in China makes the children fail to consume the extra energy through exercise, thus leading to the possibility of being overweight.

According to the present cross-sectional study [39], food preference was an independent risk factor for overweight among children. It is known that children who had selectivity for a particular kind of food would prefer more fast food, snacks, and sugary beverage [40] and fewer fruits and vegetables [41]. However, the frequency of

dessert and fast food consumption had no significant effect in our study, perhaps because the data were provided by parents or guardians who provided an inaccurate account of how often their children ate sweets and fast food. Currently, several studies have considered that food intake is a primary factor that determines body weight [42-44]. Y Li et al. concluded that excessive intake of cooking oil might be one of the risk factors for overweight [22]. Consistent with a previous study in Tianjin [42], overweight students preferred significantly more sweet foods and take-out food than their counterparts with normal weight. The result might be influenced by many elements, such as peer influence, food price, convenience, and online influence and so on, based on a recent report[45]. To decrease the prevalence of overweight and obesity, a series of interventions have been implemented, such as controlling TV time and increasing sport time.

In our research, we found that if fathers and mothers were overweight, adolescents were less likely to be overweight, which was the opposite of the previous conclusions [46-48]. Studies [49, 50]have found that a higher BMI of the father increased the risk of overweight/ obesity among males and females. However, this finding was not consistent across studies. In a previous study, the researchers found that the relationship between parents' and children's BMI did not exist when longitudinal analyses of changes in BMI over four years were performed [51]. This may explain why a short period of periodic surveys alone does not fully demonstrate a parent-child link to obesity, and we still need long-term research to further explore the relationship

between the two factors. Moreover, children's growing environment and living habits will also affect their own obesity level, which will have an impact on our results [45]. Further prospective studies that assess both energy expenditure and energy intake in children are more likely to clarify this concept. In addition, the use of BMI to assess parental weight status may be a limitation of this study, as BMI does not always reflect a person's body fat percentage, and we did not take into account parental waist circumference in this survey[49].

There are several limitations to this study. First, the analysis results were restricted by the small sample size, and we interpolated missing values in the data, potentially resulting in random errors. Second, the conclusion might seem slightly limited in regard to assessing whether children were obese or not based on the value of BMI, which is a single index and may have potential for bias. If we could analyze the risk factors for obesity in teenagers from multiple perspectives based on the height-for-age Z-score (HAZ), we might obtain a more accurate conclusion, which is also a problem we need to address in the future. Third, the contents of the questionnaire were most recalled by the parents or guardians, and there might be information bias and confounding bias in this survey. Fourth, our data came from six schools in Changchun, which was not representative of the specific circumstances in Jilin Province. Further research should be conducted to validate the conclusion.

Conclusions

In summary, in this cross-sectional study, we found that the prevalence of overweight and obesity among adolescents in Changchun, Jilin Province was high. Sex, age, birth history, dietary habits, and parental weight were important factors for overweight and obesity in adolescents. Therefore, reasonable lifestyle and effective weight control are necessary to prevent overweight and obesity in adolescents. There are still several limitations in this study, and we need to obtain more accurate information and perform more specific analysis. Further research should be conducted on the health of adolescents in China and further intervention measures should be implemented to decrease the prevalence of overweight and obesity.

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Footnotes

Contributors: RD, CK and HY conceived the study, participated in the design of the study. HY, JJ and XL collected data. RD carried out the measurements, analyzed the data and drafted the manuscript. XY and BZ participated in the coordination of the study and interpreted the data. WB and YL revised the manuscript. All authors have approved the final article.

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Competing interests: None declared.

Ethical approval: The investigation was conducted by the First Hospital of Jilin University in April 2016, our data collected from the questionnaire in the survey as well. The study was approved by the ethics committee of the First Hospital of Jilin University (Reference Number: 2013-031). The investigation has received informed consent from students and parents.

Data sharing: Data referenced in this study are available in the project titled "Effect and mechanism of weight loss on upper airway collapsibility in obese patients with OSAS". We selected a portion of the data from the database, including body measurements of adolescents from six middle schools in Changchun City. The data that support the findings of this study are available on request from the corresponding author [HY]. The data are not publicly available because they contain information that could compromise research participant privacy or consent.

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page/line number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2-3, line 23-47
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 3-5, line 61-88
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 5, line 89-92
Methods			
Study design	4	Present key elements of study design early in the paper	Page 5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 5, line 95-102
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 7-8, line 127-158
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 6, line 109-125
Bias	9	Describe any efforts to address potential sources of bias	Page 9, line 167-172
Study size	10	Explain how the study size was arrived at	Page 5, line 95-99
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 7-8, line 127-158
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 8-9, line 160-167
		(*b*) Describe any methods used to examine subgroups and interactions	Page 8-9, line 160-167
		(*c*) Explain how missing data were addressed	Page 9, line 167-172
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	Page 8-9, line 160-167
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page10, line 186-192
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential	Page 9-10

		confounders	
		(b) Indicate number of participants with missing data for each variable of interest	Page 10, line 186-190
Outcome data	15*	Report numbers of outcome events or summary measures	Page10, line 186-192
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 11-12
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 12-15
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 16, line 242-245
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 19, line 306-317
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 15-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 19-20, line 319-327
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 20, line 336-338

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence and correlates of overweight and obesity among adolescents in northeastern China: a cross-sectional study

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Prevalence and correlates of overweight and obesity among adolescents in northeastern China: a cross-sectional study

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Abstract

Objectives: To estimate the prevalence of overweight/obesity among adolescents and to evaluate the associated factors in this group in Changchun City, northeastern China.

Methods: A cross-sectional study of 1955 adolescents aged 11–18 years was conducted in Changchun City, using stratified cluster sampling. Parents and caregivers of children completed the questionnaires as requested without objection; the questionnaire included demographic characteristics and anthropometric parameters. Univariate and multivariate logistic regression analyses were performed to analyze the relationship between overweight /obesity and related factors.

Results: In total, the prevalence of overweight was 12.7% (male 17.4%; female 10.1%), and the prevalence of obesity was 4.9% (male 8.8%; female 3.1%) in Changchun, Jilin Province. The prevalence of overweight and obesity was higher in males than that in females (P <0.001). Multivariate logistic regression showed that overweight and obesity were significantly associated with male (OR=1.91, 95% CI: 1.48-2.47), fresh fruits two or more days per week (OR=1.41, 95% CI: 1.09-1.84), eating quickly (OR=1.37, 95% CI: 1.06-1.78). The students who were not picky (OR=0.69, 95% CI: 0.53-0.90) were less likely to be overweight. And adolescents whose father were overweight or obese (OR=0.67, 95% CI: 0.52-0.86) or mother were overweight or obese (OR=0.72, 95% CI: 0.52-0.99) were less likely to be overweight.

Conclusion: The prevalence of overweight and obesity among adolescents in

Changchun was high in recent years. The prevalence of overweight and obesity among males was higher than that among females. Sex, dietary habits (weekly frequency of fruit consumption, picky eating and slowness in eating) and parental weight were important factors for overweight and obesity in adolescents. Further research should be conducted on the health of adolescents in China and further intervention measures should be implemented to reduce the prevalence of overweight/obesity.

Keywords: overweight; obesity; adolescent; association

Strengths and limitations of this study

- In the cross-sectional study, participants were randomly selected from rural and urban areas by stratified cluster sampling.
- Weight category was defined using age- and sex- specific BMI cutoff points specifically developed for the Chinese adolescent population.
- The influence of confounding factors on the results was effectively controlled by the multivariate logistic regression method.
- Missing data from childhood measurements were handled with a mean imputation technique.
- The contents of the questionnaire were most recalled by the parents or guardians and there might be information bias in this survey.

Introduction

The prevalence of obesity has increased dramatically among children, adolescents and adults worldwide in recent decades [1]. Overall, the global proportion of adolescents with obesity has increased significantly from just 4% in 1975 to just over 18% in 2016 [2]. There is compelling evidence revealing a significantly higher proportion of overweight or obese adolescents in recent years, which has reached alarming levels. Recently, scholars have conducted many studies on overweight and obesity. Overweight and obesity are predisposing factors for many chronic diseases, such as type 2 diabetes, cardiovascular diseases, respiratory diseases, musculoskeletal disorders, and various types of cancer [3]. Yan R et al. found an association of adolescent obesity with nonalcoholic fatty liver disease (NAFLD) and revealed that the incidence of NAFLD increased with increasing body weight [4]. Lisan Q et al. compared patients with obesity and severe obstructive sleep apnoea (OSA) with and without prescription of positive airway pressure (PAP) therapy and found that participants with PAP prescriptions had a higher BMI (Body mass index) than participants not prescribed PAP [5] . It has been estimated that overweight and obesity are the fifth leading cause of death worldwide, accounting for nearly 3.4 million deaths annually [6]. In addition, obesity is considered a risk factor for the development of chronic kidney disease [7]. In this context, the American Medical Association classified obesity as a disease to get physicians to pay more attention to the condition [8].

In China, the largest developing country, nearly one-third of adolescents were overweight or obese in 2016, and the obesity prevalence rate increased from 0.10% in 1976 to 8.50% in 2016. Sun HP found that the prevalence of obesity and of overweight and obesity combined was 8.1% and 19.2%, respectively, among children and adolescents at the age of 7–18 [9]. Zhang XY reported that the prevalence rates of overweight and obesity among primary school children were 15.2% and 11.7%, respectively, in Jiangsu Province [10]. Therefore, it is of key importance to understand the risk factors for overweight and obesity to prevent adolescents from developing the disease.

We investigated the physical condition of adolescents aged 11-18 years from six middle schools in Changchun which is the capital of Jilin Province. The aim of the current study was to reveal the prevalence of overweight and obesity and to analyze various associated factors among adolescents with overweight and obesity in Changchun, Jilin.

Methods

Subjects

A cross-sectional survey was conducted in Changchun City, the capital of Jilin Province in Northeast China. The study sample comprised middle and high school students from six middle schools (three in urban areas and three in rural areas), selected randomly using stratified cluster sampling. Overall, 1955 students aged 11–

18 years were included in this cross-sectional survey; subjects with overweight/obesity due to known metabolic and endocrine diseases were excluded. Students were also excluded if they had mental or physical impairments severe enough to cause abnormal behaviors, including congenital disease, intellectual disability, and a psychiatric disorder [11]. We used the STROBE checklist in this study.

Data collection

The study was carried out by the First Hospital of Jilin University in April 2016. The study was approved by the ethics committee of the First Hospital of Jilin University (Reference Number: 2013-031). The investigation received informed consent from students and parents. The project was named “Effect and mechanism of weight loss on upper airway collapsibility in obese patients with OSAS” and studied the associations of overweight, obesity and related factors with sleep-related breathing disorders and snoring in adolescents. In this database, we focused on the relevant indicators of overweight and obesity in adolescents and analyzed the risk factors for obesity in adolescents. The interviewers from the First Hospital of Jilin University helped parents or guardians complete the questionnaire and provided the data. The questionnaire included demographic characteristics (age, sex, area, dietary habits, sleep, exercise, highest parental education, birth history, BMI classification, paternal weight and maternal weight), anthropometric parameters (weight, height) and a

paediatric sleep questionnaire- the Sleep-Related Breathing Disorder (PSQ-SRBD). The data about sleep duration and dietary habits (frequency of fresh fruits consumption, frequency of dessert consumption, frequency of breakfast consumption, frequency of fast food consumption, slowness in eating, picky eating) were selected from the PSQ-SRBD scale according to various reports [12-14] about adolescent obesity.

Key variables

Body mass index (BMI) is used here as an indicator of overweight and obesity in adolescents and adults. Weight category was defined using age- and sex- specific BMI cutoff points specifically developed for the Chinese adolescent population [15]. We used the 85th and 95th percentiles to define overweight and obesity in adolescents. Therefore, BMI values of 24 and 28 were used as cut-off points for overweight and obesity, both for males and females aged 18 years, which were consistent with Chinese adults. In our study, parental overweight was divided into 2 groups: normal (BMI<24) and overweight or obese (BMI≥24) [14, 16]. Parents and caregivers provided information on adolescents' weight (to the nearest 1 kg) and height (to the nearest 1 cm). Overall children were classified by age into 3 groups (<13 years, 13-15 years, >15 years), by region into 2 groups (urban, rural) and by sex into 2 groups (male, female). Participants who slept less than 8 hours 3 days a week were classified as 'sleep <8 h', and those who slept more than 10 hours 3 days a week

were defined as ‘sleep >10 h’ [17]. Birth history was divided into 3 groups: preterm birth (infants born alive before 37 weeks of pregnancy), full-term birth (infants born alive after 37 completed weeks to less than 42 completed weeks) and post-term birth (infants born alive at 42 completed weeks or after) [18]. Parental educational level was divided into 4 groups: primary school or lower (including those who had never attended school and those with elementary schooling only), junior high school, senior high school (including those with 3 years of secondary vocational schooling) and university or above [17]. According to the contents of the questionnaire, we classified the participants’eating habits. According to the Food Guide Pagoda [19], fruit intake should be 200-350 g/d, and sugar intake should be no more than 50 g/d, so we used eating “fresh fruits two or more days per week (350 g/d)”, “dessert two or more days per week”, “breakfast two or more days per week”, and “fast food two or more days per week” as cut-offs. Participants who were classified as “picky eating” were defined as adolescents who had selectivity for a particular kind of food [20]. “Slowness in eating” was defined as adolescents with higher masticatory performance and who ate slowly [21]. Groups were formed according to the number of exercise days (aerobic, strength training or both for at least 30 minutes a day), including never (participate in sports $\leqslant$1 day per week), sometimes (participate in sports 2-3 days per week) and often (participate in sports $\geqslant$4 days per week) [22, 23].

Statistical analysis

Data input was performed using Epidata 3.1, and statistical analysis was performed using SPSS 24.0. Frequency distributions are used to characterize subjects, and percentage data are used to report prevalence. The relationship between each factor and the adolescents' weight status was reflected by χ^2 tests and univariate and multivariate logistic regression. In univariate analysis, when $P < 0.10$, significant correlation factors were included in a forward stepwise multivariate logistic regression to exclude confounding factors. In all analyses, a two-tailed P value < 0.05 was considered statistically significant. Since the database was manually collated, some variables in the database had missing values, which resulted in waste and bias of data resources. The missing value was numeric, and the data were approximately normally distributed. The mean interpolation method was adopted in this study. Therefore, we used the "replace missing value" function in SPSS 24.0 and selected the "mean of nearby points" method to interpolate the missing values.

Data availability

Data referenced in this study are available in the project titled "Effect and mechanism of weight loss on upper airway collapsibility in obese patients with OSAS". We selected a portion of the data from the database, including body measurements of adolescents from six middle schools in Changchun City. The data that support the findings of this study are available on request from the corresponding author [HY]. The data are not publicly available because they contain information that could

compromise research participant privacy or consent.

Patient and public involvement

The interviewers from the First Hospital of Jilin University helped parents or guardians complete the questionnaire and provided the data. The adolescents were not involved in the design, recruitment or conduction of the study.

Results

On the basis of the inclusion and exclusion criteria, we chose 1955 adolescents from Changchun, and of these adolescents, 1825 were finally analyzed in this study. Participants with missing BMI values were excluded from the study. Since the survey was already completed, we were unable to verify the source of data errors, so we deleted data with missing BMI values. According to the analysis of the frequency distribution, we found that there were 837 boys and 988 girls included; the median age of the students was 15.30 years, ranging from 11 to 18 years; of all these subjects, 42.9% were from rural regions and 57.1% were from urban regions; and most of the subjects were Han Chinese, accounting for 98.2%, with only a few participants with minority ethnicities.

According to the worldwide BMI classification, the overall prevalence of overweight was 12.7% (male 17.4%; female 10.1%), and the prevalence of obesity was 4.9% (male 8.8%; female 3.1%) in Changchun City, Jilin Province (Table 1). The

overweight and obese rates were both higher in males than that in females (P <0.001). A higher prevalence of overweight was found in subjects whose ages ranged from 11-12 years, and the prevalence of obesity was higher in the age group from 13-15 years (P =0.008). Children from urban areas showed a significantly higher proportion of overweight. Full-term birth subjects had a higher prevalence of overweight than others (P =0.014). In addition, students' dietary habits, such as those who ate fruits less than twice a week (P =0.029), ate slowly (P =0.004) and those who were picky (P =0.028) had significant differences in overweight in the study. Paternal weight (P =0.018) and maternal weight (P =0.006) also had an effect on the children's weight.

Table 1

Prevalence of overweight and obesity according to demographic characteristics

		Overweight		Obesity	
Variables	n	*PR* (%)	*p*	*PR* (%)	*p*
Sex					
Male	837	17.4(14.9-20.3)	<0.001	8.8(6.9-11.2)	<0.001
Female	988	10.1 (8.3-12.2)		3.1(2.2-4.5)	
Area					
Urban	1042	14.4(12.4-16.7)	0.14	5.6(4.2-7.3)	0.863
Rural	783	12(9.8-14.5)		5.8(4.3-7.8)	
Age					
<13	168	19.3(13.9-26.1)	0.008	5.1(2.5-10.3)	0.816
13-15	1157	11.6(9.8-13.6)		5.9(4.6-7.5)	
>15	500	15.5(12.5-19.0)		5.2(3.4-7.7)	
Birth history					
Full-term birth	1621	14.2(12.5-16.0)	0.014	6.0(4.9-7.4)	0.285
Preterm birth	133	5.4(2.6-11.0)		3.2(1.2-8.2)	
Post-term birth	71	10.1(4.9-19.8)		3.1(0.8-11.7)	
Fruit≤2 times/week					
Yes	1259	12.2(10.5-14.2)	0.029	4.8(3.7-6.2)	0.02
No	566	16.1(13.2-19.5)		7.7(5.6-10.4)	
Dessert ≤ 2					

times/week					
Yes	887	12.4(10.4-14.8)	0.252	5.2(3.9-7.0)	0.49
No	938	14.3(12.1-16.7)		6.0(4.6-7.9)	
Breakfast ⩽ 2 times/week					
Yes	1478	13.9(12.2-15.8)	0.185	5.8(4.7-7.3)	0.491
No	347	11.1(8.2-15.0)		4.8(2.9-7.9)	
Fast food ⩽ 2 times/week					
Yes	264	10.0(6.8-14.3)	0.095	5.4(3.2-9.1)	0.402
No	1561	13.9(12.3-15.8)		5.7(4.6-7.1)	
Slowness in eating					
Yes	1174	16.5(13.8-19.7)	0.004	6.2(4.5-8.5)	0.496
No	651	11.6(9.9-13.6)		5.4(4.1-6.9)	
Picky eating					
Yes	1133	14.8(12.8-17.1)	0.028	6.7(5.3-8.4)	0.027
No	692	11.1(8.9-13.7)		4.0(2.7-5.9)	
Exercise					
Never	451	15.9(12.7-19.6)	0.194	4.2(2.6-6.7)	0.315
Sometimes	478	12(9.3-15.3)		6.6(4.6-9.4)	
Often	896	12.8(10.7-15.2)		5.8(4.4-7.7)	
Highest parental education					
Primary school or lower	95	8.0(3.8-15.8)	0.196	8.0(3.8-15.8)	0.724
Junior high school	799	13.0(10.8-15.6)		5.1(3.7-7.1)	
Senior high school	468	15.8(12.7-19.5)		6.0(4.1-8.8)	
University or above	463	12.7(9.9-16.2)		5.7(3.8-8.4)	
Sleep (hours/night)					
<8	884	13.6(11.5-16.1)	0.809	5.3(3.9-7.2)	0.302
⩾8	861	13.3(11.1-15.8)		5.6(4.2-7.5)	
>10	80	11.0(5.6-20.4)		9.7(4.7-19.0)	
Paternal weight					
Normal	827	15.4(13.1-18.1)	0.018	7.6(6.0-9.8)	0.002
Ow or ob	998	11.6(9.6-13.7)		3.8(2.7-5.4)	
Maternal weight					
Normal	1099	14.8(13.0-16.8)	0.006	5.6(4.4-7.0)	0.807
Ow or ob	726	8.5(6.1-11.7)		5.8(3.9-8.7)	

214 Note: *PR* (%), Prevalence rate; Ow or ob, Overweight or obese

215 To facilitate regression analysis, we divided the participants into two groups:

underweight and normal and overweight and obese. Table 2 shows the univariate analysis of correlates of overweight and obesity in adolescents. As impressively demonstrated in this table, the following factors all showed significant differences between two groups: sex, age, birth history, frequency of eating fruits, eating habits (slowness in eating, picky eating), and parental weights (P <0.05). According to the results, we added all these significant factors to a forward stepwise multivariate logistic regression model.

Table 2

Univariate analysis of correlates of overweight and obesity in adolescents in Changchun

Variables	*p*	*OR*	95% *CI*
Sex			
Female	<0.001	1	
Male		2.13	1.66-2.72
Area			
Urban	0.256	1	
Rural		1.15	0.90-1.47
Age			
<13	0.070	1	
13-15	0.041	0.67	0.45-0.98
>15	0.339	0.81	0.53-1.24
Birth history			
Full-term birth	0.008	1	
Preterm birth	0.004	0.40	0.21-0.74
Post-term birth	0.209	0.63	0.31-1.29
Fresh fruits≤2 times/week			
Yes	0.003	1	
No		1.46	1.13-1.87
Dessert≤2 times/week			
Yes	1.197	1	
No		1.17	0.92-1.49
Breakfast≤2 times /week			
Yes	0.15	1	
No		0.79	0.57-1.09

Fast food≤2 times /week			
Yes	0.135	1	
No		1.32	0.92-1.91
Slowness in eating			
Yes	0.007	1	
No		0.71	0.56-0.91
Picky eating			
Yes	0.004	1	
No		0.69	0.53-0.88
Exercise			
Never	0.74	1	
Sometimes	0.502	0.89	0.64-1.25
Often	0.484	0.90	0.67-1.21
Highest parental education			
Primary school or lower	0.411	1	
Junior high school	0.594	1.18	0.65-2.14
Senior high school	0.229	1.45	0.79-2.68
University or above	0.58	1.19	0.64-2.21
Sleep (hours/night)			
<8	0.964	1	
≥8	0.952	0.99	0.78-1.27
>10	0.805	1.08	0.60-1.94
Paternal weight			
Normal	0.001	1	
Ow or ob		0.64	0.51-0.83
Maternal weight			
Normal	0.011	1	
Ow or ob		0.67	0.49-0.91

Note: Ow or ob, Overweight or obesity

Table 3 shows the results of logistic regression models comparing the prevalence of the potential risk factors: sex, age, birth history, frequency of eating fruits, dietary habits (slowness in eating, picky eating) and parental weight. In this forward stepwise multivariate logistic regression model, males were more likely to be overweight and obese than females (OR=1.91, 95% CI: 1.48-2.50). Students aged 13-15 years (OR=0.63, 95% CI: 0.42-0.96) were less likely to be overweight than those aged

11-12 years. Compared with full-term birth, preterm birth (OR=0.45, 95% CI: 0.24-0.85) was associated with normal weight. Participants who ate fruit more than twice a week (OR=1.41, 95% CI: 1.09-1.84) were more likely to be overweight or obese. Moreover, the prevalence of overweight was higher in students who ate quickly (OR=1.37, 95% CI: 1.06-1.78) than those who ate slowly. Students who were not picky (OR=0.69, 95%CI: 0.53-0.90) were less likely to be overweight than the subjects who ate a healthy diet.

Table 3

Multivariate regression analysis of correlates of overweight and obesity in adolescents in Changchun

Variables	*p*	*β*	SE	*OR*	95% *CI*
Sex					
Female				1	
Male	<0.001	0.65	0.13	1.91	1.48-2.50
Age					
<13				1	
13-15	0.030	-0.46	0.21	0.63	0.42-0.96
>15	0.121	-0.35	0.23	0.70	0.45-1.10
Birth history					
Full-term birth				1	
Preterm birth	0.014	-0.80	0.33	0.45	0.24-0.85
Post-term birth	0.337	-0.36	0.37	0.70	0.34-1.45
Fresh fruits≤2 times/week					
Yes				1	
No	0.010	0.35	0.14	1.41	1.09-1.84
Slowness in eating					
Yes				1	
No	0.016	0.32	0.13	1.37	1.06-1.78
Picky eating					
Yes				1	
No	0.007	-0.37	0.14	0.69	0.53-0.90
Paternal weight					

Normal				1	
Ow or ob	0.002	-0.41	0.13	0.67	0.51-0.83
Maternal weight					
Normal					
Ow or ob	0.049	-0.32	0.17	0.72	0.53-0.99

Note: Ow or ob, Overweight or obese

Discussion

To describe the epidemiology of overweight and obesity in Changchun City and analyze the influencing factors in adolescents, we conducted this survey of middle school students aged 11–18 years from urban and rural areas. We found that sex, dietary habits and parental weight had a significant impact on the children's weight.

Based on the data, we found that the prevalence of overweight was 12.7% (male 17.4%; female 10.1%) and that the prevalence of obesity was 4.9% (male 8.8%; female 3.1%) among adolescents in Changchun City, Jilin Province. However, in recent studies, the overall prevalence of obesity in school-aged children in Xi'an was 4.11%, and the rate of overweight was 6.6% among Nanjing adolescents; these rates were both lower than the corresponding rates in Changchun. This difference may be caused by the sample size, sex, and age of the studied population [24, 25]. In addition, demographic distribution and environmental factors are probable factors [26]. The economy in northeast China is less developed than that in east and south China to some extent [27]. Rates of overweight and obesity in rural areas were also higher in the north than that in the south [28]. Depending on the season, people in the north might eat high-energy foods to combat the cold, which is referred to “energy balance

related behaviors [29, 30]". In our data, boys were more often obese than girls, in general, which was in agreement with previous Chinese reports [30-32]. A Swedish report [33] predicted that there was an alarming increase in the prevalence of overweight and obesity among adolescent boys, which was consistent with our finding. On the one hand, in traditional Chinese culture, the preference for boys may be the reason for the differences in diet, and the elderly believe that fat boys are more powerful than thin boys. On the other hand, well-groomed and fit girls are more favored by Chinese society [34-36]. Girls also tend to be more concerned about their weight than boys.

We also found that adolescents who were picky, ate more fruits in general and ate quickly were more likely to be overweight or obese according to our survey. In recent reports [37, 38], a greater fruit intake was a protective factor against overweight, which was opposite of our result. Fructose, which is ubiquitous found in fruit and sugar-sweetened beverages, is one of the factors contributing to rising obesity rates [39, 40]. High intakes of fructose may decrease the abundance of the bacterial species Eubacterium eligens, reduce metabolism of monosaccharide and lose the ability to consume large amounts of fat [41]. The fructose intake threshold of adolescents is currently average 75g/d. If teenagers get too much fructose without consuming glycogen in time, fructose will be converted into fat at a higher rate [42, 43]. Based on the results of our study, it was reasonable to speculate that the children were already full in addition to the excessive intake of fruits with high sugar content. However, the

heavy study demand in China makes the children fail to consume the extra energy through exercise, thus leading to the possibility of being overweight. Further research should be conducted to validate the conclusion.

According to the present cross-sectional study [44], food preference was an independent risk factor for overweight among children. It is known that children who had selectivity for a particular kind of food would prefer more fast food, snacks, and sugary beverage [45] and fewer fruits and vegetables [46]. However, the frequency of dessert and fast food consumption had no significant effect in our study, perhaps because the data were provided by parents or guardians who provided an inaccurate account of how often their children ate sweets and fast food. Currently, several studies have considered that food intake is a primary factor that determines body weight [47-49]. Y Li et al. concluded that excessive intake of cooking oil might be one of the risk factors for overweight [22]. Consistent with a previous study in Tianjin [47], overweight students preferred significantly more sweet foods and take-out food than their counterparts with normal weight. The result might be influenced by many elements, such as peer influence, food price, convenience, and online influence and so on, based on a recent report [50]. To decrease the prevalence of overweight and obesity, a series of interventions have been implemented, such as controlling TV time and increasing sport time.

In our research, we found that if fathers and mothers were overweight, adolescents were less likely to be overweight, which was inconsistent with the previous

conclusions [51-53]. Studies [54, 55]have found that a higher BMI of the father increased the risk of overweight/ obesity among males and females. However, this finding was not consistent across studies. In a previous study, the researchers found that the relationship between parents' and children's BMI did not exist when longitudinal analyses of changes in BMI over four years were performed [56]. This may explain why a short period of periodic surveys alone does not fully demonstrate a parent-child link to obesity, and we still need long-term research to further explore the relationship between the two factors. Berge JM et al. found that overweight or obese parents were more likely to adopt a strict dietary restriction to prevent adolescent obesity [57]. Moreover, children's growing environment and living habits will also affect their own obesity level, which will have an impact on our results [50]. Further prospective studies that assess both energy expenditure and energy intake in children are more likely to clarify this concept.

However, some potential limitations exist in this cross-sectional study. The contents of the questionnaire were most recalled by the parents or guardians and there might be information bias in this survey. In addition, we set the classification standard of eating fruit frequency as "eating fruit 2 days a week" combined with the questionnaire data recalled by the parents or guardians, which may not be appropriate, so different results could have been obtained. Further research should be conducted to validate the conclusion.

Conclusions

In summary, in this cross-sectional study, we found that the prevalence of overweight and obesity among adolescents in Changchun, Jilin Province was high. Sex, age, birth history, dietary habits, and parental weight were important factors for overweight and obesity in adolescents. Therefore, reasonable lifestyle and effective weight control are necessary to prevent overweight and obesity in adolescents. There are still several limitations in this study, and we need to obtain more accurate information and perform more specific analysis. Further research should be conducted on the health of adolescents in China and further intervention measures should be implemented to decrease the prevalence of overweight and obesity.

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Footnotes

Contributors: RD, CK and HY conceived the study, participated in the design of the study. HY, JJ and XL collected data. RD carried out the measurements, analyzed the data and drafted the manuscript. XY and BZ participated in the coordination of the study and interpreted the data. WB and YL revised the manuscript. All authors have approved the final article.

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Competing interests: None declared.

Ethical approval: The investigation was conducted by the First Hospital of Jilin University in April 2016, our data collected from the questionnaire in the survey as well. The study was approved by the ethics committee of the First Hospital of Jilin University (Reference Number: 2013-031). The investigation has received informed consent from students and parents.

Data sharing: Data referenced in this study are available in the project titled "Effect and mechanism of weight loss on upper airway collapsibility in obese patients with OSAS". We selected a portion of the data from the database, including body measurements of adolescents from six middle schools in Changchun City. The data that support the findings of this study are available on request from the corresponding author [HY]. The data are not publicly available because they contain information that could compromise research participant privacy or consent.

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577

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page/line number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2-3, line 23-48
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 3-5, line 61-90
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 5, line 91-94
Methods			
Study design	4	Present key elements of study design early in the paper	Page 5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 5-6, line 97-104
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 7-8, line 127-158
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 6, line 107-125
Bias	9	Describe any efforts to address potential sources of bias	Page 9, line 167-172
Study size	10	Explain how the study size was arrived at	Page 5, line 97-101
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 7-8, line 127-158
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 8-9, line 160-172
		(*b*) Describe any methods used to examine subgroups and interactions	Page 8-9, line 160-172
		(*c*) Explain how missing data were addressed	Page 9, line 167-172
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	Page 8-9, line 160-172
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page10, line 186-192
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential	Page 9-10

		confounders	
		(b) Indicate number of participants with missing data for each variable of interest	Page 10, line 186-190
Outcome data	15*	Report numbers of outcome events or summary measures	Page10, line 186-192
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 11-12
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 12-15
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 16, line 240-243
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 19, line 310-316
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 15-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 19-20, line 318-326
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 20, line 335-337

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence and correlates of overweight and obesity among adolescents in northeastern China: a cross-sectional study

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Keywords:	PUBLIC HEALTH, EPIDEMIOLOGY, Risk management < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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Prevalence and correlates of overweight and obesity among adolescents in northeastern China: a cross-sectional study

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Abstract

Objectives: To estimate the prevalence of overweight/obesity among adolescents and to evaluate the associated factors in this group in Changchun City, northeastern China.

Methods: A cross-sectional study of 1955 adolescents aged 11–18 years was conducted in Changchun City, using stratified cluster sampling. Parents and caregivers of children completed the questionnaires as requested without objection; the questionnaire included demographic characteristics and anthropometric parameters. Univariate and multivariate logistic regression analyses were performed to analyze the relationship between overweight /obesity and related factors.

Results: In total, the prevalence of overweight was 12.7% (male 17.4%; female 10.1%), and the prevalence of obesity was 4.9% (male 8.8%; female 3.1%) in Changchun, Jilin Province. The prevalence of overweight and obesity was higher in males than that in females (P <0.001). Multivariate logistic regression showed that overweight and obesity were significantly associated with male sex (OR=1.91, 95% CI: 1.48-2.47), eating fresh fruits more than two days per week (OR=1.41, 95% CI: 1.09-1.84), eating quickly (OR=1.37, 95% CI: 1.06-1.78). The students who were not picky (OR=0.69, 95% CI: 0.53-0.90) were less likely to be overweight. And adolescents whose father were overweight or obese (OR=0.67, 95% CI: 0.52-0.86) or mother were overweight or obese (OR=0.72, 95% CI: 0.52-0.99) were less likely to be overweight.

Conclusion: The prevalence of overweight and obesity among adolescents in

Changchun was high in recent years. The prevalence of overweight and obesity among males was higher than that among females. Sex, dietary habits (weekly frequency of fruit consumption, picky eating and slowness in eating) and parental weight were important factors for overweight and obesity in adolescents. Further research should be conducted on the health of adolescents in China and further intervention measures should be implemented to reduce the prevalence of overweight/obesity.

Keywords: overweight; obesity; adolescent; association

Strengths and limitations of this study

- In the cross-sectional study, participants were randomly selected from rural and urban areas by stratified cluster sampling.
- Weight category was defined using age- and sex- specific BMI cutoff points specifically developed for the Chinese adolescent population.
- The influence of confounding factors on the results was effectively controlled by the multivariate logistic regression method.
- Missing data from childhood measurements were handled with a mean imputation technique.
- The contents of the questionnaire were most recalled by the parents or guardians and there might be information bias in this survey.

Introduction

The prevalence of obesity has increased dramatically among children, adolescents and adults worldwide in recent decades [1]. Overall, the global proportion of adolescents with obesity has increased significantly from just 4% in 1975 to just over 18% in 2016 [2]. There is compelling evidence revealing a significantly higher proportion of overweight or obese adolescents in recent years, which has reached alarming levels. Recently, scholars have conducted many studies on overweight and obesity. Overweight and obesity are predisposing factors for many chronic diseases, such as type 2 diabetes, cardiovascular diseases, respiratory diseases, musculoskeletal disorders, and various types of cancer [3]. Yan R et al. found an association of adolescent obesity with nonalcoholic fatty liver disease (NAFLD) and revealed that the incidence of NAFLD increased with increasing body weight [4]. Lisan Q et al. compared patients with obesity and severe obstructive sleep apnoea (OSA) with and without prescription of positive airway pressure (PAP) therapy and found that participants with PAP prescriptions had a higher BMI (Body mass index) than participants not prescribed PAP [5] . It has been estimated that overweight and obesity are the fifth leading cause of death worldwide, accounting for nearly 3.4 million deaths annually [6]. In addition, obesity is considered a risk factor for the development of chronic kidney disease [7]. In this context, the American Medical Association classified obesity as a disease to get physicians to pay more attention to the condition [8].

In China, the largest developing country, nearly one-third of adolescents were overweight or obese in 2016, and the obesity prevalence rate increased from 0.10% in 1976 to 8.50% in 2016. Sun HP found that the prevalence of obesity and of overweight and obesity combined was 8.1% and 19.2%, respectively, among children and adolescents at the age of 7–18 [9]. Zhang XY reported that the prevalence rates of overweight and obesity among primary school children were 15.2% and 11.7%, respectively, in Jiangsu Province [10]. Therefore, it is of key importance to understand the risk factors for overweight and obesity to prevent adolescents from developing the disease.

We investigated the physical condition of adolescents aged 11-18 years from six middle schools in Changchun which is the capital of Jilin Province. The aim of the current study was to reveal the prevalence of overweight and obesity and to analyze various associated factors among adolescents with overweight and obesity in Changchun, Jilin.

Methods

Subjects

A cross-sectional survey was conducted in Changchun City, the capital of Jilin Province in Northeast China. The study sample comprised middle and high school students from six middle schools (three in urban areas and three in rural areas), selected randomly using stratified cluster sampling. Overall, 1955 students aged 11–

18 years were included in this cross-sectional survey; subjects with overweight/obesity due to known metabolic and endocrine diseases were excluded. Students were also excluded if they had mental or physical impairments severe enough to cause abnormal behaviors, including congenital disease, intellectual disability, and a psychiatric disorder [11]. We used the STROBE checklist in this study.

Data collection

The study was carried out by the First Hospital of Jilin University in April 2016. The study was approved by the ethics committee of the First Hospital of Jilin University (Reference Number: 2013-031). The investigation received informed consent from students and parents. The project was named “Effect and mechanism of weight loss on upper airway collapsibility in obese patients with OSAS” and studied the associations of overweight, obesity and related factors with sleep-related breathing disorders and snoring in adolescents. In this database, we focused on the relevant indicators of overweight and obesity in adolescents and analyzed the risk factors for obesity in adolescents. The interviewers from the First Hospital of Jilin University helped parents or guardians complete the questionnaire and provided the data. The questionnaire included demographic characteristics (age, sex, area, dietary habits, sleep, exercise, highest parental education, birth history, BMI classification, paternal weight and maternal weight), anthropometric parameters (weight, height) and a

paediatric sleep questionnaire- the Sleep-Related Breathing Disorder (PSQ-SRBD). The data about sleep duration and dietary habits (frequency of fresh fruits consumption, frequency of dessert consumption, frequency of breakfast consumption, frequency of fast food consumption, slowness in eating, picky eating) were selected from the PSQ-SRBD scale according to various reports [12-14] about adolescent obesity.

Key variables

Body mass index (BMI) is used here as an indicator of overweight and obesity in adolescents and adults. Weight category was defined using age- and sex- specific BMI cutoff points specifically developed for the Chinese adolescent population [15]. We used the 85th and 95th percentiles to define overweight and obesity in adolescents. Therefore, BMI values of 24 and 28 were used as cut-off points for overweight and obesity, both for males and females aged 18 years, which were consistent with Chinese adults. In our study, parental overweight was divided into 2 groups: normal (BMI<24) and overweight or obese (BMI≥24) [14, 16]. Parents and caregivers provided information on adolescents' weight (to the nearest 1 kg) and height (to the nearest 1 cm). Overall children were classified by age into 3 groups (<13 years, 13-15 years, >15 years), by region into 2 groups (urban, rural) and by sex into 2 groups (male, female). Participants who slept less than 8 hours over 3 days a week were classified as 'sleep <8 h', and those who slept more than 10 hours over 3

days a week were defined as 'sleep >10 h' [17]. Birth history was divided into 3 groups: preterm birth (infants born alive before 37 weeks of pregnancy), full-term birth (infants born alive after 37 completed weeks to less than 42 completed weeks) and post-term birth (infants born alive at 42 completed weeks or after) [18]. Parental educational level was divided into 4 groups: primary school or lower (including those who had never attended school and those with elementary schooling only), junior high school, senior high school (including those with 3 years of secondary vocational schooling) and university or above [17]. According to the contents of the questionnaire, we classified the participants'eating habits. According to the Food Guide Pagoda [19], fruit intake should be 200-350 g/d, and sugar intake should be no more than 50 g/d, so we used eating "fresh fruits more than two days per week (350 g/d)", "dessert more than two days per week", "breakfast more than two days per week", and "fast food more than two days per week" as cut-offs. Participants who were classified as "picky eating" were defined as adolescents who had selectivity for a particular kind of food [20]. "Slowness in eating" was defined as adolescents with higher masticatory performance and who ate slowly [21]. Groups were formed according to the number of exercise days (aerobic, strength training or both for at least 30 minutes a day), including never (participate in sports $\leqslant$1 day per week), sometimes (participate in sports 2-3 days per week) and often (participate in sports $\geqslant$ 4 days per week) [22, 23].

Statistical analysis

Data input was performed using Epidata 3.1, and statistical analysis was performed using SPSS 24.0. Frequency distributions are used to characterize subjects, and percentage data are used to report prevalence. The relationship between each factor and the adolescents' weight status was reflected by χ^2 tests and univariate and multivariate logistic regression. In univariate analysis, when $P < 0.10$, significant correlation factors were included in a forward stepwise multivariate logistic regression to exclude confounding factors. In all analyses, a two-tailed P value < 0.05 was considered statistically significant. Since the database was manually collated, some variables in the database had missing values, which resulted in waste and bias of data resources. The missing value was numeric, and the data were approximately normally distributed. The mean interpolation method was adopted in this study. Therefore, we used the "replace missing value" function in SPSS 24.0 and selected the "mean of nearby points" method to interpolate the missing values.

Data availability

Data referenced in this study are available in the project titled "Effect and mechanism of weight loss on upper airway collapsibility in obese patients with OSAS". We selected a portion of the data from the database, including body measurements of adolescents from six middle schools in Changchun City. The data that support the findings of this study are available on request from the corresponding author [HY]. The data are not publicly available because they contain information that could

compromise research participant privacy or consent.

Patient and public involvement

The interviewers from the First Hospital of Jilin University helped parents or guardians complete the questionnaire and provided the data. The adolescents were not involved in the design, recruitment or conduction of the study.

Results

On the basis of the inclusion and exclusion criteria, we chose 1955 adolescents from Changchun, and of these adolescents, 1825 were finally analyzed in this study. Participants with missing BMI values were excluded from the study. Since the survey was already completed, we were unable to verify the source of data errors, so we deleted data with missing BMI values. According to the analysis of the frequency distribution, we found that there were 837 boys and 988 girls included; the median age of the students was 15.30 years, ranging from 11 to 18 years; of all these subjects, 42.9% were from rural regions and 57.1% were from urban regions; and most of the subjects were Han Chinese, accounting for 98.2%, with only a few participants with minority ethnicities.

According to the worldwide BMI classification, the overall prevalence of overweight was 12.7% (male 17.4%; female 10.1%), and the prevalence of obesity was 4.9% (male 8.8%; female 3.1%) in Changchun City, Jilin Province (Table 1). The

overweight and obese rates were both higher in males than that in females (P <0.001). A higher prevalence of overweight was found in subjects whose ages ranged from 11-12 years, and the prevalence of obesity was higher in the age group from 13-15 years (P =0.008). Children from urban areas showed a significantly higher proportion of overweight. Full-term birth subjects had a higher prevalence of overweight than others (P =0.014). In addition, students who ate fruits more than twice a week (P =0.029), ate slowly (P =0.004), and were picky (P =0.028) had a lower higher prevalence of overweight in the study. Paternal weight (P =0.018) and maternal weight (P =0.006) also had an effect on the children's weight.

Table 1

Prevalence of overweight and obesity according to demographic characteristics

		Overweight		Obesity	
Variables	n	*PR* (%)	*p*	*PR* (%)	*p*
Sex					
Male	837	17.4(14.9-20.3)	<0.001	8.8(6.9-11.2)	<0.001
Female	988	10.1 (8.3-12.2)		3.1(2.2-4.5)	
Area					
Urban	1042	14.4(12.4-16.7)	0.14	5.6(4.2-7.3)	0.863
Rural	783	12(9.8-14.5)		5.8(4.3-7.8)	
Age					
<13	168	19.3(13.9-26.1)	0.008	5.1(2.5-10.3)	0.816
13-15	1157	11.6(9.8-13.6)		5.9(4.6-7.5)	
>15	500	15.5(12.5-19.0)		5.2(3.4-7.7)	
Birth history					
Full-term birth	1621	14.2(12.5-16.0)	0.014	6.0(4.9-7.4)	0.285
Preterm birth	133	5.4(2.6-11.0)		3.2(1.2-8.2)	
Post-term birth	71	10.1(4.9-19.8)		3.1(0.8-11.7)	
Fruit≤2 times/week					
Yes	1259	12.2(10.5-14.2)	0.029	4.8(3.7-6.2)	0.02
No	566	16.1(13.2-19.5)		7.7(5.6-10.4)	
Dessert ≤ 2					

times/week					
Yes	887	12.4(10.4-14.8)	0.252	5.2(3.9-7.0)	0.49
No	938	14.3(12.1-16.7)		6.0(4.6-7.9)	
Breakfast ⩽ 2 times/week					
Yes	1478	13.9(12.2-15.8)	0.185	5.8(4.7-7.3)	0.491
No	347	11.1(8.2-15.0)		4.8(2.9-7.9)	
Fast food ⩽ 2 times/week					
Yes	264	10.0(6.8-14.3)	0.095	5.4(3.2-9.1)	0.402
No	1561	13.9(12.3-15.8)		5.7(4.6-7.1)	
Slowness in eating					
Yes	1174	16.5(13.8-19.7)	0.004	6.2(4.5-8.5)	0.496
No	651	11.6(9.9-13.6)		5.4(4.1-6.9)	
Picky eating					
Yes	1133	14.8(12.8-17.1)	0.028	6.7(5.3-8.4)	0.027
No	692	11.1(8.9-13.7)		4.0(2.7-5.9)	
Exercise					
Never	451	15.9(12.7-19.6)	0.194	4.2(2.6-6.7)	0.315
Sometimes	478	12(9.3-15.3)		6.6(4.6-9.4)	
Often	896	12.8(10.7-15.2)		5.8(4.4-7.7)	
Highest parental education					
Primary school or lower	95	8.0(3.8-15.8)	0.196	8.0(3.8-15.8)	0.724
Junior high school	799	13.0(10.8-15.6)		5.1(3.7-7.1)	
Senior high school	468	15.8(12.7-19.5)		6.0(4.1-8.8)	
University or above	463	12.7(9.9-16.2)		5.7(3.8-8.4)	
Sleep (hours/night)					
<8	884	13.6(11.5-16.1)	0.809	5.3(3.9-7.2)	0.302
8-10	861	13.3(11.1-15.8)		5.6(4.2-7.5)	
>10	80	11.0(5.6-20.4)		9.7(4.7-19.0)	
Paternal weight					
Normal	827	15.4(13.1-18.1)	0.018	7.6(6.0-9.8)	0.002
Ow or ob	998	11.6(9.6-13.7)		3.8(2.7-5.4)	
Maternal weight					
Normal	1099	14.8(13.0-16.8)	0.006	5.6(4.4-7.0)	0.807
Ow or ob	726	8.5(6.1-11.7)		5.8(3.9-8.7)	

Note: *PR* (%), Prevalence rate; Ow or ob, Overweight or obese

To facilitate regression analysis, we divided the participants into two groups:

underweight/normal weight and overweight/obese. Table 2 shows the univariate analysis of correlates of overweight and obesity in adolescents. As impressively demonstrated in this table, the following factors all showed significant differences between two groups: sex, age, birth history, frequency of eating fruits, eating habits (slowness in eating, picky eating), and parental weights (P <0.05). According to the results, we added all these significant factors to a forward stepwise multivariate logistic regression model.

Table 2

Univariate analysis of correlates of overweight and obesity in adolescents in Changchun

Variables	*p*	*OR*	95% *CI*
Sex			
Female	<0.001	1	
Male		2.13	1.66-2.72
Area			
Urban	0.256	1	
Rural		1.15	0.90-1.47
Age			
<13	0.070	1	
13-15	0.041	0.67	0.45-0.98
>15	0.339	0.81	0.53-1.24
Birth history			
Full-term birth	0.008	1	
Preterm birth	0.004	0.40	0.21-0.74
Post-term birth	0.209	0.63	0.31-1.29
Fresh fruits≤2 times/week			
Yes	0.003	1	
No		1.46	1.13-1.87
Dessert≤2 times/week			
Yes	1.197	1	
No		1.17	0.92-1.49
Breakfast≤2 times /week			
Yes	0.15	1	
No		0.79	0.57-1.09

Fast food≤2 times /week			
Yes	0.135	1	
No		1.32	0.92-1.91
Slowness in eating			
Yes	0.007	1	
No		0.71	0.56-0.91
Picky eating			
Yes	0.004	1	
No		0.69	0.53-0.88
Exercise			
Never	0.74	1	
Sometimes	0.502	0.89	0.64-1.25
Often	0.484	0.90	0.67-1.21
Highest parental education			
Primary school or lower	0.411	1	
Junior high school	0.594	1.18	0.65-2.14
Senior high school	0.229	1.45	0.79-2.68
University or above	0.58	1.19	0.64-2.21
Sleep (hours/night)			
<8	0.964	1	
8-10	0.952	0.99	0.78-1.27
>10	0.805	1.08	0.60-1.94
Paternal weight			
Normal	0.001	1	
Ow or ob		0.64	0.51-0.83
Maternal weight			
Normal	0.011	1	
Ow or ob		0.67	0.49-0.91

Note: Ow or ob, Overweight or obesity

Table 3 shows the results of logistic regression models comparing the prevalence of the potential risk factors: sex, age, birth history, frequency of eating fruits, dietary habits (slowness in eating, picky eating) and parental weight. In this forward stepwise multivariate logistic regression model, males were more likely to be overweight and obese than females (OR=1.91, 95% CI: 1.48-2.50). Students aged 13-15 years (OR=0.63, 95% CI: 0.42-0.96) were less likely to be overweight than those aged

11-12 years. Compared with full-term birth, preterm birth (OR=0.45, 95% CI: 0.24-0.85) was associated with normal weight. Participants who ate fruit more than twice a week (OR=1.41, 95% CI: 1.09-1.84) were more likely to be overweight or obese. Moreover, the prevalence of overweight was higher in students who ate quickly (OR=1.37, 95% CI: 1.06-1.78) than those who ate slowly. Compared with picky eaters, students who were not picky (OR=0.69, 95%CI: 0.53-0.90) were less likely to be overweight.

Table 3

Multivariate regression analysis of correlates of overweight and obesity in adolescents in Changchun

Variables	*p*	*β*	SE	*OR*	95% *CI*
Sex					
Female				1	
Male	<0.001	0.65	0.13	1.91	1.48-2.50
Age					
<13				1	
13-15	0.030	-0.46	0.21	0.63	0.42-0.96
>15	0.121	-0.35	0.23	0.70	0.45-1.10
Birth history					
Full-term birth				1	
Preterm birth	0.014	-0.80	0.33	0.45	0.24-0.85
Post-term birth	0.337	-0.36	0.37	0.70	0.34-1.45
Fresh fruits≤2 times/week					
Yes				1	
No	0.010	0.35	0.14	1.41	1.09-1.84
Slowness in eating					
Yes				1	
No	0.016	0.32	0.13	1.37	1.06-1.78
Picky eating					
Yes				1	
No	0.007	-0.37	0.14	0.69	0.53-0.90
Paternal weight					

Normal				1	
Ow or ob	0.002	-0.41	0.13	0.67	0.51-0.83
Maternal weight					
Normal					
Ow or ob	0.049	-0.32	0.17	0.72	0.53-0.99

Note: Ow or ob, Overweight or obese

Discussion

To describe the epidemiology of overweight and obesity in Changchun City and analyze the influencing factors in adolescents, we conducted this survey of middle school students aged 11–18 years from urban and rural areas. We found that sex, dietary habits and parental weight had a significant impact on the children's weight.

Based on the data, we found that the prevalence of overweight was 12.7% (male 17.4%; female 10.1%) and that the prevalence of obesity was 4.9% (male 8.8%; female 3.1%) among adolescents in Changchun City, Jilin Province. However, in recent studies, the overall prevalence of obesity in school-aged children in Xi'an was 4.11%, and the rate of overweight was 6.6% among Nanjing adolescents; these rates were both lower than the corresponding rates in Changchun. This difference may be caused by the sample size, sex, and age of the studied population [24, 25]. In addition, demographic distribution and environmental factors are probable factors [26]. The economy in northeast China is less developed than that in east and south China to some extent [27]. Rates of overweight and obesity in rural areas were also higher in the north than that in the south [28]. Depending on the season, people in the north might eat high-energy foods to combat the cold, which is referred to “energy balance

related behaviors [29, 30]". In our data, boys were more often obese than girls, in general, which was in agreement with previous Chinese reports [30-32]. A Swedish report [33] predicted that there was an alarming increase in the prevalence of overweight and obesity among adolescent boys, which was consistent with our finding. On the one hand, in traditional Chinese culture, the preference for boys may be the reason for the differences in diet, and the elderly believe that fat boys are more powerful than thin boys. On the other hand, well-groomed and fit girls are more favored by Chinese society [34-36]. Girls also tend to be more concerned about their weight than boys.

We also found that adolescents who were picky, ate more fruits in general and ate quickly were more likely to be overweight or obese according to our survey. In recent reports [37, 38], a greater fruit intake was a protective factor against overweight, which was opposite of our result. Fructose, which is ubiquitous found in fruit and sugar-sweetened beverages, is one of the factors contributing to rising obesity rates [39, 40]. High intakes of fructose may decrease the abundance of the bacterial species Eubacterium eligens, reduce metabolism of monosaccharide and lose the ability to consume large amounts of fat [41]. The fructose intake threshold of adolescents is currently average 75g/d. If teenagers get too much fructose without consuming glycogen in time, fructose will be converted into fat at a higher rate [42, 43]. Based on the results of our study, it was reasonable to speculate that the children were already full in addition to the excessive intake of fruits with high sugar content. Moreover, the

heavy study demand in China makes the children fail to consume the extra energy through exercise, thus leading to the possibility of being overweight. For obese children, their parents believe they can control their weight by increasing their fruit intake. This may also have contributed to the fact that the children in our cross-sectional study who ate more fruit were more likely to be overweight. However, given our inconsistent results with previous finding [37, 38], whether the reason is due to different classification needs further research.

According to a recent study [44], food preference was an independent risk factor for overweight among children. It is known that children who had selectivity for a particular kind of food would prefer more fast food, snacks, and sugary beverage [45] and fewer fruits and vegetables [46]. However, the frequency of dessert and fast food consumption had no significant effect in our study, perhaps because the data were provided by parents or guardians who provided an inaccurate account of how often their children ate sweets and fast food. Currently, several studies have considered that food intake is a primary factor that determines body weight [47-49]. Y Li et al. concluded that excessive intake of cooking oil might be one of the risk factors for overweight [22]. According to a previous study in Tianjin [47], overweight students preferred significantly more sweet foods and take-out food than their counterparts with normal weight. The result might be influenced by many elements, such as peer influence, food price, convenience, and online influence and so on, based on a recent report [50]. To decrease the prevalence of overweight and obesity, a series of

interventions have been implemented, such as controlling TV time and increasing sport time.

In our research, we found that if fathers and mothers were overweight, adolescents were less likely to be overweight, which was inconsistent with the previous conclusions [51-53]. Studies [54, 55]have found that a higher BMI of the father increased the risk of overweight/ obesity among males and females. However, this finding was not consistent across studies. In a previous study, the researchers found that the relationship between parents' and children's BMI did not exist when longitudinal analyses of changes in BMI over four years were performed [56]. This may explain why a short period of periodic surveys alone does not fully demonstrate a parent-child link to obesity, and we still need long-term research to further explore the relationship between the two factors. Berge JM et al. found that overweight or obese parents were more likely to adopt a strict dietary restriction to prevent adolescent obesity [57]. Moreover, children's growing environment and living habits will also affect their own obesity level, which will have an impact on our results [50]. Further prospective studies that assess both energy expenditure and energy intake in children are more likely to clarify this concept.

However, some potential limitations exist in this cross-sectional study. The contents of the questionnaire were most recalled by the parents or guardians and there might be information bias in this survey. In addition, we set the classification standard of eating fruit frequency as "eating fruit 2 days a week" combined with the questionnaire data

recalled by the parents or guardians, which may not be appropriate. Further studies considering different classification and a quantitative measurement are required.

Conclusions

In summary, in this cross-sectional study, we found that the prevalence of overweight and obesity among adolescents in Changchun, Jilin Province was high. Sex, age, birth history, dietary habits, and parental weight were important factors for overweight and obesity in adolescents. Therefore, reasonable lifestyle and effective weight control are necessary to prevent overweight and obesity in adolescents. There are still several limitations in this study, and we need to obtain more accurate information and perform more specific analysis. Further research should be conducted on the health of adolescents in China and further intervention measures should be implemented to decrease the prevalence of overweight and obesity.

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Footnotes

Contributors: RD, CK and HY conceived the study, participated in the design of the study. HY, JJ and XL collected data. RD carried out the measurements, analyzed the data and drafted the manuscript. XY and BZ participated in the coordination of the

study and interpreted the data. WB and YL revised the manuscript. All authors have approved the final article.

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Competing interests: None declared.

Ethical approval: The investigation was conducted by the First Hospital of Jilin University in April 2016, our data collected from the questionnaire in the survey as well. The study was approved by the ethics committee of the First Hospital of Jilin University (Reference Number: 2013-031). The investigation has received informed consent from students and parents.

Data sharing: Extra data can be accessed via the Dryad data repository at http://datadryad.org/ with the doi:10.5061/dryad.g1jwstqnw

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page/line number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Page 1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2-3, line 23-48
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 3-5, line 61-90
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 5, line 91-94
Methods			
Study design	4	Present key elements of study design early in the paper	Page 5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 5-6, line 97-104
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 7-8, line 127-158
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 6, line 107-125
Bias	9	Describe any efforts to address potential sources of bias	Page 9, line 167-172
Study size	10	Explain how the study size was arrived at	Page 5, line 97-101
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 7-8, line 127-158
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 8-9, line 160-172
		(*b*) Describe any methods used to examine subgroups and interactions	Page 8-9, line 160-172
		(*c*) Explain how missing data were addressed	Page 9, line 167-172
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	Page 8-9, line 160-172
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page10, line 186-192
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential	Page 9-10

		confounders	
		(b) Indicate number of participants with missing data for each variable of interest	Page 10, line 186-190
Outcome data	15*	Report numbers of outcome events or summary measures	Page10, line 186-192
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 11-12
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Page 12-15
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 16, line 240-243
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 19, line 310-316
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 15-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 19-20, line 318-326
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 20, line 335-337

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.